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BENTHIC ANIMAL COMMUNITIES OF EXPOSED BAYS IN THE WESTERN GULF OF FINLAND (BALTIC SEA)

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Abstract. An overview of the distribution of macrozoobenthos communities in Nõva and Keibu bays, western Gulf of Finland, is given. The dominant species of the region were *Mytilus edulis* and *Macoma balthica*. The biomass of *M. edulis* correlated positively with the proportion of grain particles coarser than 5 mm in the sediment and *M. balthica* with the proportion of silt. High biomasses of *M. edulis* were found at the upwelling areas, *M. balthica* preferred sedimentation areas.

Key words: Gulf of Finland, macrozoobenthos, sediment structure.

INTRODUCTION

The complexity of nearshore areas and the multitude of influencing forces require a multidisciplinary approach and a variety of different techniques in order to adequately describe the processes in these areas. That is findings in physics, geology, biology, etc. should be compiled.

As Keibu and Nõva bays are exposed to wave action, salinity values are relatively high, and sandy substrate prevails, the macrozoobenthic communities in the area are rather untypical for the entire Gulf of Finland. Previously only Yarvekyulg (1979) has collected grab samples from a transect in Keibu Bay. Unfortunately, no detailed description of the fauna was given.

The aim of this study was to carry out the mapping of sediment and macrozoobenthos in Nõva and Keibu bays and in adjacent sea areas. Our main interest was to find out the relationships between the granulometry of sediment and the structure of macrozoobenthic communities. Traditional visual classification of sediment types is insufficient for describing the variation in the distribution of macrozoobenthic species.

MATERIAL AND METHODS

Keibu and Nõva bays are situated at the southern coast of the western Gulf of Finland (Fig. 1). The area is extremely exposed to the sea. Salinity is between 6 and 8‰ in the study area. The depth interval of 0.5 and 50 m was studied, but most stations were situated between 0.5 and 10 m. Hard bottoms, consisting of sand or gravel, prevail in the area with the exception of a stone bottom in the vicinity of the Ristna Peninsula. Because of bottom types and exposure the region is practically devoid of vegetation and therefore we may neglect its effect on macrozoobenthos.

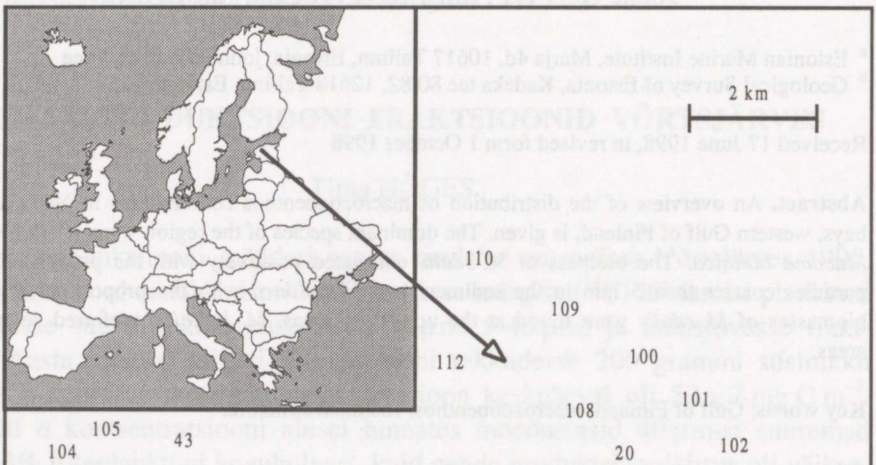

Fig. 1. Study area.

Sediment and macrozoobenthos sampling was performed with an Ekman-Lenz bottom grab (400 cm^2) in the shallower parts (< 15 m) and with a van Veen bottom grab (1000 cm^2) in the deeper parts of the study area. A total of 87 stations were sampled. The sample was considered representative if at least 1 L sediment was caught with the Ekman-Lenz grab and 3 L sediment with the van Veen grab.

According to visual observation sediments were classified as follows: silt, fine sand, medium sand, coarse sand, gravel, pebbles, stone.

For granulometrical analysis sediments were sieved using the following mesh sizes: 0.045, 0.053, 0.063, 0.075, 0.090, 0.106, 0.125, 0.150, 0.180, 0.212, 0.250, 0.300, 0.355, 0.425, 0.500, 0.600, 0.710, 0.850, 1.000, 1.180, 1.400, 1.700, 2.000, 2.360, 2.800, 3.350, 4.000, 4.750, 5.600, 6.300, 6.700, 8.000, 10.000, 11.200, 12.500, 13.200, 16.000, and 19.000 mm. Sediment fraction smaller than 0.063 mm is defined as silt, sediments between 0.063 and 0.212 mm fine sand, 0.212–0.5 mm medium sand, 0.5–2.0 mm coarse sand, 2–10 mm gravel, and bigger than 10 mm pebbles. The granulometrical analysis was made according to Kask & Ramst (1992). Figure 2 depicts the distribution of bottom deposits in the study area.

The macrozoobenthos samples were sieved through a 0.25 mm mesh and preserved in 4% buffered formaldehyde solution. In the laboratory, animals were counted and identified under a stereo dissecting microscope. Wet weights for each taxon were found to the nearest 0.5 mg. Dry weights were obtained after keeping the material at 60 °C for 48 h.

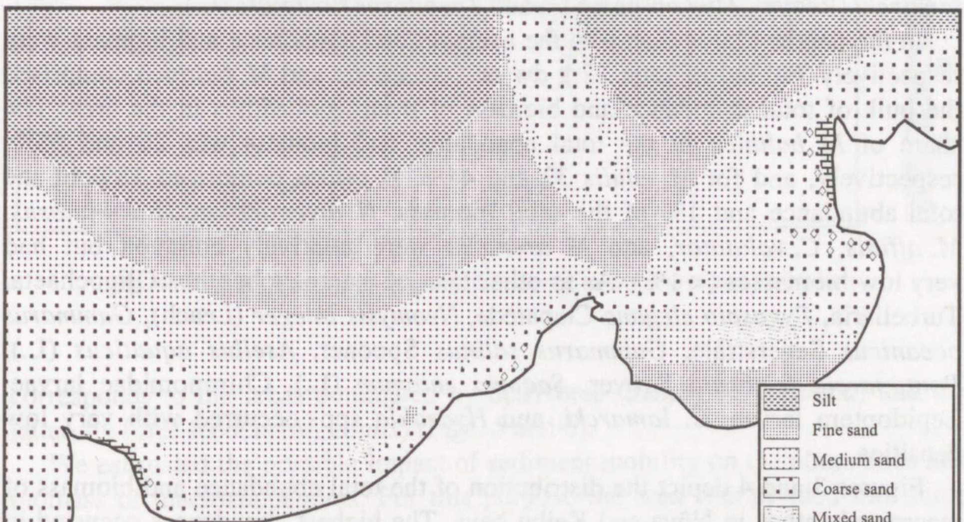

Fig. 2. Bottom deposits in Nõva and Keibu bays.

The distribution maps of the abundance and biomass of macrozoobenthos were made with "Surfer for Windows" (Golden Software, 1994). For gridding Kriging's method was used. Correlation analysis was applied to describe the relationship between different size fractions of the sediment and the density of various functional groups of macrozoobenthos. The importance of depth and granulometry on the structure of the macrozoobenthos community was assessed with the help of the multidimensional scaling procedure (Krebs, 1989; Clarke & Warwick, 1994).

RESULTS

In Keibu and Nõva bays two subareas of macrozoobenthos can be distinguished separated by the 6 m depth isobath. Shallow areas were characterized by moderate or high abundances and very low biomasses. Abundances varied between 200 and 4500 ind m^{-2}, the average was 750 ind m^{-2}. Biomasses never exceeded 5 g dw m^{-2}, the average was 2.7 g dw m^{-2}, which is about 5–10 times lower than biomasses found elsewhere in the bays of the Gulf of Finland (e.g. Kotta, I. & Kotta, J., 1997; Kotta, J. & Kotta, I., 1997). The abundance was dominated by *Bathyporeia pilosa* Lindström (89%), biomasses by small-sized *Macoma balthica* L. (84%) and *Mytilus edulis* L. (8%). Species contributing less than 10% of the total abundance or biomass were *Nereis diversicolor* (O. F. Müller), *Halicryptus spinulosus* (Siebold), *Corophium volutator* (Pallas), *Monoporeia affinis* Lindström, Chironomidae larvae, *Cerastoderma lamarcki* (Reeve), *Mya arenaria* L., and *Theodoxus fluviatilis* (L.).

In the depths higher than 6 m the average total abundance and biomass were respectively 790 ind m^{-2} and 22 g dw m^{-2}. *M. edulis* and *M. balthica* comprised the bulk of total abundance and biomass of macrozoobenthos in the area. The share of *M. balthica* in the total abundance and biomass was 26 and 53%, respectively, and for *M. edulis* 32 and 44%. *B. pilosa* comprised 18% of the total abundance and 1% of the total biomass. *N. diversicolor*, *H. spinulosus*, *M. affinis*, *C. volutator*, and *M. arenaria* were relatively common but had very low biomasses (< 1%). As to other taxa of macrozoobenthos Oligochaeta, Turbellaria, *Pygospio elegans* Claparède, *Neomysis integer* (Leach), *Gammarus oceanicus* Segerstråle, *Gammarus salinus* Spooner, *Asellus aquaticus* (L.), *Pontoporeia femorata* Kröyer, *Saduria entomon* (L.), Chironomidae larvae, Lepidoptera larvae, *C. lamarcki*, and *Hydrobia* spp. occurred with very low densities.

Figures 3 and 4 depict the distribution of the total abundance and biomass of macrozoobenthos in Nõva and Keibu bays. The highest abundances occurred in the north-western parts of both bays and the lowest in the extensive shoals between these areas. Two maxima of biomasses were recorded. One was situated north from Keibu Bay and the other north-west from Nõva Bay. The former

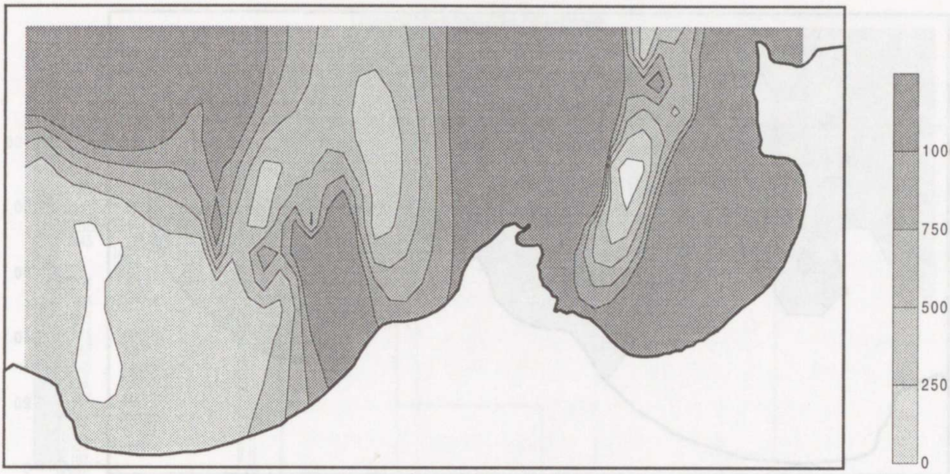

Fig. 3. Total abundance of macrozoobenthos (ind m^{-2}) in Nõva and Keibu bays.

Fig. 4. Total dry biomass of macrozoobenthos (g m^{-2}) in Nõva and Keibu bays.

corresponds to the areas dominated by detrivores (mainly *M. balthica*) and the latter, by filter-feeders (*M. edulis*) (Figs. 5 and 6).

We estimated the possible impact of sediment mobility on the abundance and biomass of macrozoobenthos. For this purpose the area was divided into three groups: accumulation, stable (i.e. net sediment transport equals zero), and erosion areas. Neither the abundance nor biomass of macrozoobenthos differed significantly between these three areas (Kruskal Wallis ANOVA probability 0.179 and 0.288, respectively).

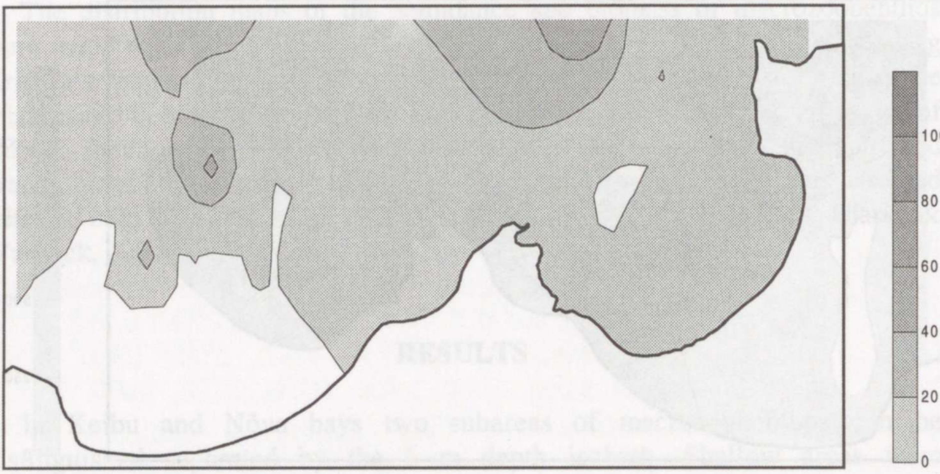

Fig. 5. Biomass distribution of detrivores (g m^{-2}) in Nõva and Keibu bays.

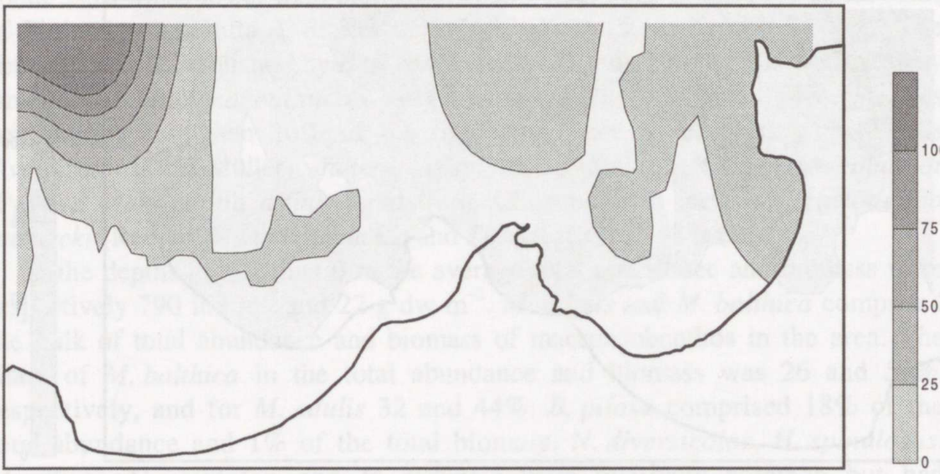

Fig. 6. Biomass distribution of filter-feeders (g m^{-2}) in Nõva and Keibu bays.

According to ANOVA the sediment type (based on visual observation) did not have any effect on the abundance and biomass of macrozoobenthos ($p > 0.05$).

In order to relate the variability in the structure of macrobenthic communities and environmental gradients, MDS analysis was performed, based on the dissimilarity matrix calculated from square root transformed macrozoobenthos biomass (Fig. 7). The transformation was used to increase the importance of rare species and decrease the contribution of abundant species in the analysis. The results do not indicate any clear grouping of the stations. Deeper areas are

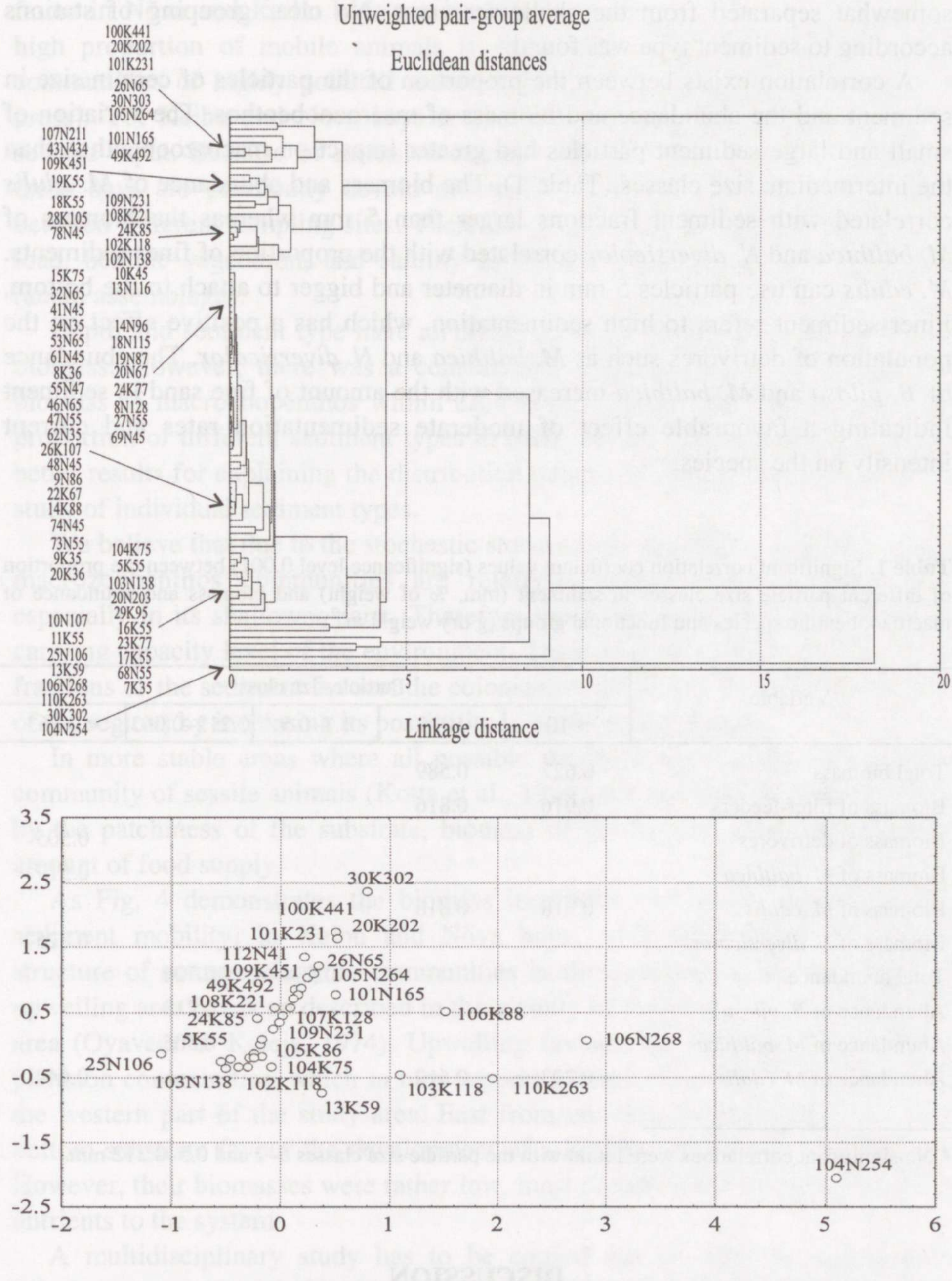

Fig. 7. Dendrogram and MDS ordination of sampling stations based on square root transformed biomass of macrozoobenthos species. N, Nõva Bay; K, Keibu Bay; the number preceding the letter is station code; the last number is bottom code (1, silt; 2, silty clay; 3, sandy clay; 4, clay sand; 5, fine sand; 6, sand; 7, coarse sand; 8, gravel, pebbles; 9, stone); and the numbers between the letter and bottom code show depth (m).

somewhat separated from the shallower areas. No clear grouping of stations according to sediment type was found.

A correlation exists between the proportion of the particles of certain size in sediment and the abundance and biomass of macrozoobenthos. The variation of small and large sediment particles had greater impact on macrozoobenthos than the intermediate size classes (Table 1). The biomass and abundance of *M. edulis* correlated with sediment fractions larger than 5 mm whereas the biomass of *M. balthica* and *N. diversicolor* correlated with the proportion of finer sediments. *M. edulis* can use particles 5 mm in diameter and bigger to attach to the bottom. Finer sediment refers to high sedimentation, which has a positive effect on the population of detrivores such as *M. balthica* and *N. diversicolor*. The abundance of *B. pilosa* and *M. balthica* increased with the amount of fine sand in sediment indicating a favourable effect of moderate sedimentation rates and current intensity on the species.

Table 1. Significant correlation coefficient values (significance level 0.001) between the proportion of different particle size classes in sediment (mm, % of weight) and biomass and abundance of macrozoobenthic species and functional groups (g dry weight m^{-2})

Variable	Particle size class*				
	> 10	10–5	1.7–0.5	0.212–0.063	< 0.063
Total biomass	0.627	0.589			
Biomass of filter-feeders	0.916	0.816			
Biomass of detrivores					0.505
Biomass of *M. balthica*					0.517
Biomass of *M. edulis*	0.918	0.818			
Biomass of *N. diversicolor*					0.825
Total abundance			–0.534	0.704	
Abundance of *B. pilosa*				0.718	
Abundance of *M. balthica*				0.505	
Abundance of *M. edulis*	0.703	0.612			0.644

* No significant correlations were found with the particle size classes 5–2 and 0.5–0.212 mm.

DISCUSSION

For the major part of the Estonian coastal sea it is relatively easy to define the environmental factors that explain most of the variation in macrozoobenthic communities (e.g. Kotta, J. & Kotta, I., 1995; Kotta, I. & Kotta, J. 1997; Kotta et al., 1998). However, the key factors responsible for the development of benthic fauna in Nõva and Keibu bays are hard to demonstrate. The low biomass and high proportion of mobile animals in these bays make them similar to the communities of highly polluted areas of the Gulf of Riga (Kautsky et al., in press). Yet Keibu and Nõva bays are situated far from any bigger municipal sewage input. Because of intensive currents and the lack of suitable substrate these bays are practically devoid of benthic vegetation. Salinity varies little between different sampling sites. Therefore we may neglect municipal pollution load, benthic vegetation, and salinity as the key variables structuring benthic faunal assemblages.

Depth and sediment type have an effect on macrozoobenthos abundance and biomass. However, there was a considerable variation in the abundance and biomass of macrozoobenthos within each class of depth and bottom type. The proportion of different sediment types in each site, i.e. sediment structure, gave better results for explaining the distribution pattern of macrozoobenthos than the study of individual sediment types.

We believe that due to the stochastic storm events and high sediment mobility macrozoobenthos communities are relatively unstable in the study area, especially in its shallower parts. Therefore these communities hardly reach the carrying capacity level of the environment. The bigger proportion of coarser size fractions of the sediment favours the colonization of *M. edulis* (dominant species of the region) by increasing its possibility to attach to the bottom.

In more stable areas where all possible substrata are covered by a diverse community of sessile animals (Kotta et al., 1998), the biomass level is controlled by the patchiness of the substrate, biomass of the benthic vegetation, and the amount of food supply.

As Fig. 4 demonstrates the biomass increased with depth (i.e. decreasing sediment mobility) in Keibu and Nõva bays. Also other factors affect the structure of macrozoobenthic communities in these deeper areas. An important upwelling area has been described in the vicinity of the western part of our study area (Oyaveer & Kalejs, 1974). Upwelling favours the development of phytoplankton communities, which in turn support a dense filter-feeder community in the western part of the study area. East from this area slow currents and finer bottom substrate favour the development of a healthy community of detrivores. However, their biomasses were rather low, most probably due to the low input of nutrients to the system.

A multidisciplinary study has to be carried out in order to obtain more information on the relationships between the distribution of upwelling areas, sedimentation processes, and the structure of macrozoobenthic communities. Coastal areas such as Keibu and Nõva bays suit well for these purposes as environmental parameters which usually dump down the impact of the above-mentioned variables play a minor role there.

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AVATUD MERELAHTEDE PÕHJALOOMASTIKU KOOSLUSED SOOME LAHE LÄÄNEOSAS

Jonne KOTTA, Ilmar KOTTA ja Jüri KASK

On antud ülevaade põhjaloomastiku koosluste levikust Nõva ja Keibu lahes. Söödav rannakarp ja lamekarp olid piirkonna olulisimad liigid. Söödava rannakarbi biomass korreleerus positiivselt 5 mm ja suuremate osakeste proportsiooniga setetes, lamekarbi biomass saviosakeste hulgaga setetes. Esimese suuremad biomassid paiknesid süvavete kerke piirkonnas, teine eelistas sedimentatsioonialasid.