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DISTRIBUTION OF BENTHIC DIATOM ASSEMBLAGES IN THE WESTERSCHELDE (ZEELAND, THE NETHERLANDS)

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ABSTRACT. — The benthic diatom assemblages of the Westerschelde-estuary were studied by means of multivariate analysis. Two main groups and eight subgroups were distinguished. The relation with salinity and sediment composition was investigated. A clear relation between grain size and the distribution of the assemblages was found.

SAMENVATTING. — *Verspreiding van benthische diatomeeëngemeenschappen in de Westerschelde (Zeeland, Nederland).* — De benthische diatomeeëngemeenschappen van het Westerschelde-estuarium werden onderzocht met behulp van multivariate technieken. In totaal werden twee hoofdgroepen en acht subgroepen onderscheiden. De relaties met de saliniteit en de sedimentsamenstelling werden onderzocht. Hierbij bleek een duidelijk verband te bestaan tussen de korrelgrootte van het sediment en de verspreiding van de gemeenschappen.

A. INTRODUCTION

The Schelde estuary is of great importance economically (trade, transport, industry and fisheries) and ecologically (hatchery for shrimp and sole, feeding areas and wintering grounds for wildfowl and waders). However, few research has been carried out on its ecology in comparison with other European estuaries (HEIP 1988). Recently, interest in the Schelde estuary has increased : several scientific projects are in preparation (such as FKFO — Fund for Collective and Fundamental Research) or have already started (EEC-project MAST, Marine Science and Technology — PL890046).

The microphytobenthos is a longly neglected and underestimated group of primary producers. Especially in turbid estuaries, like the Schelde, it can make up for a large proportion of the total primary production (MCLUSKY 1989).

In 1989 the benthic diatom flora of the Westerschelde was investigated (SABBE 1990). This paper deals with the distribution of the diatom assemblages in relation to salinity and sediment composition.

B. MATERIAL AND METHODS

B.1. STUDY AREA

The Westerschelde forms part of the Schelde estuary which stretches from Gent (Belgium) to its mouth near Vlissingen (the Netherlands) (fig. 1). The Dutch part is called the Westerschelde, the Belgian part the Zeeschelde. The Schelde is one of the longest tidal rivers of Europe. The continuous mixing of fresh and salt water results in a very regular longitudinal salinity gradient. Nutrient levels are high due to organic pollution. For more data, see Heip (1988 : 212).

B.2. Sampling

Forty-three intertidal sites (fig. 1) were sampled at the end of October 1989. Samples were taken at low tide by pushing a perspex cylinder (diameter 22 mm) into the sediment. Only the upper 10 mm of the core was kept for examination, since this part contains most of the photosynthetically active diatoms (Van den Hoek *et al.* 1979). At each station three mixed samples of five times the upper 10 mm were taken. One of these was used for cell counts, the second one for sediment analysis and the third for chlorophyll a analysis. This last sample was stored at -20°C until analysis. Both the pigment and sediment analysis were done at the "Delta Instituut voor Hydrobiologisch Onderzoek" (Yerseke, the Netherlands).

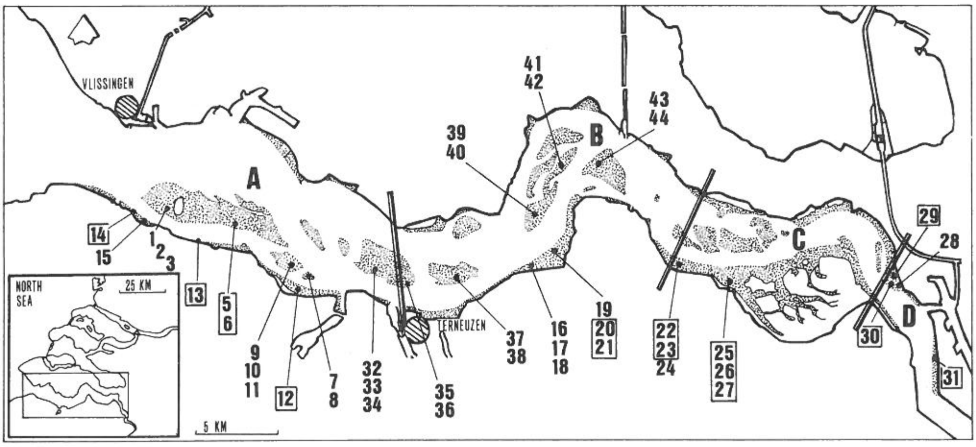


Fig. 1. — The Westerschelde : site, sampling locations (1-3, 5-44) and salinity sectors (A : the marine zone ; B : the marine transitional zone ; C : the brackish zone (Dutch part) ; D : the brackish zone (Belgian part)) — (dotted : intertidal areas). Main group 1 is indicated by numbers in a frame.

B.3. Cleaning and counting

The mixed samples for the counts were oxidized with hydrogen peroxyde (27%) and acetic acid (99.9%), according to a sligthly modified version of a cleaning procedure proposed by Schrader (1973). Permanent preparations were made with Naphrax.

The relative abundance of each taxon was determined by counting the first 400 thecae of each sample. The counting scores were then expressed as percentages. As most diatoms were attached to (or simply obscured by) sediment particles, no distinction could be made between dead and living cells.

The results of the non-transformed countings were analysed using two multivariate techniques : a classification (TWINSPAN — default cutlevels (Hill 1979a)) and an ordination (Detrended Correspondence Analysis — DCA (Hill 1979b)) technique.

B.4. Chlorophyll a analysis

The chlorophyll a content of the sediment (used as a biomass parameter) was measured using the HPLC (High Performance Liquid Chromatography) technique (see Daemen & de Leeuw-Vereecken 1985).

C. RESULTS

C.1. Chlorophyll a

Chlorophyll a levels were highest (> 20 mg/kg) in stations 7, 13, 14, 18 and 21-24. No relation with sediment composition or salinity was found.

Due to the limited number of samples it is not possible to give a relevant estimation of microphytobenthos biomass distribution in the Westerschelde. For example, samples 32-44 were taken after a period of rough weather. Strong winds can easily suspend free-living diatoms, thus causing biomass values in the sediments to drop considerably (Van den Hoek *et al.* 1979). This makes comparison of samples 32-44 with the other ones impossible.

In future research we plan to visit the sampling sites more frequently and to execute quantitative cell counts in order to determine the microphytobenthos biomass, as these counts give more information on the algal composition.

C.2. Description of the diatom assemblages

240 diatom taxa were identified ; 74 of these could be determined to genus-level only. This was mainly due to the small size (< 20 µm) of many taxa and the rather limited amount of systematic literature on estuarine benthic diatoms. Currently, further research is done on the taxonomy and systematics of these diatoms. A complete systematic list of the observed taxa is in preparation.

Both the DCA (fig. 2) and TWINSPAN analysis resulted in a clear division of the samples in two main groups, 0 and 1. The results of both were then compared and on this basis a sligthly modified Twinspan dendrogram was formed (table 1, top). Eigth subgroups (four in each main group) were distinguished. Table 1 shows the relative abundance of the most important taxa in the eight subgroups.

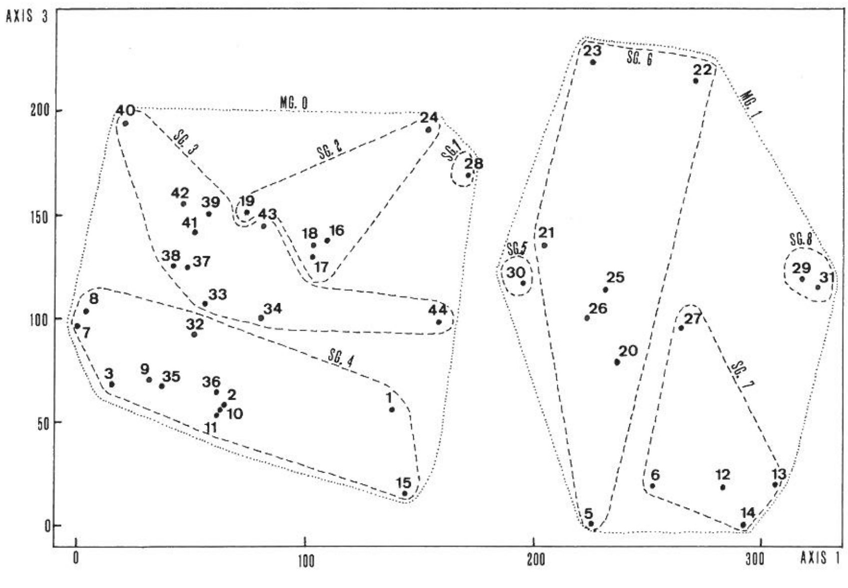
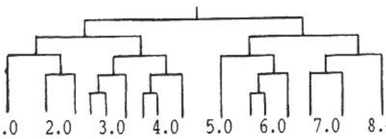


Fig. 2. — DCA-diagram (axis 1 - axis 3) of 43 samples from the Westerschelde. The 2 main groups (MG. 0-1, dotted lines) and the 8 subgroups (SG. 1-8, dashed lines) are indicated.

TABLE 1

Relative abundance (%) and ecological category of the most important diatom taxa
(PS = epipsammon ; PE = epipelon ; IN = indifferent ; PL = plankton ; UN = category unknown)

TWINSPAN diagram



subgroup		1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
no. of samples		1.0	5.0	10.0	12.0	1.0	7.0	5.0	2.0
average no. of taxa (spec.+ var.)/sample		52	45	62	54	67	67	56	81
Anorthoneis spec.	PS	-	-	0.8	0.1	-	-	-	-
Navicula pseudoscutiformis Hust.	UN	-	-	0.8	-	-	-	-	-
Navicula spec.24	UN	-	-	2.1	-	-	-	-	-
Navicula spec.28	UN	-	-	4.1	-	-	-	-	-
Rhaphoneis scalaris Ehr.	PS	-	-	-	0.5	-	-	-	-
Fragilaria spec.1	PS	-	0.1	1.1	4.0	-	0.2	-	-
Navicula spec.11	UN	-	0.3	0.6	1.4	0.3	-	-	-
Navicula spec.19	UN	-	0.2	1.0	2.1	-	-	-	-
Amphora spec.1	PS	-	4.1	1.1	4.8	0.3	0.7	0.1	0.8
Opephora schulzii (Brockm.) Sim.	PS	2.8	4.9	1.0	4.4	1.3	0.7	0.2	0.4
Nitzschia frustulum (Kütz.) Grun.	PS	1.0	4.1	0.8	0.7	-	0.5	0.1	0.2
Achnanthes spec.1	PS	-	1.3	6.2	7.7	0.3	0.7	-	-
Amphora spec.3	UN	-	-	0.1	1.2	-	0.1	0.1	-
Fragilaria spec.2	PS	-	-	-	0.5	-	0.1	-	-
Hantzschia marina (Donk.) Grun.	PE	-	-	0.1	0.2	0.3	-	-	0.1
Navicula cryptolyra Brockm.	PS	-	1.4	2.2	2.5	-	0.2	-	-
Navicula incertata Lange-Bert.	PS	0.5	0.6	1.2	2.2	2.8	0.1	-	-
Navicula perminuta Grun.	PS	0.5	7.0	6.6	15.7	1.3	1.1	0.4	0.3
Navicula spec.7	UN	-	0.1	0.2	1.7	-	-	0.3	-
Plagiogramma minimum Salah	PS	-	0.1	0.8	2.4	-	0.2	0.1	0.2
Amphora spec.6	UN	0.8	0.4	0.7	0.1	-	0.3	0.1	0.5
Navicula spec.2	UN	0.5	2.2	4.9	2.4	4.0	0.3	-	-
Navicula spec.21	PE	-	0.4	1.3	0.4	-	0.2	0.1	-
Navicula cf. accomoda Hust.	UN	-	0.7	6.1	0.9	-	0.3	0.1	0.5
Opephora spec.3	PS	-	0.8	2.8	0.4	-	0.1	0.2	0.2
Achnanthes spec.5	UN	0.3	-	1.5	0.2	3.3	-	-	0.1
Amphora spec.5	UN	0.8	-	0.2	-	-	0.2	-	-
Amphora spec.2	UN	-	-	1.5	0.2	-	-	0.1	-
Navicula spec.18	UN	-	-	3.4	1.3	0.8	0.3	-	-
Navicula palpebralis Bréb.	PE	-	0.5	1.8	0.7	1.3	0.2	0.4	0.2
Navicula pygmaea Kütz.	PE	-	-	0.7	0.2	-	-	0.2	0.3
Navicula spec.3	UN	-	-	1.4	0.4	-	0.3	0.1	-
Nitzschia dissipata (Kütz.) Grun.	PE	-	0.9	5.3	6.4	6.8	1.7	0.1	0.2
Amphora coffeiformis (Ag.) Kütz.	PE	2.3	1.5	4.0	2.6	1.8	1.6	1.0	1.3
Opephora spec.4	PS	2.0	2.6	2.7	7.9	1.8	2.6	1.9	0.2
Plagiogramma staurophorum (Greg.) Heib.	PS	-	2.5	0.2	0.4	-	0.2	0.1	0.1
Navicula lucens Hust.	UN	0.5	7.4	1.6	1.9	1.5	1.9	0.1	0.4
Opephora cf. parva (Grun.) Krasske	PS	7.0	6.5	1.7	1.0	0.5	3.3	0.6	0.2
Opephora cf. olsenii Möller	PS	5.5	6.3	2.9	2.9	1.3	2.7	1.3	-
Cocconeis spec.1	PS	-	2.1	0.4	0.2	-	1.0	0.1	-

subgroup		1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
no. of samples		1.0	5.0	10.0	12.0	1.0	7.0	5.0	2.0
average no. of taxa (spec.+ var.)/sample		52	45	62	54	67	67	56	81
Opephora spec.5	PS	40.0	0.8	0.1	0.6	11.3	0.3	0.1	0.1
Cocconeis peltoides Hust.	PS	-	1.3	0.6	0.4	-	0.5	0.1	0.2
Achnanthes hauckiana Grun.	PS	13.0	23.3	5.5	3.1	9.8	10.6	2.3	1.6
Catenula adhaerens Mereschk.	PS	0.5	6.0	0.6	0.6	0.8	3.6	0.5	0.3
Navicula tenera Hust.	PS	0.3	0.8	0.2	0.1	-	0.4	0.1	-
Navicula cf. normalis Hust.	PE	3.0	0.1	0.4	0.5	0.5	1.7	1.8	0.7
Plagiogrammopsis vanheurckii (Hust.) HvSS.	UN	0.3	0.1	0.5	0.2	0.5	0.8	1.2	1.7
Eunotogramma dubium Hust.	PS	0.3	-	-	0.1	-	-	0.1	-
Thalassionema nitzschioides Grun.	PL	0.3	0.2	0.7	0.5	2.0	2.0	3.9	3.9
Navicula cryptocephala Kütz.	PE	-	-	-	-	-	-	-	0.2
Spec.1	UN	-	-	0.5	0.1	4.0	1.9	0.4	10.4
Cyclotella meneghiniana Kütz.	PE	0.3	-	0.2	-	0.8	0.6	0.4	7.0
Cyclotella atomus Hust.	PL	-	0.2	0.1	-	1.5	0.1	0.3	4.8
Actinoptychus senarius Ehr.	PE	0.3	-	0.1	0.1	0.3	0.9	1.5	0.7
Cymatosira belgica Grun.	IN	1.8	0.8	1.9	2.1	6.5	7.5	13.9	6.4
Delphineis surirella (Ehr.) Andrews	PS	0.5	0.2	0.2	0.6	1.0	1.6	5.7	1.0
Paralia sulcata (Ehr.) Cleve	PE	0.5	0.3	0.7	1.0	4.3	3.9	9.7	2.4
Rhaphoneis amphiceros Ehr.	PS	0.3	0.3	1.2	1.0	2.3	5.2	11.0	6.2
Stauroneis salina W.Sm.	PE	0.8	-	0.1	0.2	0.5	0.2	0.8	4.6
Thalassiosira spec.1	PE	0.3	0.1	0.3	1.2	4.3	3.2	1.9	8.8
Campylosira cymbelliformis (A.Schm.) Grun.	PE	-	0.1	-	0.1	-	0.3	0.4	0.2
Navicula phyllepta Kütz.	PE	-	-	0.2	-	-	1.1	0.5	1.2
Pleurosigma aestuarii (Bréb.) W.Sm.	PE	-	0.1	-	-	-	0.3	1.0	-
Rhaphoneis minutissima Hust.	PS	1.5	0.9	2.6	2.3	7.8	6.9	15.3	8.8
Nitzschia constricta (Kütz.) Ralfs	PE	1.3	0.2	-	-	0.3	1.2	0.8	1.2
Gyrosigma fasciola (Ehr.) Griff. & Henf.	PE	0.3	-	-	-	-	1.9	0.1	0.2
Navicula flanatica Grun.	IN	0.3	0.2	0.2	-	0.5	1.7	1.5	1.9
Navicula gregaria Donk.	PE	2.3	1.6	0.2	0.2	1.8	10.4	1.8	1.7
Podosira stelliger (Bail.) Mann	PE	-	-	0.1	0.1	0.8	0.3	0.4	0.3
Gyrosigma spenceri (Quek.) Griff. & Henf.	PE	-	-	-	-	-	1.0	0.1	0.1
Nitzschia bergii CL.-E.	PE	-	-	-	-	-	1.1	-	-

As only one (limited) sampling campaign was performed, the delimitation of the subgroups remains 'arbitrary'. We chose to make 'larger' subgroups (e.g. subgroups 3 and 4, containing 10 and 12 samples respectively) until the stability of these subgroups is better known through further research.

Main group 0

This group is characterized by the generally high abundance of *Navicula perminuta*. Other important taxa are *Fragilaria* spec. 1, *Achnanthes* spec. 1, *Amphora* spec. 1, *Nitzschia frustulum, Opephora* spec. 3 and *Opephora schulzii.*

Subgroup 1

This subgroup contains only one sample (28). *Opephora* spec. 5 is dominant (up to 40% of the total number of diatoms). *Navicula perminuta* and *Achnanthes* spec. 1 are practically absent, which explains the isolated position of this sample in main group 0.

Subgroup 2

Samples 16, 17, 18, 19 and 24 are grouped in this subgroup, which is characterized by *Nitzschia constricta* and large numbers of *Achnanthes hauckiana, Opephora* cf. *parva, Catenula adhaerens, Navicula lucens* and *Nitzschia frustulum.*

Subgroup 3

This subgroup contains the samples 33, 34 and 37-44, which were taken at stations on sandflats in the middle part of the Westerschelde. They are mainly characterized by the occurrence of a few rare taxa, such as *Navicula pseudoscutiformis, N.* cf. *accomoda, N.* spec. 24, *N.* spec. 28 and *Anorthoneis* spec.

Subgroup 4

This large subgroup (containing samples 1-3, 7-11, 15, 32, 35 and 36) differs from subgroup 3 by the larger numbers of *Opephora schulzii* and negatively by the absence of taxa characteristic for subgroup 3 (e.g. *Navicula spec.* 24 and *N.* spec. 28).

In addition *Navicula* spec. 7, *Rhaphoneis scalaris* and *Eunotogramma dubium* often occur in large numbers in samples 7 and 8.

Main group 1

Paralia sulcata, Rhaphoneis amphiceros and *Podosira stelligera* are characteristic of this group. *Cymatosira belgica, Rhaphoneis minutissima, Delphineis surirella, Nitzschia constricta* and *Navicula gregaria* are often abundant.

Subgroup 5

This subgroup contains only one sample (30), in which *Opephora* spec. 5 is dominant (cfr. subgroup 1). This sample shares a number of taxa with subgroup 8, many of which are characteristic of freshwater habitats (e.g. *Fragilaria brevistriata* Grunow, *Fragilaria construens* (Ehrenberg) Grunow, *Caloneis silicula* (Ehrenberg) Cleve, *Gomphonema* spp.). The samples of these subgroups (29-31) are from the eastern, more brackish part of the study area.

Subgroup 6

Samples 5, 20, 21, 22, 23, 25 and 26 are comprised in this subgroup. *Navicula* spec. 2, *Achnanthes* spec. 1 and *Opephora* cf. *parva* are characteristic taxa. Subgroup 6 differs from subgroup 7 by the larger numbers of *Nitzschia dissipata, Navicula gregaria, Achnanthes hauckiana, Opephora* cf. *olsenii* and *Navicula lucens.* In addition samples 21 and 22 contain high numbers of *Gyrosigma fasciola* and *Nitzschia bergii.*

Subgroup 7

This subgroup contains the samples 6, 12, 13, 14 and 27. An important species in these samples is *Delphineis surirella*, while *Navicula gregaria* is very rare in samples 6, 12, 13 and 14.

Subgroup 8

Samples 29 and 31 form this separate subgroup. Both samples contain a high number of taxa (72 respectively 90 taxa). Especially centric diatoms, such as *Cyclotella meneghiniana, Cyclotella atomus* and *Thalassiosira* spec. 1, are common in these samples. Many taxa only occur in this subgroup, among them many freshwater species : *Epithemia sorex* Kützing, *Eunotia* spec., *Tabellaria fenestrata* (Lyngbye) Kützing, *Synedra fasciculata* (Agardh) Kützing, ...

C.3. Relation with environmental factors

C.3.1. *Salinity*

De Pauw (1975 : 51) proposed a division of the Schelde estuary based on the Venice system. The position of these salinity zones can shift considerably along its course depending on river discharge. We used the outmost positions of a few isohalines (as given by De Pauw (l.c.)) to divide the Westerschelde into four sectors (fig. 1). A similar division is used by Meire & Kuijken (1988 : 216, fig. 2).

- sector A : the euhaline - polyhaline sector (= the marine zone ; salinity always > 10 ppm).
- sector B : the polyhaline — α-mesohaline sector (= the marine transitional zone ; salinity always > 5,5 ppm and < 16,5 ppm).
- sector C : the polyhaline - oligohaline sector (= the brackish zone (Dutch part) ; salinity always > 0,3 ppm).
- sector D : the α-mesohaline - limnetic sector (= the brackish zone (Belgian part) ; salinity sometimes < 0,3 ppm).

Fig. 1 shows that the longitudinal salinity gradient is not responsible for the division of the samples in the two main groups 0 and 1. The samples of both main groups are scattered over the entire salinity gradient.

In contrast there does seem to be some relation with salinity on subgroup level. The distribution of the samples of each subgroup over the different salinity sectors is shown in fig. 3 (a fifth (imaginary) sector AB was created for the samples 32-38, because these are located on the border of the sectors A and B).

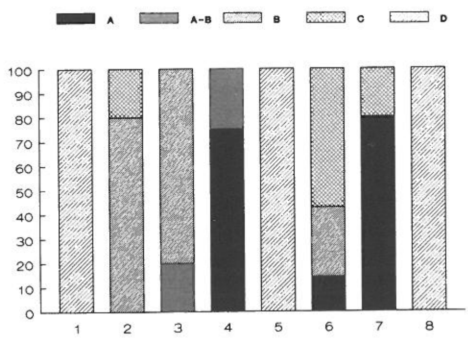


FIG. 3. — Distribution of the samples of subgroups 1-8 over the different salinity sectors A, AB, B, C and D (cf. fig. 1 and chapter C.3.1.).

Subgroups 3 and 4 contain only samples from the western part of the Westerschelde. Samples 28-31 were taken at sites located in sector D, where a high river discharge can bring in freshwater. This explains the isolated (subgroups 1, 5 and 8) position of these samples in the TWINSPAN-dendrogram.

Subgroups 6 and 7, however, group samples from the sectors A, B and C and A and C respectively, which shows that other factors than salinity must be responsible for the division of the samples over the different subgroups.

C.3.2. *Sediment composition*

Previous studies (e.g. TEMMERMAN 1988) showed that the Westerschelde sediments mainly consist of sand (> 200 μm) and fine sand (200-50 μm). Sediment analysis of our samples yielded similar results : only in subgroups 7 and 8 (7 stations) the silty fraction (< 50 μm) adds up to more than 50% (fig. 4). Subgroups 1 to 4 consist mainly of sand and fine sand, while subgroup 5 has a very high sand fraction.

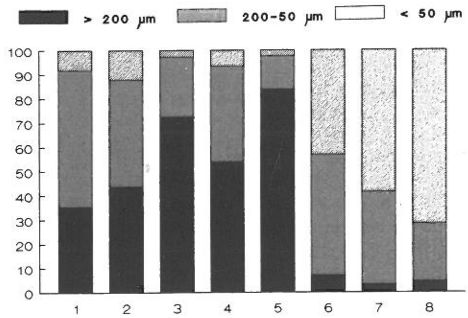


FIG. 4. — Percentage of sand (> 200 μm), fine sand (50-200 μm) and silt (< 50 m) in the samples of the subgroups 1-8.

A clear relation exists between the species composition of the two main groups and the sediment composition of the samples (figs. 5 and 6). All stations with a low sand fraction are situated on the right side of the ordination diagram (fig. 5). Only sample 30 shows a very high sand fraction (up to 84%). This group of stations (plus sample 30) corresponds to main group 1. All samples with a low (< 25%) silty fraction are situated on the left side of the diagram in fig. 6. These are the samples of main group 0. All samples (except 14 and 30) on the right side, belonging to main group 1, have a higher silty fraction.

C.4. DISCUSSION

The division between the main groups 0 and 1 is caused by qualitative as well as quantitative differences in species composition.

Some taxa are almost exclusively confined to one of the two main groups. *Achnanthes* spec. 1, *Navicula cryptolyra, Navicula* spec. 2 and *Navicula* spec. 9 are common in main group 0. *Navicula gregaria, Actinoptychus senarius* and *Podosira stelligera* are frequently found in main group 1 but are scarcely present in main group 0.

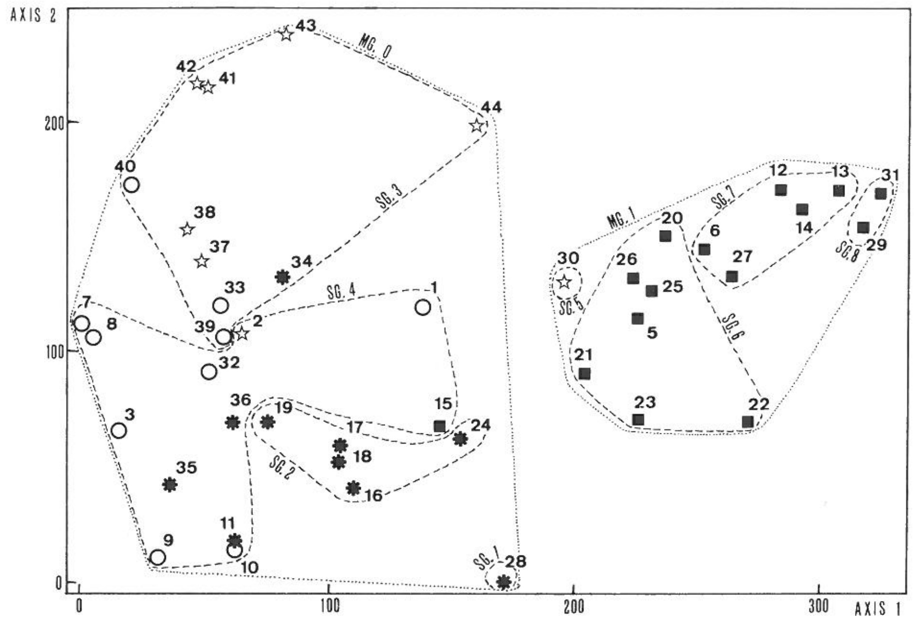


FIG. 5. — DCA-diagram (axis 1 - axis 2) of 43 samples from the Westerschelde — Percentage of sand particles (> 200 μm) for each sampling site (☆ > 75% ; ○ = 50-75% ; ✱ = 25-50% ; ■ < 25%) (MG. = main group ; SG. = subgroup).

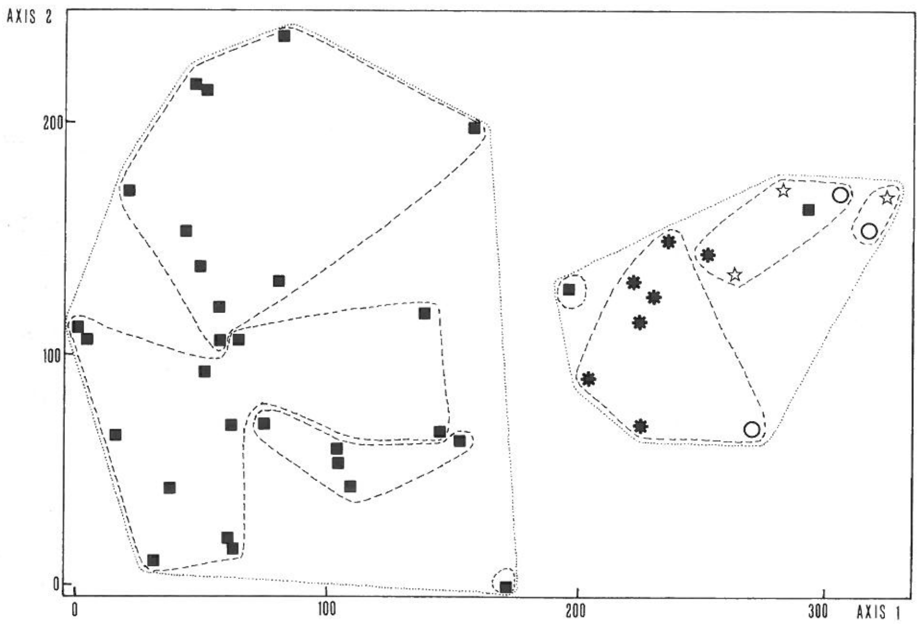


FIG. 6. — As fig. 5 — Percentage of silt particles (< 50 μm) for each sampling station (the same symbols as in fig. 5 are used).

Other taxa are present in practically all samples but show a clear preference for one of both main groups. *Navicula perminuta* is much more abundant in the samples of main group 0 while *Cymatosira belgica, Rhaphoneis amphiceros* and *Paralia sulcata* are strongly represented in main group 1. The choice of these last four species as indicator-species for the first division in the TWINSPAN-classification could indicate that the quantitative differences between the main groups are more important than qualitative differences.

The division into 8 subgroups is mainly based on quantitative differences in species composition.

The species composition of the samples is mainly (indirectly ?) determined by the amount of sand or silty particles. The ratio sand/silt reflects the degree of exposition to currents and/or wave action. Thus a sheltered station will be characterized by a relatively high silty fraction.

The sediment-inhabiting diatoms are often divided in two main groups : the epipelon and the epipsammon (ROUND 1971, VAN DEN HOEK *et al.* 1979, ADMIRAAL 1984, VOS 1989). Epipsammic diatoms are immobile or only slightly mobile, small species which are firmly attached to the substrate, i.e. sand grains, thus becoming totally dependent on the mixing and transport of these. Epipelic species are often larger and can move freely through the sediment particles. Other species (e.g. *Paralia sulcata*) are immobile but are not attached to the substrate.

Recently objections have been made to this division : some immobile species are capable of slight movement (HENDEY cit. in ADMIRAAL 1984) while some free-living species can sometimes attach themselves to the substrate. DE JONGE (1985 : 614) showed that in the Ems-estuary (the Netherlands) 8O% of the taxa living on sand-grains occur in the mud coating of these grains. It is questionable whether these taxa should be placed in the epipsammic or the epipelic group. On the whole however, epipelic species will dominate in sheltered habitats where they will not be easily suspended, while epipsammic species will abund in more exposed places.

We tried to examine whether the relation between species distribution and sediment composition was caused by a dominance of epipelic or epipsammic taxa in sheltered and exposed places respectively. Five categories were made (table 1 and fig.7) :

— epipsammon : PS
— epipelon : PE
— indifferent taxa : these taxa either live attached or free (e.g. *Cymatosira belgica*) : IN
— plankton (e.g. *Thalassionema nitzschioides*) : PL
— category unknown : UN

We determined to which category the 10 most important taxa of each sample belong.

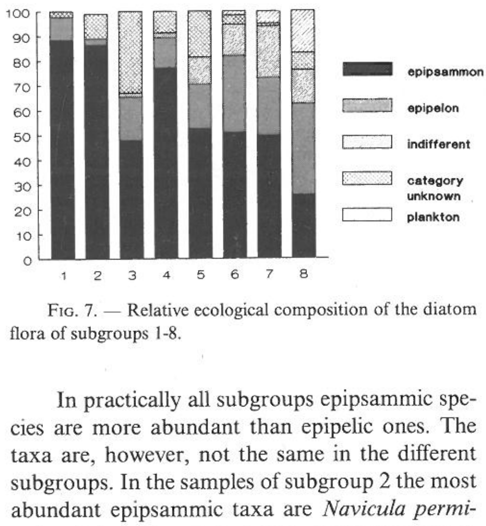


FIG. 7. — Relative ecological composition of the diatom flora of subgroups 1-8.

In practically all subgroups epipsammic species are more abundant than epipelic ones. The taxa are, however, not the same in the different subgroups. In the samples of subgroup 2 the most abundant epipsammic taxa are *Navicula perminuta, Achnanthes* spec. 1 and *Amphora* spec. 1, while in the subgroups 6 and 7 *Rhaphoneis amphiceros, R. minutissima* and *Delphineis surirella* dominate.

Epipelic species are better represented in the samples of main group 1, thus showing a clear relation between a higher amount of silty particles and higher numbers of these species. The numbers of epipelic species are on the whole rather low : this could be due to bad weather circumstances (winds up to 8 Beaufort the day before sampling)