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A cooperative study of the macrobenthos of three sandbanks
in the Belgian coastal waters in 1980-1984

Has sand exploitation an influence on the macrobenthos?

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Abstract

Three sandbanks (Goote Bank, Buiten Ratel and Kwinte Bank) were investigated over a period of five years (1980-1984) in order to establish the impact of sand and gravel extraction on the macrobenthos. Two stations on each sandbank were sampled twice a year.

All six stations are characterized by clean sand; the median grain size of the sand fraction ranges between fine sand (in the southern stations of the Kwinte Bank and the Buiten Ratel) and coarse sand (in the northern stations of the Kwinte Bank and Buiten Ratel); the stations on the Goote Bank are characterized by fine to medium sand. The macrobenthos is a typical sand fauna; 118 species were identified.

Density (range: 37-3337 ind./m.) and species number (range: 1-34) can be correlated with sediment characteristics. Both increase with increasing grain size. Diversity (H' ; range: 0.00-4.15 bits/ind.), evenness (J ; range: 0.00-0.76) and dominance (SI ; range: 0.09-1) do not follow the same trend. In general, there is no indication of changes in any of these parameters due to sand and gravel exploitation over the five years.

However, at one station of the Goote Bank a striking fall in density, species number and diversity was recorded in April 1982; this may be due to the sandextractions on the Goote Bank. The fauna recovered within seven months.

Introduction

In the late seventies a research programme was set up by the "Management Unit of the Mathematical Model North Sea" (Ministry of Public Health, Belgium) in order to make a study of the Flemish and Zeeland Banks, as they became of interest to dredging companies. At that time the demand for sand and gravel increased and moreover the exploitation of terrestrial sand pits became expensive and gave rise to environmental concern. Therefore concessions were given for exploitation in the North Sea in two well delimited areas. Zone I including the Thornton Bank and Goote Bank and Zone II including the Oost Dyck, Buiten Ratel and Kwinte Bank (figure 1).

This study is part of a research programme and investigates the impact of sand and gravel extractions on the benthic fauna, the macrobenthos particularly. Several papers and reports have already appeared on the subject, concerning both macro- and meiobenthos (Vanosmael *et al.*, 1979; 1982a; 1982b; 1984 and Willems *et al.*, 1982a; 1982b). This report presents a summary of the results from a long term survey (5 years) on three sandbanks: the Goote Bank (zone I) is exploited partially by the Ministry of Public Transport; the Kwinte Bank and Buiten Ratel (zone II) are exploited by private companies.

Each sandbank is represented by two stations which are sampled twice a year, in spring and in autumn. Basic parameters such as density, diversity, species number, evenness and dominance are used to compare the communities and to investigate whether there is an impact of the sand exploitation on the macrofauna. The four major groups are the Polychaeta, Mollusca, Crustacea and Echinodermata. Nemertini, Archiannelida and Oligochaeta have also been counted.

A detailed inventory has been made but is not included in this paper.

Material and methods

In this study we have concentrated on six stations located on three sandbanks. Their position is given in Table 1 and Figure 1.

Due to logistic problems the autumn samples of the Kwinte Bank (40004-40007) and Buiten Ratel (44009) have not been taken in October 1984 but in early December 1984. Samples were taken by a Van Veen grab (0.1 m²). They were immediately fixed with 40% neutralized formalin up to a final concentration of about 7%. The fauna was elutriated in the laboratory on a 1 mm sieve. Three replicates of each station were examined (except for 44003-March '84 only one sample was taken for 44002 and 40009-April '82; 44009-April '83 and 40004-September '83, only two samples were used).

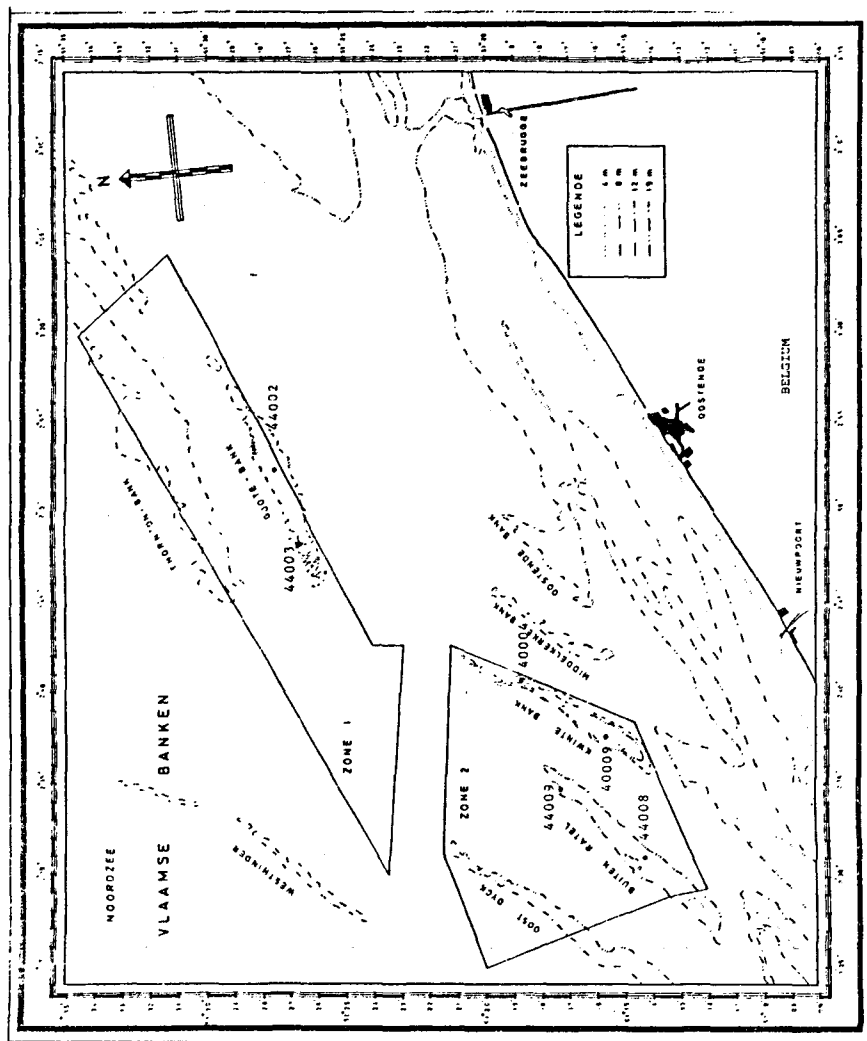


Fig. 1. Localisation of the six stations in the two exploitation zones.

All macro-organisms (Nemertini-Polychaeta-Archiannelida-Oligochaeta-Mollusca-Crustacea and Echinodermata) were identified where possible and counted.

Species diversity was estimated using the Shannon Wiener formula

$$H' = - \sum_i p_i \log_2 p_i$$

with $p_i = n_i/N_i$ the relative abundance of the i -th species.

Evenness - equitability of the allocation of individuals between the species - was calculated using the formula proposed by Heip (1974)

$$H_e = (e^{H'} - 1) / (S - 1)$$

with H' = species diversity and S = number of species. Evenness was also calculated using the formula

$$N_2 = 1/SI$$

in which SI = Simpson index = $\sum p_i^2$ $0 < SI < 1$.

Results and discussion

Sediment analysis

The location of the sampled stations and their sediment characteristics (mean values) are given in Table 1.

Table 1. Coordinates of the six stations and sediment characteristics over the 1980-1984 period. (Mean grain size of the sand fraction, mean % mud, sand and gravel).

Station	Lat. N	Long. E	Grain size Md mm	% mud < 63 μ m	% sand	% gravel
40004	51.18'40"	2.40'45"	0.516 \pm 0.079	0.55 \pm 0.41	92.27 \pm 2.75	7.19 \pm 2.82
40009	51.15'35"	2.37'35"	0.260 \pm 0.011	0.09 \pm 0.02	99.91 \pm 0.02	0
44008	51.14'17"	2.31'29"	0.217 \pm 0.004	0.46 \pm 0.25	99.54 \pm 0.25	0
44009	51.17'30"	2.34.40"	0.651 \pm 0.105	0.46 \pm 0.28	92.51 \pm 3.64	7.03 \pm 3.69
44002	51.27'37"	2.52'20"	0.250 \pm 0.011	0.20 \pm 0.05	99.80 \pm 0.05	0
44003	51.26'37"	2.48'12"	0.328 \pm 0.015	0.18 \pm 0.03	92.06 \pm 2.21	7.76 \pm 2.21

The sediments are clean sands with a very low mud content. This can be explained by the very high hydrodynamic pressure on all three sandsbanks, a situation we also found on the other Flemish Banks (Oost Dyck and Middelkerke Bank) and Zeeland Bank (Thornton Bank). The perturbations are much stronger in the Northern part of the Buiten Rattel and Kwinse Bank which results in a coarser sediment (40004 and 44009 both coarse sand) with a relatively high amount of gravel than in the southern parts (40009 : medium sand and 44008 fine sand). This was already established on the Kwinse Bank by Bastin (1974) and brought into relation with

the macro- and meiofauna by Vanosmael et al., 1982b and Willems et al., 1982a, b.

Remarkable are the relative great differences in grain size (cfr. standard error) at stations 40004 and 44009. According to De Moor (pers.comm.) there seems to be a continuous sand transport from the northern part of the Buiten Ratel to the northern part of the Kwinte Bank. This can explain the greater fluctuations in grain size over the five years. On the Goote Bank the differences between the two stations are not so extreme. At the stations 44002 and 44003 we found respectively fine and medium sand. The gravel content in 44003 (7.8%) is much higher than in 44002 (none). These observations are reflected in the faunal composition of the sandbanks.

The fluctuations of the sediment characteristics within one station are the result of three factors :

- on the sandbanks there are many relative small patches of different sediment compositions (cfr. surface structure of the sandbanks (Bastin, op.cit.)).
- because of strong turbulence and currents, often large displacements of sand take place, for example after a storm.
- often it is very difficult to get the ship in the right position because of heavy currents and stations are not always sampled exactly on the same place.

Species composition

Species numbers are represented in Table 2 and Figure 2.

The total number of species in a station for the three sandbanks varies between 9 and 34 species. Only 1 species was recorded from the Goote Bank at station 44003 in April 1982. Seven months later we found at that station the highest number of species (34) ever recorded. On the two Flemish banks the highest means (20 species at 40004 and 19 species at 44009) are found at the northern stations with the coarsest sand and the highest amount of gravel. The same is true on the Goote Bank where the mean number of species is highest at the station with the coarsest sediment (19 species at 44003 ; 17 at 44002).

Station 44008 is the most stable (cfr. low standard error on the mean) while at station 44003 the number of species varies most over the different years.

Table 2. Species number in sandbank stations.

	Kwinte Bank		Buiten Ratel		Goote Bank	
	40004	40009	44008	44009	44002	44003
03/80:	22	12	11	15	12	14
09/80:	25	15	13	13	17	16
03-04/81:	21	9	16	13	17	19
09-10/81:	23	13	15	22	12	27
04/82:	19	20	15	30	10	1
10-11/82:	27	9	14	19	-	34
04/83:	17	17	15	10	26	28
09/83:	12	11	18	17	30	20
03/84:	25	20	16	30	14	9
10-12/84:	9	12	13	24	13	19
mean	20.0±1.9	13.0±1.3	14.6±0.6	19.3±2.2	16.8±2.3	18.4±3.0

The species that are responsible for the differences in species number between fine-medium and coarse sand stations are mainly interstitial polychaetes. Coarse sediments offer more interstitial space than fine sands.

Our findings confirm the observations of Wieser (1959) and Fenchel (1978). Interstitial life only occurs when the median grain size is larger than 200 µm. Interstitial polychaetes get very abundant above 300 µm grain size, although they can also occur in finer sediments.

At the coarse sand station 40004 of the Kwinte Bank, we find several species that are restricted to that station. The following species occur during at least three out of ten investigated periods (regardless of density) : Pisione remota, Microphthalmus similis, Streptosyllis arenae, Sphaerosyllis bulbosa, Glycera capitata, Goniadella bobretzkii, Orbinia sertulata, Aonides paucibranchiata, Macrochaeta heloqlandica, Polycirrus medusa, Nucula sp., Mytilus edulis, Thia scutellata and Ophiura texturata. Very abundant at 40004 are also Hesionura augeneri, Polygordius appendiculatus and Spisula solida.

Species restricted to 44009 (coarse sand-Buiten Ratel) are : Pisione remota, Eteone longa, Typosyllis armillaris, Streptosyllis arenae, Sphaerosyllis bulbosa, Glycera capitata, Goniadella bobretzkii, Aonides paucibranchiata, Polycirrus medusa, Polygordius appendiculatus, Protodrilus sp., Protodriloides chaetifer, Saccocirrus sp., Spisula elliptica, Spisula solida, Bodotria scorpioides and Ophiura sp. Abundant and occurring with a high frequency are : Hesionura augeneri and Oligochaeta.

Table 3. Mean densities (N.m⁻²) of the soft bottom macrofauna in three sand banks during the period 1980-1984.

	1980				1981				1982				1983				1984			
	March		September		April		October		April		October		April		September		March		December	
	44002	44009	44002	44009	44002	44009	44002	44009	44002	44009	44002	44009	44002	44009	44002	44009	44002	44009	44002	44009
NEMERTINI	70	30	110	107	50	40	157	87	27	25	40	3	57	7	5	30	30	37	60	10
POLYCHAETA	550	167	313	273	620	237	770	227	747	240	333	123	393	130	140	227	387	87	103	77
ARCHIANNELIDA	97	--	--	--	10	--	340	7	313	--	27	--	67	3	100	--	--	--	--	--
OLIGOCOAETA	67	3	3	--	37	--	73	7	40	--	30	--	80	--	--	--	20	--	--	--
MOLLUSCA	90	3	10	3	20	--	20	--	70	30	70	--	40	30	30	--	27	47	--	3
CRUSTACEA	3	27	143	47	7	--	17	40	--	235	37	60	10	937	85	43	307	107	3	17
ECHINODERMATA	10	--	17	7	--	--	--	--	--	3	--	--	--	3	--	--	20	--	--	7
TOTAL MACROBENTHOS	977	230	626	437	744	277	1377	368	1197	533	537	186	647	1110	360	300	791	278	166	114

	1980				1981				1982				1983				1984				
	Febr.		March		September		April		October		April		October		April		September		March	Oct.	Dec.
	44008	44009	44008	44009	44008	44009	44008	44009	44008	44009	44008	44009	44008	44009	44008	44009	44008	44009	44008	44009	
NEMERTINI	+	+	57	127	7	53	17	183	10	60	--	110	7	10	7	110	--	153	23	197	
POLYCHAETA	73	3083	110	243	223	280	63	1107	183	543	100	417	247	295	250	337	93	276	63	600	
ARCHIANNELIDA	--	50	--	--	--	390	--	37	--	37	--	60	--	380	--	77	--	103	--	197	
OLIGOCOAETA	7	197	--	--	--	53	--	70	--	3	--	10	--	35	--	20	--	40	--	120	
MOLLUSCA	10	--	--	--	57	17	10	37	90	40	--	20	53	--	3	23	20	153	--	50	
CRUSTACEA	120	7	149	119	150	--	147	50	63	37	220	33	87	--	237	63	27	83	83	13	
ECHINODERMATA	--	--	10	27	23	--	7	--	57	10	--	--	17	--	7	--	--	10	77	3	
TOTAL MACROBENTHOS	(210)	(3337)	326	516	460	793	244	1484	403	1020	320	650	411	720	504	530	140	818	246	1180	

	1980				1981				1982				1983				1984			
	March		September		March		September		April		November		April		September		March		October	
	44002	44003	44002	44003	44002	44003	44002	44003	44002	44003	44002	44003	44002	44003	44002	44003	44002	44003	44002	44003
NEMERTINI	+	+	+	+	10	23	17	60	--	--	217	23	73	57	90	37	240	7	113	
POLYCHAETA	440	1560	220	272	323	280	117	405	520	--	257	1027	223	1013	173	337	210	40	97	
ARCHIANNELIDA	7	13	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	
OLIGOCOAETA	3	217	7	87	7	--	3	15	--	--	7	--	10	--	7	2	150	10	33	
MOLLUSCA	7	13	17	13	20	10	13	45	--	--	23	17	27	83	10	30	--	--	17	
CRUSTACEA	20	20	107	140	60	30	240	420	210	07	187	267	467	213	77	47	10	70	77	
ECHINODERMATA	--	--	--	7	--	--	--	10	--	--	13	10	87	3	20	--	10	3	3	
TOTAL MACROBENTHOS	(477)	(1223)	(351)	(519)	420	343	390	960	730	37	704	1344	887	1369	377	453	620	130	340	

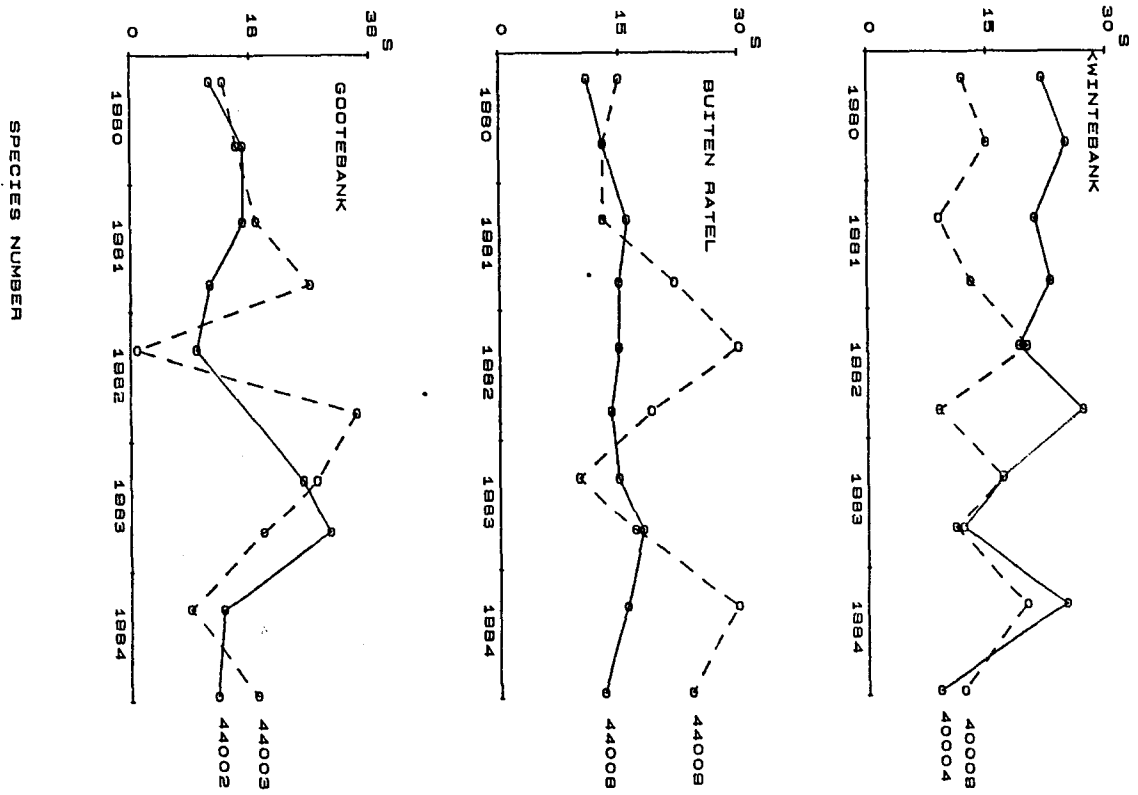


Fig. 2. Species number (S) in six sandbank stations over the period 1980-1984.

On the Goote Bank the difference in grain size is not so great as on the other two sandbanks. Species number at both stations (44002 and 44003) are very similar. Only Polycirrus medusa, Spisula solida, Thia scutellata, Ophiothrix fragilis and Echinocyamus pusillus are restricted to 44003 (mean Md = 328 μm). H. augeneri and G. capitata reach higher densities at 44003 than at 44002 and also occur with a higher frequency at 44003.

Density (N/m^2)

The densities of the macrobenthic taxonomic groups on the six stations in 1980-1984 are given in Table 3 and Figure 3.

The highest density in the investigated area is recorded at station 44009 (Buiten Ratel) in March '80 (3337 ind./ m^2 ; Nemertini not included), the lowest at 44003 (Goote Bank) in April '82 (37 ind./ m^2).

The mean abundances of each station over the whole period are:

Kwinte Bank		Buiten Ratel		Goote Bank	
40004	40009	44008	44009	44002	44003
742 \pm 116	383 \pm 89	326 \pm 37	1116 \pm 263	629 \pm 147	661 \pm 156

Not only species number but also density fluctuates very little at station 44008 (Buiten Ratel).

- On the Kwinte Bank the highest densities are found at station 40004 in October '81 (1377 ind./ m^2) and April '82 (1197 ind./ m^2) and at 40009 in April '83 (1110 ind./ m^2). At station 40004 polychaetes have the greatest share in the total population (resp. 53.9% and 62.4%), at station 40009 the Crustacea are dominant (84.4%).

Looking at species level, the interstitial polychaete Hesionura augeneri (330 ind./ m^2) and the interstitial archiannelid Polygoroides appendiculatus (320 ind./ m^2) are responsible for the high density at 40004 in October '81. In April '82 it is the interstitial polychaete Sphaerosyllis bulbosa (220 ind./ m^2), Goniadella bobretzkii (250 ind./ m^2). At station 40009 (April '83) Bathyporeia elegans is the most abundant animal (885 ind./ m^2).

- On the Buiten Ratel the macrofauna density at station 44009 is always higher than at 44008. The highest values are 3337 ind./ m^2 in March '80, 1484 ind./ m^2 in October '81, 1030 ind./ m^2 in April '82 and 1180 in December '84. In all the periods polychaetes have the largest density (resp. 92%, 75%, 82% and 51%). On this sandbank we note the highest and the lowest mean density of all three sandbanks over the whole period: 326 ind./ m^2 at 44008 and 1116 ind./ m^2 in 44009.

In March '80 H. augeneri is very abundant: 2585 ind./ m^2 . Ophelia borealis reaches a density of 385 ind./ m^2 . In the other periods (10/81, 04/82 and 12/84) H. augeneri is also the most important species (resp. 955, 435 and 380 ind./ m^2). In April '82 Scoloplos armiger has a density of 150 ind./ m^2 , which is high within the area.

- On the Goote Bank the overall means are very similar (629 ind./ m^2 in 44002 and 661 ind./ m^2 in 44003). The highest densities are recorded at station 44003 (1823 ind./ m^2 in March '80) and station 44002 in April and September '83 (resp. 1344 and 1369 ind./ m^2). In the three cases the polychaetes are the most abundant (resp. 86%, 76% and 74%). More in detail: the following species are responsible for the high densities: Hesionura augeneri (920 ind./ m^2), Spio filicornis (240 ind./ m^2) and Ophelia borealis (327 ind./ m^2) at station 44003 in March '80; Scoloplos armiger and Spiophanes bombyx (resp. 410 and 490 ind./ m^2 at 44002 in April '83) and S. bombyx (with a density of 740 ind./ m^2 at 44002 in September '83).

It is clear that density is generally highest in the coarse sediments (stations 40004 and 44009) where interstitial life gets very important. This is reflected in the abundance of the interstitial annelids at these stations.

On the Goote Bank, Buiten Ratel and Kwinte Bank, but also on the Thornton Bank, Oost Dyck and Middelkerke Bank, the share of the molluscs is very low, although they can raise the biomass highly, especially when the genus Spisula is present. At station 44009 (March '84) 146 ind./ m^2 are found. The crustaceans on the other hand are common on the sandbanks. Sometimes they are more numerous than polychaetes (Table 3). The highest crustacean density is recorded at station 40009 in April '83 (937 ind./ m^2 of which 885 ind. belong to the species Bathyporeia elegans. Not very abundant are the echinoderms. The highest densities are found at station 44008 in October '84 and at 44003 in April '83: resp. 77 ind./ m^2 (all Echinocardium cordatum) and 87 ind./ m^2 of which 77 ind. are Ophiothrix fragilis. It must be said that O. fragilis is not common on the sandbanks and is only recorded on the Goote Bank.

Diversity (H') - Evenness (H_e) - Dominance (SI)

The values are given in Tables 4, 5 and 6 and represented in the figures 4, 5 and 6. The mean diversities per station are varying between 2.59 bits/ind. at 44009 (Buiten Ratel) and 3.11 bits/ind. at 40004 (Kwinte Bank).

Evenness mean values are fluctuating between $H_e = 0.33$ (Buiten Ratel - 44009) and $H_e = 0.54$ (Kwinte Bank - 40009). The lowest mean Simpson Index: $SI = 0.19$ is found on the Kwinte Bank (40004) and Goote Bank (44003). The highest value ($SI = 0.30$) at 44009.

The highest and the lowest diversity are both recorded from the Goote Bank at station 44003 and are respectively $H' = 4.15$ (Nov. '82) and $H' = 0.00$ (April '82). The corresponding evenness values are $H_e = 0.51$ and $H_e = 0.00$. The intermediate evenness can be explained by the dominance of two species: *Ophelia borealis* (60 ind./m²) and *Bathyporeia elegans* (83 ind./m²). The Simpson index in November '82 is very low: $SI = 0.09$.

Worth mentioning are also the high diversity scores at 40004 (Kwinte Bank) in September '80 ($H' = 3.90$) and October '82 ($H' = 3.84$). Corresponding evenness values are respectively $H_e = 0.58$ and $H_e = 0.51$. In both periods the Simpson's dominance index is very low (resp. $SI = 0.10$ and 0.11). Low diversities are also recorded at 40009 (Kwinte Bank) in April '83 ($H' = 1.30$), at 44009 (Buiten Ratel) in March '80 and October '81 (resp. $H' = 1.00$ and 1.58). With the low diversities at the two stations corresponds a low evenness (resp. $H_e = 0.09$, 0.07 and 0.09) and high Simpson indices (resp. $SI = 0.66$, 0.69 and 0.61). As for the number of species we found respectively $S = 17$, 15 and 22 which are not extremely low values for the area.

Table 4. Species diversity (H') in six sandbank stations.

	Kwinte Bank		Buiten Ratel		Goote Bank	
	40004	40009	44008	44009	44002	44003
03/80:	2.43	2.84	2.71	1.00	2.67	1.81
09/80:	3.90	2.92	2.60	2.90	3.52	3.43
03-04/81:	2.93	2.46	3.27	2.57	3.38	2.98
09-10/81:	2.94	3.06	2.53	1.58	2.69	3.07
04/82:	3.00	3.16	3.12	3.07	1.68	0.00
10-11/82:	3.84	2.74	2.51	3.16	-	4.15
04/83:	3.18	1.30	3.33	2.14	2.75	2.76
09/83:	2.96	2.79	3.37	2.95	2.80	3.53
03/84:	3.20	3.59	3.18	3.57	2.61	2.35
10-12/84:	2.72	3.23	2.37	2.37	2.97	3.64
mean	3.11±0.15	2.81±0.19	2.90±0.12	2.59±0.25	2.79±0.18	2.77±0.37

Table 5. Evenness (H_e) in six sandbank stations.

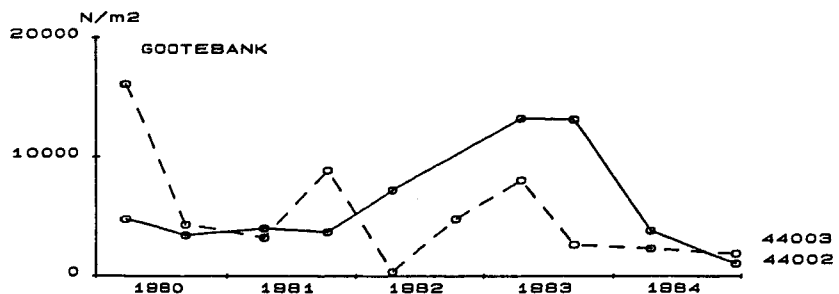
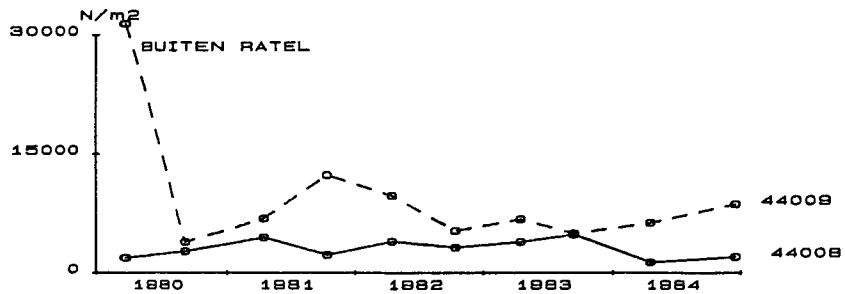
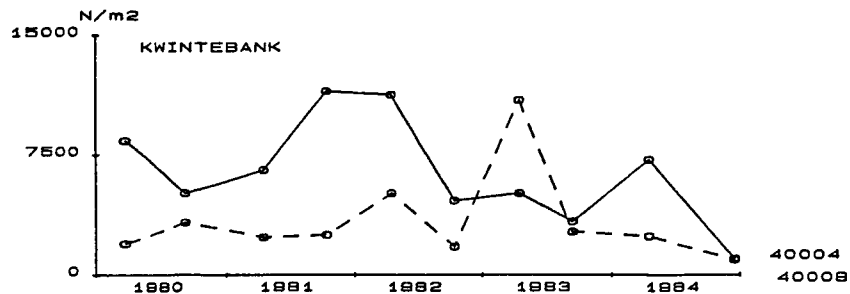
	Kwinte Bank		Buiten Ratel		Goote Bank	
	40004	40009	44008	44009	44002	44003
03/80:	0.21	0.56	0.56	0.07	0.49	0.19
09/80:	0.58	0.47	0.42	0.54	0.66	0.65
03-04/81:	0.33	0.56	0.57	0.41	0.59	0.38
09-10/81:	0.30	0.61	0.34	0.09	0.50	0.28
04/82:	0.39	0.42	0.55	0.25	0.24	0.00
10-11/82:	0.51	0.71	0.36	0.44	-	0.51
04/83:	0.51	0.09	0.65	0.38	0.23	0.21
09/83:	0.62	0.59	0.55	0.42	0.21	0.55
03/84:	0.34	0.58	0.54	0.38	0.39	0.51
10-12/84:	0.70	0.76	0.35	0.29	0.57	0.64

Table 6. Simpson index (SI) in six sandbank stations.

	Kwinte Bank		Buiten Ratel		Goote Bank	
	40004	40009	44008	44009	44002	44003
03/80:	0.36	0.20	0.23	0.69	0.20	0.40
09/80:	0.10	0.19	0.24	0.19	0.11	0.11
03-04/81:	0.27	0.23	0.13	0.23	0.13	0.22
09-10/81:	0.19	0.16	0.31	0.61	0.20	0.22
04/82:	0.17	0.19	0.14	0.24	0.47	1.00
10-11/82:	0.11	0.17	0.31	0.17	-	0.09
04/83:	0.15	0.66	0.13	0.31	0.25	0.32
09/83:	0.16	0.18	0.13	0.19	0.33	0.13
03/84:	0.19	0.12	0.19	0.13	0.28	0.28
10-12/84:	0.18	0.14	0.29	0.24	0.21	0.12
Mean	0.19±0.02	0.22±0.05	0.21±0.02	0.30±0.06	0.24±0.04	0.19±0.04

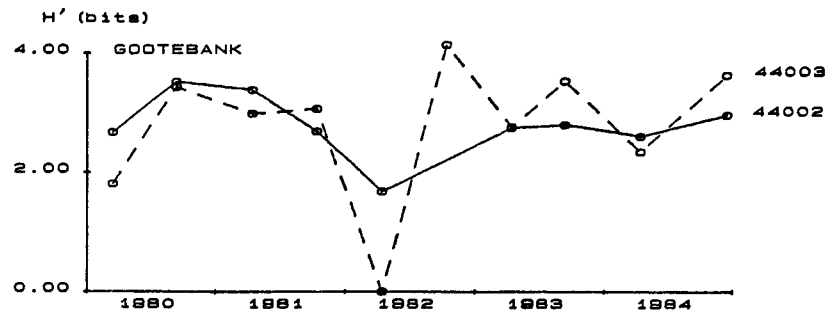
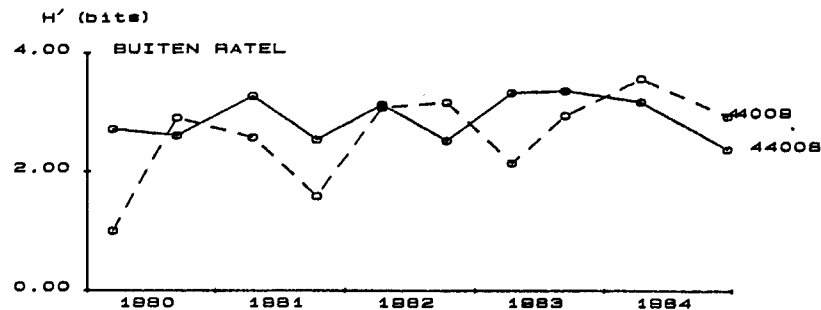
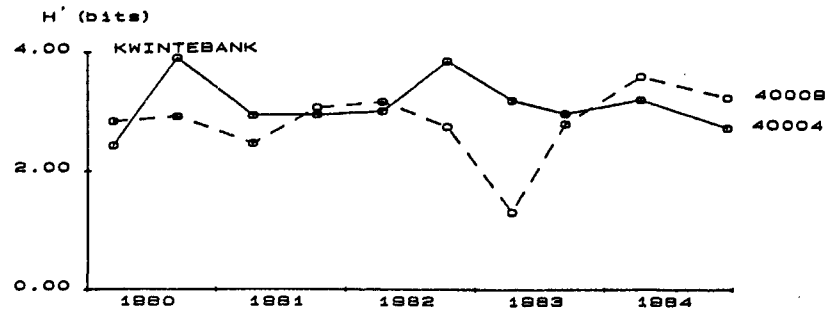
On the Kwinte Bank (40009-April '83) the amphipod *Bathyporeia elegans* is clearly dominant (80% of the total fauna). *Hesionura augeneri* is dominant at station 44009 in March '80 and October '81. The species reaches relative abundances of respectively 77% and 64%. In March '80, *Ophelia borealis* is also dominant (42%).

Fig. 3. Fluctuation in density ($N \cdot m^{-2}$) in six sandbank stations over a period of five years.



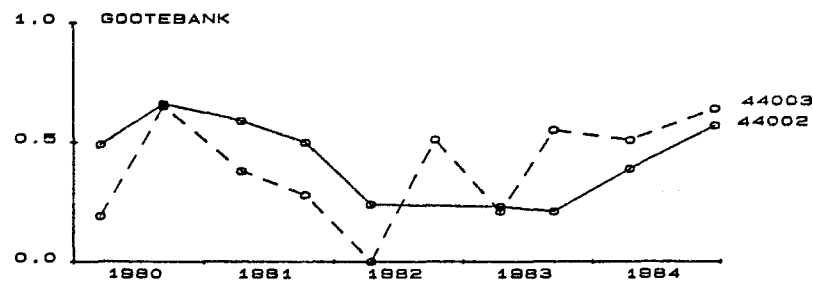
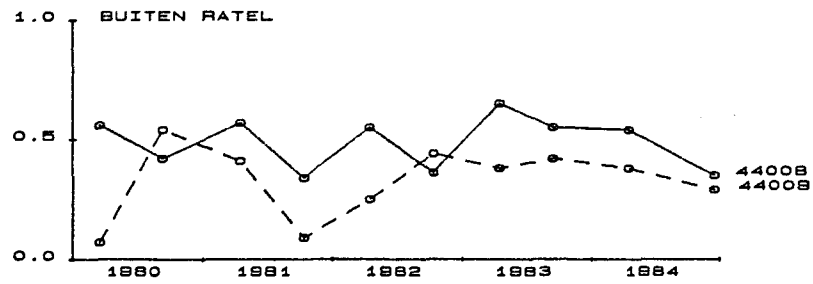
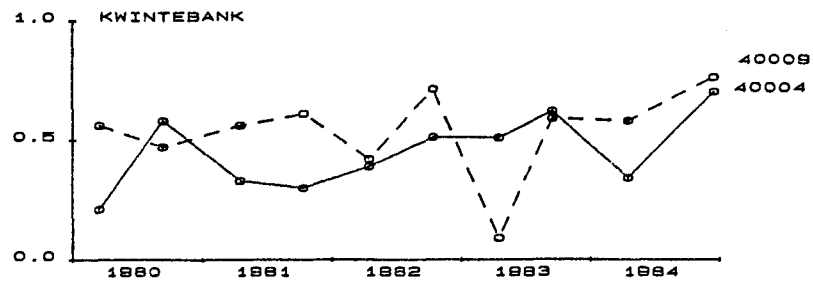
DENSITY

Fig. 4. Evolution of the diversity (H') in six sandbank stations during the period 1980-1984.



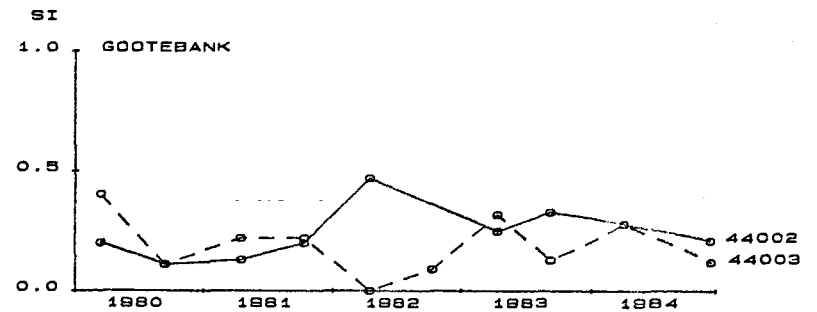
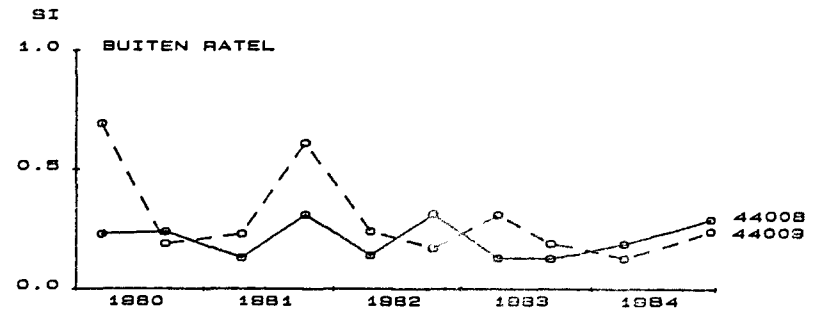
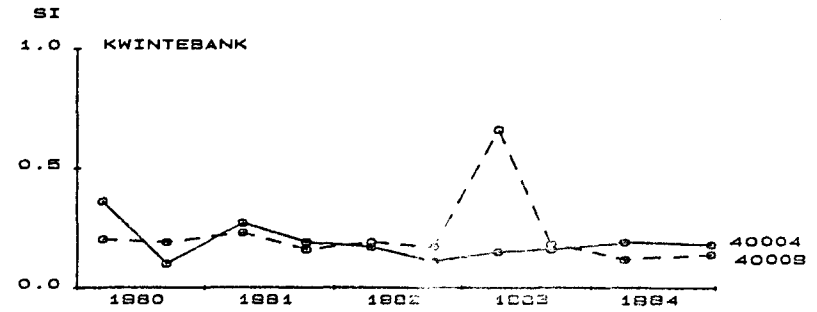
DIVERSITY

Fig. 5. Evolution of the evenness H_c in six sandbank stations during the period 1980-1984.



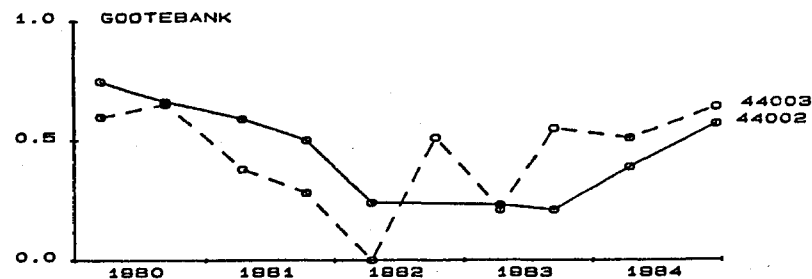
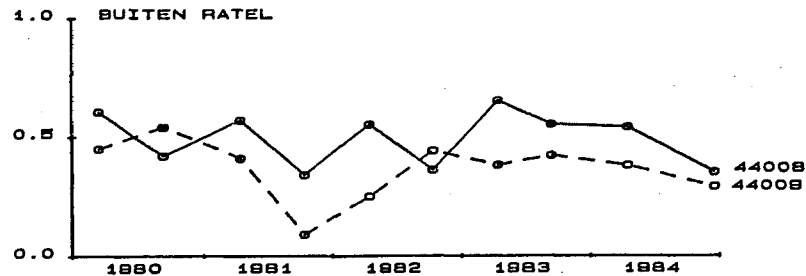
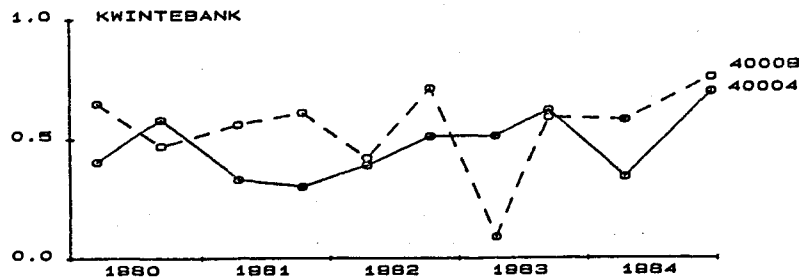
EVENNESS

Fig. 6. Evolution of the dominance SI in six sandbank stations during the period 1980-1984.



DOMINANCE

Fig. 7. Evolution of the evenness N_2 in six sandbank stations during the period 1980-1984.



EVENNESS N_2

The dominance of one or two species explains the observations mentioned above.

It is easy to correlate density (N), species number (S) and species composition with the sediment characteristics of the three sandbanks. This is not the case for the community parameters diversity (H'), Evenness (H_e) and dominance (SI). Lacking at the overall means per station no trends corresponding to the sediment composition can be established.

General considerations

The species composition of the Kwinte Bank, Buiten Ratel and Goote Bank is very similar. Among the Polychaeta, 26 species are common to the three sandbanks. In total 57 different species are recorded within the investigated area. As to the Archiannelida, three species are uncommon on a total of four species; for the Mollusca it is five species on a total of 36 species and two Echinodermata species on a total of six species.

Polychaeta species occurring on all three sandbanks are : Pisione remota, Eteone longa, Hesionura augeneri, Anaitides subulifera, A. mucosa, Eumida sanguinea, Microphthalmus similis, Streptosyllis arenae, Nephtys cirrosa, N. caeca, N. longosetosa, Glycera capitata, Goniadella bobretzkii, Scoloplos armiger, Orbinia sertulata, Spio filicornis, Spiophanes bombyx, Aonides paucibranchiata, Scolecopsis bonnieri, Magelona papillicornis, Chaetozone setosa, Ophelia borealis, Capitella capitata, Notomastus latericeus, Heteromastus filiformis and Polycirrus medusa.

For the Archiannelida : Polygordius appendiculatus, Protodrilus sp. and Protodriloides chaetifer.

For the Mollusca : Mysella bidentata, Fellina fabula, Abra alba, Spisula elliptica and S. solida.

For the Crustacea : Gastreasaccus spinifer, Pseudocuma longicornis, Diastylis rathkei, D. bradyi, Tanaissus lilljeborgi, Megaluropus agilis, Melita obtusata, Atylus falcatus, Urothoe poseidonis, Bathyporeia guilliamsoniana, B. elegans, Pontocrates altamarinus, Panambus typicus, Thia scutellata and Liocarcinus holsatus.

For the Echinodermata : Echinocyamus pusillus and Echinocardium cordatum.

Most of the species are typical clean sand inhabitants well adapted to life in an environment with high hydrodynamical stress. Many are mobile species, as settling is hampered by the large displacements of sand after storms and even at the turning of the tide.

In median and coarse sands, interstitial life gets very important. This is also reflected in the sandbank fauna. Nine interstitial polychaete species are recorded: Pisione remota, Hesionura augeneri, Microphthalmus similis, Typosyllis armillaris, Streptosyllis avenae, S. websteri, Sphaerosyllis bulbosa, Autolytis sp. and Macrochaeta helgolandica. Their densities are of course very much underestimated since a 1 mm sieve was used.

A high density does not necessarily correspond with a high diversity. On the sandbanks the highest densities are recorded from the coarse stations. On these, interstitial species often dominate the community. A fall of the diversity is the result.

A positive correlation between median grain size of the sediment and number of species and density is striking. The same can not be said of the other community parameters such as diversity (H'), evenness (H_e) and dominance (SI).

Mean H' , H_e and SI -values per station do not vary very much, species composition is also very similar on the three sandbanks. Meheus (1981) and De Rycke (1982) made the same observations for all the sandbanks in the area (Thornton Bank, Gooite Bank, Oost Dyck, Buiten Ratel, Kwinte Bank and Middelkerke Bank). The sediment of the investigated sandbanks is similar and consists of clean sand with a very small amount of mud. Other conditions are also similar: same water masses, high temperature, depth, etc.

At the Gooite Bank an 'accident' occurred in April '82 at station 44002. The number of species fell to one, density to 37 ind./m², diversity and evenness to zero. However seven months later the old situation was reestablished. The number of species rose to the maximal value for the area: 34 species. Density reached 704 ind./m² and diversity came to a maximum value of $H' = 4.15$ ($H_e = 0.51$ and $SI = 0.09$). It is clear that a major disturbance occurred. It is also clear that recovery of the fauna was quick with some overshoot of equilibrium values. Whether the unexpected fluctuations have something to do with the sand extractions is impossible to say, since the exact localizations of exploitation on this sandbank is not known to us. However the disturbance did not occur on other sandbanks or on the other Gooite Bank station.

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