The distribution of molluscs in beach deposits as identification of recent evolution in the littoral

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ABSTRACT. Several factors are responsible for the distribution of the malacological fauna on the beaches of our coast.A detailed analysis of this fauna (4309 individuals from 93 species), sampled in the mean tide level on the beach over a distance of 6 km (starting from the harbour of Ostend towards Klemskerke), shows the presence of marine, brackishwater, freshwater shells together with landsnails. After grouping the different species with reference to their ecological affinity, distribution histograms were made and a statistical analysis was executed. Due to these distribution tests the unexpected presence of freshwater and brackishwater species has been corresponded with the existence in the past of outflow channels and a wadden landscape. Such type of analysis seems to give very good complementary research tools for the study of the recent geology of the coast and for local archaeological investigations.

RESUME. Différents facteurs sont responsables de la distribution de la faunule malacologique sur les plages de notre littoral. L'analyse détaillée de cette faunule (4309 exemplaires comprenant 93 espèces), échantillonnée dans les laisses de mer et au niveau de l'estran, sur une distance de 6 km (depuis le chenal d'Oostende jusque Klemskerke), révèle la présence de coquilles marines, d'eau saumâtre, dulçaquicoles et terrestres. Des histogrammes de répartition des échantillons ont été dressés et leur analyse statistique a été effectuée en groupant les différentes espèces suivant leur affinité écologique. A la lumière de ces tests de répartition, la présence insolite d'espèces d'eau douce et saumâtre a pu être mise en rapport avec l'existence de chenaux d'écoulements et de systèmes lagunaires anciens. De telles analyses se révèlent être de bons outils d'investigations complémentaires pour les études de la géologie récente du littoral ainsi que pour les recherches archéologiques locales.

SAMENVATTING. Verschillende factoren zijn verantwoordelijk voor de verdeling van de molluskenfauna op de stranden van onze kust. De gedetailleerde analyse van deze fauna (4309 stuks met 93 soorten), waarbij steekproeven genomen werden op het niveau van het strand en in de vloedlijn over een afstand van 6 km (vanaf de haveningang van Oostende tot Klemskerke), doet ons de aanwezigheid van mariene schelpen, brakwater- en zoetwater- soorten en landslakken vaststellen. Na groepering van de verschillende soorten volgens hun ecologische affiniteit werden verdelingshistogrammen van de steekproeven ongesteld en werd een statistische analyse uitgevoerd. Dankzij deze verdelingstesten werd de onverwachte aanwezigheid van zoetwater- en brakwatermollusken in verband gebracht met het bestaan van vroegere afwateringsgeulen en lagunaire systemen. Zulke analyses blijken zeer goede complementaire onderzoekswerktuigen te zijn voor de studie van de recente geologie van de kust en voor lokaal archeologisch onderzoek.

INTRODUCTION

For many years (since 1976), the authors have been undertaking malacological analyses along the sandy shores of the Southern North Sea (Belgian coast).

When sieving beach sand, many shells are found in the size fractions of less than 5 mm. Besides protoconchs and small specimens belonging to the seabottom fauna, significant quantities of shells typical for brackishwater, freshwater and even for the land environment are found. Among the typical marine species most are living or dead juvenile forms of molluscs commonly found along the coast, other delicate specimens belong to much less common or even rare species.

The present paper deals with the molluscs species originating from brackishwater, freshwater and land. For them the sea shore may be considered as a tapho- or tanathocoenosis.

This surprising heterogeneity of the malacological faunula of the beach suggests the occurence of many phenomena responsible for this distribution.

The general tidal and residual circulation in the Southern Bight of the North Sea is well documented (especially since the Belgian research program "Mathematical model of the North Sea").

Vectors carrying non marine shells to the sea could be the large rivers of the delta (Scheldt, Meuse, Rhine) or other local rivers with a less important flow like the Aa or the Yser.

On a smaller and more locale scale, outflow channels collecting waters, mostly brackish, caught in the reclaimed land of the coastal plain (polders") by the ditches ("wateringen"), and draining them to the estuaries or into harbours (Dunkirk, Ostend, Zeebrugge,...), could also carry some shells to the littoral.

Erosion may also be taken into account for explaining the presence of non-marine shells among the beach sediments.

In such case, while the seabed is eroded subfossil molluscs are extracted, worked by waves and streams and locally deposited together with recent marine shells on the beaches.

The present work demonstrates that the latter mechanism is likely to occur. The spatial and quantitative distribution of the non-marine molluscs among the beach deposits thus helps to describe the past geomorphology of the studied seashore.

MATERIAL AND METHOD

In order to describe the distribution of all the malacological components of the shore (living, dead and remains) to analyse their ecological origin and to deduce the mechanism leading to their accumulation in the sediments on the beach, we sampled beach sand and deposits at mean tide level along 5 km line running East of Ostend (starting at kilometer post 31) towards Klemskerke; the interval between the samples was 1 km. In this context our 6 sampling stations are called 31 to 36 inclusive. In this region the residual tidal nearshore circulation is moving Eastwards.

A first sampling on 19 and May 1976 was followed by a new one on 20 May 1977. At each station, 90 cm3 of superficial sediments were collected with a spatula and fixed in 10% formalin in order to preserve the live specimens.

This large bulk of material has been completely examined under a dissecting microscope. All the living molluscs, shells and fragments of shells were sorted, identified and counted at the species level. Besides the taxonomic analysis all the species were classified according to the ecological environment to which they belong.

We can define 8 classes:

1. Species from dry biotopes (dunes).
2. Species from dry biotopes with humid characteristics (bushes, groves).
3. Species from humid biotopes (permanently humid depressions, wateredges).
4. Freshwater species tolerating very low salinity.
5. Brackishwater species tolerating freshwater.
6. Brackishwater species.
7. Marine species tolerating low salinity.
8. Marine species.

If we consider also the 2 samples of 1976 we can even introduce a 9th class, namely the typical freshwater environment.

The observed frequencies for this class were however very small.

The statistical methods used for the classification and for the comparison between classes and stations, are described in sections 3 and 4 below.

ANALYSIS OF THE SAMPLES

Species and frequencies

The present analysis is based principally on the samples of 1977. These 6 samples gave a great number of specimens (4309) and a surprisingly high number of different species (93).

Table I gives for each species the present-day ecological class, the abundance and the frequency in the sample. Graphs drawn for each ecological class show the frequency of all the species at each station along the sampling line. Terrestrial, freshwater and brackishwater classes are described and discussed below.

Terrestrial molluscs

To the land molluscs belong typical dry land species which live in xerophytic dunes environments. Among them, *Hellicella* spp. are indicator species.

Land molluscs from wet environments are also present. These species are living in old dunes covered with bushes and woods or close to ponds. Typical species are *Zonitoides excavatus* and *Trichia hispida*.

Although the biomass of living molluscs is rather low in dunes, the soil contains numerous dead shells. They are well preserved since these dunes are made of carbonate sand. The presence of these remains are indicators of previous environmental conditions which in dunes may change from dry to wet.

Fig. 1 shows peaks of occurrence of land species at station 33 (2,5% of species from dry dunes), station 35 (3,6% of species from dry dunes) ans station 36 (2,3% of species from humid dunes).

Freshwater and brackishwater molluscs

We put together in one group the non-marine aquatic species. To them we added the land species from permanent humid biotopes like marshlands and wateredges which may remain submerged such as *Succinea elegans*.

Among the freshwater species able to support brackish water, *Lymnaea ovata* is a typical example. In the present study not one species living exclusively in freshwater was found in the six samples of May 1977. Some were, however, found in the 1976 samples (see the appendix). A typical brackishwater species able to tolerate freshwater is *Potamopyrgus jenkinsi*.

In Fig. 2, we see a distinct rise of the total number of freshwater and brackishwater species, when going from station 31 to 36. At station 36 this group constitutes 11,6% of the species. It is worth noting that this rise occurs as one moves eastwards away from the entrance of the Ostend harbour (the place where the land runoff occurs). This seems a rather surprising pattern since one could expect a decrease of the species of class 6. There is however no evidence for such a decrease.

Many arguments might be considered for explaining such a distribution pattern: the vicinity of the runoff at Ostend, the relative distance of the Scheldt estuary and the direction of the residual current along the shore. Not one of them gives a satisfactory explanation for the presence of increasing amounts of fresh- and brackishwater species to the East. Another surprising fact is the sensible reduction in the number of strictly marine species at station 31 (Fig. 3) to the benefit of an increasing number of marine species able to tolerate varying salinities. In the histogram the modes for both classes are clearly separated in such a way that, when taking into account other environmental factors like currents, we can not assert that there is any influence from the Ostend harbour system. The observed distribution may only result from local erosion. Such a mechanism is quite explainable when we consider the historical evolution of the geomorphology along this part of the littoral.

STATISTICAL ANALYSIS

The distribution analysis given above is based on frequencies of occurrence in the sample of species originating from environments which are completely different. This analysis has given us already strong indications to exploit the observed distribution. A more powerful tool in checking the homogeneity of the studied region is a correlation analysis. Due to the non-single distribution a correlation coefficient can't be calculated. It is however possible to achieve this aim by using a method in which the single distribution is not necessary: the contingency coefficient also called the "Pearson's coefficient of mean square contingency".

$$C = \sqrt{\frac{T}{N+T}} \quad \text{(Conover)}$$

$$T = \sum_{i=1}^{k} \sum_{j=1}^{r} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

k : total number of samples

r : total number of species in the k samples

O_{ij} : observed number of individuals of species j in sample i

E_{ij} : theorical number of individuals of species j in sample i and with

$$N = \sum_{i=1}^{k} \sum_{j=1}^{r} O_{ij}$$

The theorical numbers E_{ij} however are unknown but can be approximated. Therefore we take all the studied samples together and calculate the probability to find each observed species in all the samples in the following way

$$P\,(\text{species}\, j) = P = \frac{\sum\limits_{i=1} O_{ij}}{\sum\limits_{i=1}^{K} \sum\limits_{j=1}^{R} O_{ij}}$$

where K : all the observed samples
R : all the observed species

when

$$N_i = \sum_{j=1}^{R} O_{ij}$$

being the total number of individuals in sample i, the theorical values E will be $_{ij}$ found as

$$E_{ij} = N_i . P_j$$

The calculation of the contingency coefficient has been executed for the observed species. It is also possible to check the dependence between the samples when we consider the ecological classes, as defined above, instead of the species.

The theorical values for C are $O < C < 1$. In the species approach max C will be 0.99, when in the class approach max $C = 0.9$.

If the value of C is close to the maximum, a great affinity between the samples exists. If C is close to 0, the samples are considerably different.

The results of the calculation of C for both species and class approaches are listed in table II. This table shows us decrease of the C values between stations 33 and 35 which is an indication that in this area of the shore the distribution of species and their ecological grouping are signicantly different when compared to the other parts of the sampling line.

It is however clear that our samples are not strictly independent because of the discretisation of the area when taking the samples. Therefore we have to test the differences beween correlated samples. Due to the great number of individuals of a few species another basic assumption has to be used. Since our analysis is dealing with ecological classes concerning different environments, the number of individuals is not the selective determinant. The presence or the absence of a certain species or class is however a better potential characteristic. The best statistical test for this type of data is the Cochran Q statistic. This test is a chi-square test of homogeneity proportions for qualitative variables in correlated samples.

If we consider S samples and M species, we can build a table as shown hereafter:

with x_{ms} having the values 0 or 1.

$$T_{m.} = \sum_{s=1}^{S} x_{ms}$$

$$T_{.s} = \sum_{m=1}^{M} x_{ms}$$

Starting from these values we can calculate

$$T_{..} = \frac{1}{S} \sum_{m=1}^{M} \sum_{s=1}^{S} x_{ms} = \frac{1}{S} \sum_{s=1}^{S} x_{.s}$$

then

$$Q = \frac{S(S-1)\left(\sum_{s=1}^{S} (T_{.s} - T_{..})\right)}{\left(S \sum_{m=1}^{M} T_{M.}\right) - \left(\sum_{m-1}^{M} T_{m.}^{2}\right)}$$

is appproximately X^2 distributed with $V = S-1$

sample / species	1	2	3		s		S	Totals
1	x_{11}	x_{12}	x_{13}	...	x_{1s}	...	x_{1S}	$T_{1\cdot}$
2	x_{21}	x_{22}	x_{23}	...	x_{2s}	...	x_{2S}	$T_{2\cdot}$
3	x_{31}	x_{32}	x_{33}	...	x_{3s}	...	x_{3S}	$T_{3\cdot}$
.	.	.	.	...	.	...		
.	.	.	.	...	.	...		
m	x_{m1}	x_{m2}	x_{m3}	...	x_{ms}	...	x_{mS}	$T_{m\cdot}$
	.	.	.	...	.	...		
	.	.	.	...	.	...		
M	x_{M1}	x_{M2}	x_{M3}	...	x_{Ms}	...		$T_{M\cdot}$
Totals	$T_{.1}$	$T_{.2}$	$T_{.3}$	...	$T_{.s}$	...	$T_{.S}$	

is appproximately X^2 distributed with V = S-1 degrees of freedom. Since Q is X^2 distributed it can be used for hypothesis testing. For our purpose this is however not necessary since our conclusion can be derived from the comparison of the results. We know that the smaller the value of Q the bigger the correlation of the samples is and therefore the greater the affinity. We also applied the C Cochran Q test on 2 samples according to the method called the "Mc Nemar test for the significance of changes (Siegel)". This Mc Nemar test is slightly different from the generalised Cochran Q for 2 samples as described in Marascuilo and Mc Sweeney. Both give approximately the same results. The Q-values in Table III have been obtained with the implementation of the test in SPSS (Statistical Package for the Social Sciences).

The slowly rising values of Q from station 31 towards the studdenly culminating point between stations 34 and 35 and the sharp fall afterwards indicates the existence of a particular local distribution in that part of the studied area. It will be shown afterwards that even the slowly rising Q-values between stations 31 and 34 can be explained.

DISCUSSION

The presence of freshwater and brackishwater species at some locations of our sampling line, revealed by the frequency distribution (table I) and confirmed by the statistical analysis appears to be local and is probably due to marine erosion. As discussed already above, hydrodynamical advections from rivers or sewage runoff should not be responsible for such particular distribution. Local erosion of the seabed may explain the presence of these molluscs with enough satisfaction. Such erosion is a common feature on the Belgian coast demonstrated clearly by the abundance, at some places, of conspicuous peatmass and clay balls accumulated in the beach deposits.

This erosive activity is mining subfossil wadden environments (with dunes, marshes, brackish lagoons and channels) extending presently under the seabottom along the flemish coastal maritime plain many movements of the sea, flooding over the coastal brackish environments and retiring after a short or a longer period, happened during the holocene. The second Dunkirkian sea transgression (Dunkirkian II) in the 4th century A.D. was the last important movement in the studied portion of the Belgian coast.

The presence in our sampling line of a narrow localised area, characterised by the particular mollusc composition in the beach deposits, is related to the existence at the same place of a channel of the wadden landscape, existing before the last transgression.

In order to check this possible correlation, we did compile numerous archaeological, historical and chart data listed in the bibliography.

To the East of Ostend, two main tidal channel systems are noticed. The first one, close to Ostend, is converging towards the harbour and its older defense systems; many parts of this system still remain inland (Grote Keiaard, Oude Straatkreek, Zoutekreek, etc.).

The second main channel, easternmost, is according to our compilations, flowing northeast from near Oudenburg and Ettelgem. The sea was reached between De Haan and Wenduine.

The main arguments for determining the area covered by this channel and creek are deduced from the present geomorphology especially the presence of low altitude meadows with turf soil (fig .4)

The eastern limit of this channel must lie east of De Haan (see fig. 4) probably where the actual shoreline bends slightly towards the northeast to Wenduine.

The Wenduine Bank, a rather stable and undeep offshore sandbank, lying a few miles off the actual coast line, is a strip on the past dune who formed the littoral in historical times as suggested by archaeological remains (pottery and potsherds) found there and which can be found occasionally washed ashore.

Behind these dunes a large creek open to the sea (the actual "Grote Rede") was at that time collecting the tidal channels of this part of the coast.

The limits of these channel systems of the pretransgression wadden environment may also be traced by plotting on the chart (fig. 4) the localisation of the old farms and villages ("hoven"). They were built along these old channels (for communication) near their marshes whose productive meadows sustained sheep ranching and also close to the sandbanks where, due to the higer level, some agriculture could be practised. Nowadays, the distribution of both farming activities can still be seen on the aereal photograph (prepared by the Institut Géographique National). Moreover, the relief data and the farm locations given by the charts does correlate with the actual soil occupations: prominent culture zones and lower turf based meadows. The turf, which forms the basis of the low level meadow zones, has been dried by the digging of the "wateringen" system, collecting water throughout the whole region, and is therefore reducing in thickness. This particularity adds some sharpness in the delimitation of the depressed level of the past channel and marsh system.

We can deduce from this historical and geographical research that our sampling line, along the actual shore line, crossed a channel between stations 33 and 35. This clearly explains the presence of the sharp disturbance in the mollusc distribution.

The presence of species from so many different biotopes in the same eroded deposits indicates that all these environments were very close to each other. This is an argument in favor of the presence of a rather narrow tidal channel in connection with a small creek behind the dune line of which the remains are still present in the sea (the first range of sandbanks). According to the location of the main channel systems described above we suppose that the channel located north of Bredene (km 34) joined one of the bigger ones. It is however possible that the two main channels and the smaller one form together a delta of a river for which the general form in our region is respected. Scheldt, Meuse and Rhine are going from their sources to the north and turn west not so far from their mouth.

This can only be determined with additional research. We said already above that the Q-values are slowly increasing towards a cumulating point. Fig. 5 gives us a good indication to explain this fact. In the depthline of 4 meter we see a distinct flexion with direction east around km 34. It is therefore obvious that between Ostend and kilometer 34 the Q-values will increase since the residual tidal nearshore circulation is going east.

CONCLUSION

The analysis of the distribution of mollusc species collected along a part of the sandy shores of the Southern North Sea (Belgian coast) provides us with information concerning the past geomorphology of the nowadays sea bottom which is presently and locally submitted to erosion.

The faunal composition is rich, including besides marine ones, land, fresh- and brackishwater species. Their quantitative and spatial distribution indicates sharply (less than 1km resolution) the presence of a subfossil tidal channel belonging to the wadden environment which existed in the region before the last marine transgression and human diking activities. The location of this channel east of Ostend is confirmed by arguments from topography, toponymy, soil analysis, archaeaology and present distribution of agriculture practices. Such malacological analysis appears to be a complementary and useful tool for the investigation of recent geology and geomorphology of the littoral (transgressions, evolution of the shore line and dunes) as well as for archaeological research.

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APPENDIX

Species found in the samples of 1976 and not present in the 1977 ones. They are listed following the classification given above with insertion of class 9 on his natural place. Within each class species are ordered systematically.

Class 1: species from dry biotopes
Pupilla muscorum
Theba pisana
Hellicella intersecta

Class 3: species from humid biotopes
Succinea oblonga
Vertigo pygmaea

Class 9: typical freshwater species
Valvata piscinalis
Physa acuta
Anisus laevis
Anisus rotundatus

Class 4: freshwater species tolerating very low salinity
Bithynia leachii
Lymnaea truncatula
Anisus planorbis
Anisus albus
Anisus crista
Anisus contortus

Class 5: brackishwater species tolerating freshwater
Bithynia tentaculata

Class 7: marine species tolerating low salinity
Nucella lapillus

Class 8: marine species
Lacuna parva
Trivia europaea
Oenopota turricula
Chrysallida indistincta
Solecurtus chamasolen

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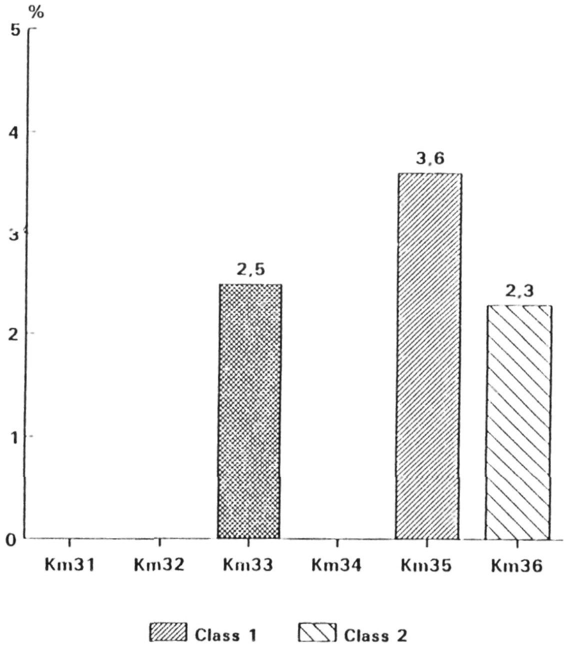

Fig. 1. Species of classes 1 and 2 compared to the total number of species.

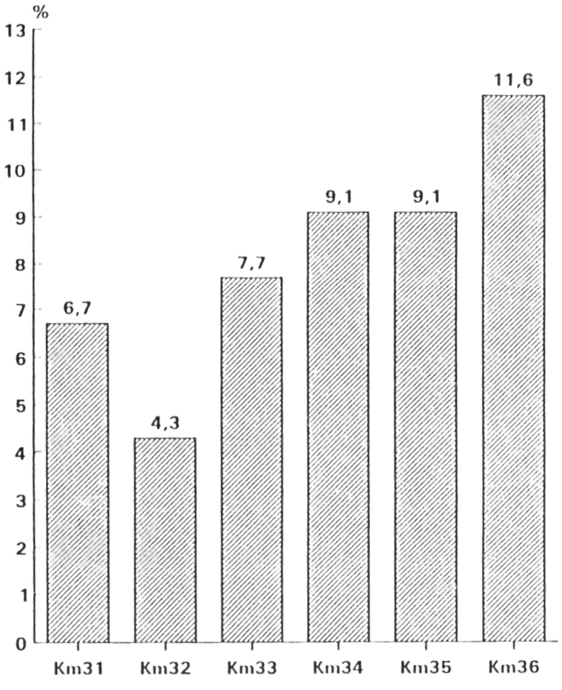

Fig. 2. Species of classes 3 to 6 included compared to the total number of species in each sample.

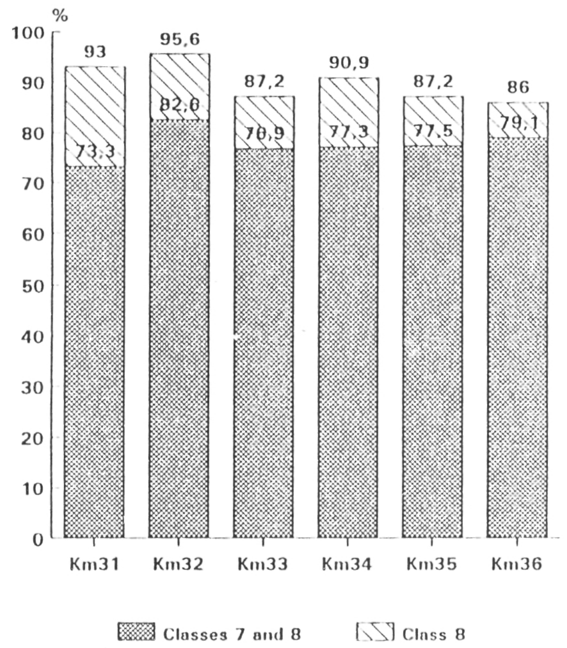

Fig. 3. Species of classes 7and 8 together and class 8 compared to the total number of species in each sample.

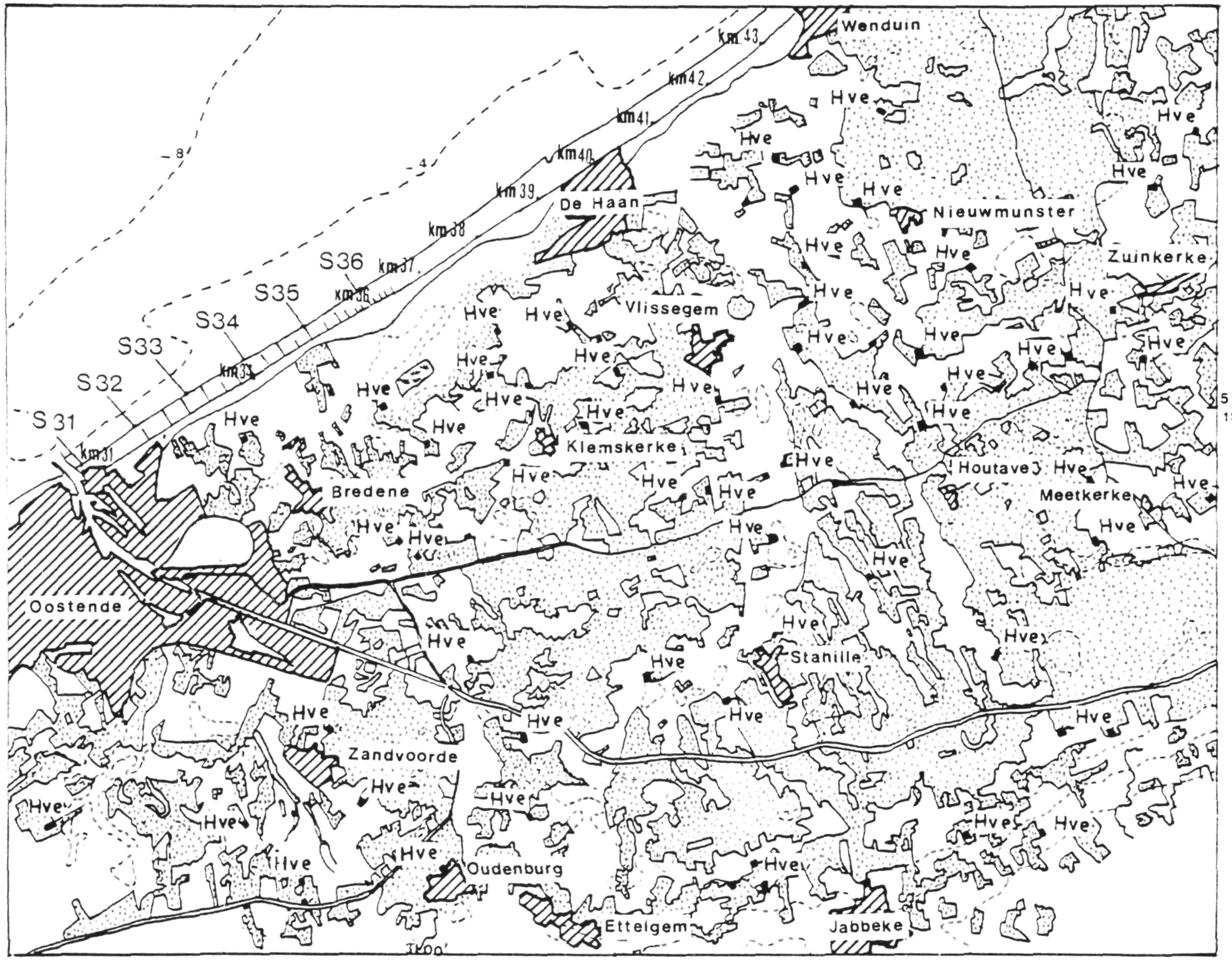

Fig. 4. Following the map of Belgium 1/25000 Sheets 4/7-8, 12/2 and 12/3-4 Institut Géographique National/ Nationaal Geografisch Instituut.

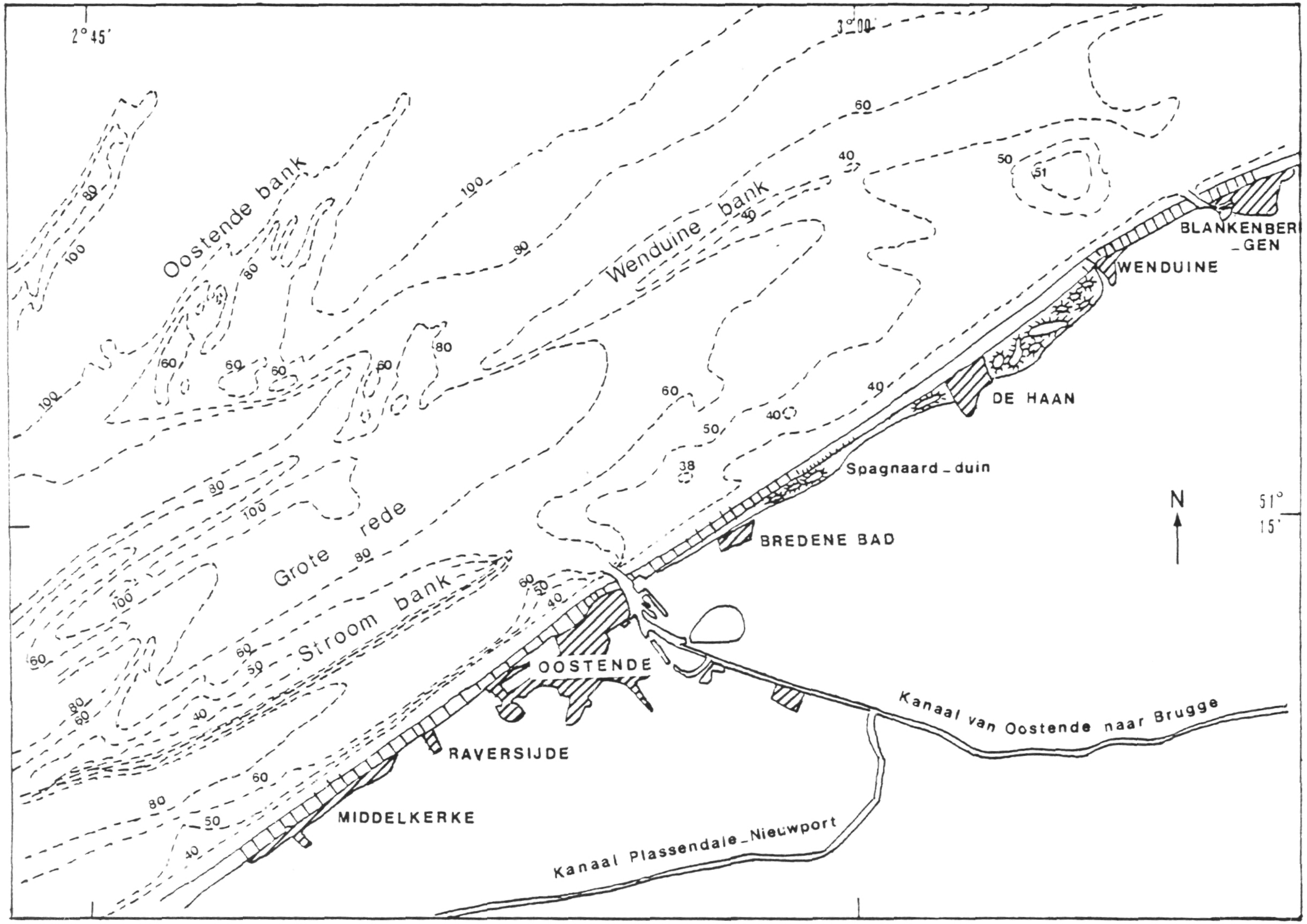

Fig. 5. Following the map "Noordzee Vlaamse Banken" collected from Belgian and foreign records of 1959-1979. 1/10000 Hydrologische Dienst der Kust.

TABLE I: Species and frequencies

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Vallonia excentrica Sterki,1892	1			1				1	1	0,023
Hellicella unifasciata (Poiret,1801)	1					1		1	1	0,023
Hellicella ericetorum (Müller, 1774)	1					1		1	1	0,023
Total class	**1**			**1**		**2**		**3**		**0,069**
Trichia hispida (Linné, 1758)	2			1				1	1	0,023
Zonitoides excavatus (Bean, 1830)	2						1	1	1	0,023
Total class	**2**			**1**			**1**	**2**		**0,046**
Succinea arenaria Bouch-Chant, 1827	3						1	1	1	0,023
Succinea elegans (Risso, 1826)	3						1	1	1	0,023
Totals class	3						2	2		0,046
Lymnaea ovata (Draparnaud, 1805)	4					1		1	1	0,023
Total class	**4**					**1**		**1**		**0,023**
Hydrobia jenkinsi Smith, 1889	5		2			9		11	2	0,26
Total class	**5**		**2**			**9**		**11**		**0,26**
Hydrobia ventrosa (Baster, 1765)	6			3		5	5	3	3	0,30
Hydrobia ulvae (Pennant, 1777)	6	19	26	76	3	40	11	175	6	4,06
Assiminea grayana Fleming, 1828	6				1	11	1	13	3	0,30
Total class	**6**	**19**	**26**	**79**	**4**	**56**	**17**	**201**		**4,66**
Littorina littorea (Linné, 1758)	7					1		1	1	0,023
Littorina saxatilis (Olivi, 1792)	7	1		2				5	3	0,12
Retusa obtusa (Montagu, 1803)	7					1		1	1	0,023
Mytillus edulis Linné, 1758	7	192	32	584	16	317	640	1781	6	41,33
Cerastoderma edule (Linné, 1767)	7	5	6	39	13	64	68	195	6	4,53
Macoma balthica (Linné, 1758)	7		3	18	9	3	11	44	5	1,02
Mya arenaria Linné, 1758	7					1		1	1	0,023
Total class	**7**	**198**	**41**	**643**	**38**	**389**	**719**	**2028**		**47,06**

TABLE I: Species and frequencies (continued)

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Emarginula fissura (Linné, 1758)	8					1		1	1	0,023
Acmaea virginea (O.F.Müller, 1776)	8		2		2	2	2	8	4	0,19
Gibbula magus (Linné, 1758)	8		1			1		2	2	0,046
Gibbula tumida (Montagu, 1803)	8					4		4	1	0,09
Gibbula umbilicalis (Da Costa, 1778)	8	2		1				3	2	0,069
Putilla soluta (Philippi, 1844)	8					7	1	8	2	0,19
Alvania semistriata (Montagu, 1808)	8					1		1	1	0,020
Rissoa inconspicua (Alder, 1844)	8					5	7	12	2	0,28
Rissoa parva (Da Costa, 1778)	8			5		8	2	15	3	0,35
Rissoa lilacina Reclus, 1843	8					2		2	1	0,046
Rissoa membranacea (J.A.Adams,1800)	8						1	1	1	0,023
Tornus subcarinatus (Montagu, 1803)	8				2	4		6	2	0,14
Skeneopsis planorbis (Fabricius, 1780)	8						1	1	1	0,023
Turritella communis Risso, 1826	8			1		4	1	6	3	0,14
Epitonium clathrus (Linné, 1758)	8	1				2		3	2	0,069
Epitonium clathratulum (Kanm., 1798)	8					2	1	3	2	0,069
Epithonium sp.	8		1					1	1	0,023
Capulus ungaricus (Linné, 1758)	8		1					1	1	0,023
Crepidula fornicata (Linné,1758)	8			1				1	1	0,023
Apporhais pespelicani (Linné,1758)	8					1		1	1	0,023
Lunatia catena (Da Costa, 1778)	8			2				2	1	0,046
Lunatia alderi (Forbes, 838)	8						2	2	1	0,046
Velutina velutina (Müller, 1776)	8		1				1	2	2	0,046
Ocenebra erinacea (Linné, 1758)	8					1		1	1	0,O23
Buccinum undatum Linné, 1758	8			1				1	1	0,023

TABLE I: Species and frequencies (continued)

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Hinia reticulata (inné, 1758)	8						1	1	1	0,023
Retusa truncatula (Bruguièra, 1792)	8			1		1	1	3	3	0,069
Chrysalida obtusa (Brown, 1827)	8					2		2	1	0,046
Odostomia nivosa (Montagu, 1803)	8					1		1	1	0,023
Odostomia truncatula Jeffreys, 1850	8						2	2	1	0,046
Odostomia plicata (Montagu, 1803)	8					1	1	2	2	0,046
Odostomia turrita Hanley, 1844	8					4		4	1	0,093
Odostomia unidentata (Mont., 1803)	8					13		13	1	0,30
Brachystomia scalaris (Mcgilliv.,1843)	8			1		4		5	2	0,12
Odostomia rissoides Hanley, 1844	8		14	16				30	2	0,70
Chrysalida spiralis (Montagu, 1803)	8					1		1	1	0,023
Turbonilla lactea (Linné, 1758)	8			1				1	1	0,023
Dentalium entalis Linné, 1758	8						3	3	1	0,069
Nucula sulcata Brown, 1831	8				1			1	1	0,023
Glycymeris glycymeris (Linné, 1758)	8		6	1	2			9	3	0,21
Anomia ephippium Linné, 1758	8	1	8	15				24	3	0,56
Anomia squama (Gmelin, 1791)	8						2	2	1	0,046
Pododesmus squamula (Linné, 1758)	8					1	2	3	2	0,069
Modiolus modiolus (Linné, 1758)	8		1					1	1	0,023
Modiolus barbatus (Linné, 1758)	8					1		1	1	0,023
Musculus discors (Linné, 1758)	8			1				1	1	0,023
Musculus niger (Gray, 1824)	8				1			1	1	0,023
Ostrea edulis Linné, 1758	8	2		1				3	2	0,069
Chlamys varia (Linné, 1758)	8			4				4	1	0,093
Delectopecten vitreus (Gmelin,1789)	8			2			2	4	2	0,093
Lima sp.	8						3	3	1	0,069

TABLE I: Species and frequencies (continued)

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Astarte sulcata (Da Costa, 1778)	8		1					1	1	0,023
Astarte sp.	8						1	1	1	0,023
Goodalia triangularis (Montagu,1803)	8		2		5		2	9	3	0,21
Kellia suborbicularis (Montagu, 1803)	8		2					2	1	0,076
Arculus sykesi (Chaster, 1894)	8						1	1	1	0,023
Montacuta ferruginosa (Montagu, 1803)	8			20	2	4	7	33	4	0,77
Mysella bidentata (Montagu, 1803)	8	10	23	168	7	122	125	455	6	10,56
Venerupis senegalensis (Gmelin, 1791)	8			2		1	2	5	3	0,12
Petricola pholadiformis Lamarck, 1818	8	1		58	7	55	56	177	5	4,11
Donax vittatus (Da Costa, 1778)	8	11	53	47	152	92	73	428	6	9,93
Tellina tenuis (Da Costa, 1778)	8			1		1		2	2	0,046
Tellina fabula Gmelin, 1791	8			4	1	2		7	3	0,16
Abra alba (W.Wood, 1802)	8	14	8	72	198	162	54	508	6	11,79
Abra prismatica (Montagu, 1808)	8					1		1	1	0,023
Solen marginatus Montagu, 1803	8				1			1	1	0,023
Mactra coralina (Linné, 1758)	8		1	13		1	6	21	4	0,49
Spisula elliptica (Brown, 1827)	8	1	4		5	3	1	14	5	0,32
Spisula solida (Linné, 1758)	8	17	2	7	17	4	3	50	1	1,16
Spisula subtruncata (Da Costa, 1778)	8		19	43	1	30	7	100	5	2,32
Saxicavella jeffreysi Winckworth, 1930	8						1	1	1	0,023
Pholas dactylus Linné, 1758	8			1				1	1	0,023
Barnea candida (Linné, 1758)	8	3		8	5	4	2	22	5	0,51
Zirfaea crispata (Linné, 1758)	8			3		4	1	8	3	0,19
Total class	**8**	**63**	**150**	**498**	**409**	**562**	**379**	**2061**		**47,83**

Grand totals		280	217	1224	451	1019	1118	4309		100,00
Number of species in each sample		15	23	39	22	55	43	93		

	Km 31 1976	Km 31 1977	Km 32 1977	Km 33 1977	Km 34 1977	Km 35 1977	Km 36 1977	Km 36 1976
Km 31 1976		0.78057	0.82212	0.67980	0.83254	0.71435	0.70368	0.78819
Km 31 1977	0.55951		0.81241	0.52975	0.83392	0.60313	0.58535	0.75124
Km 32 1977	0.56226	0.48762		0.64409	0.87121	0.69850	0.68242	0.81172
Km 33 1977	0.43592	0.31047	0.29602		0.71238	0.51263	0.50116	0.62894
Km 34 1977	0.62630	0.63418	0.64255	0.47009		0.74929	0.73721	0,82754
Km 35 1977	0.46538	0.35583	0.34435	0.26664	0.50493		0.55302	0.67439
Km 36 1977	0.5045	0.44226	0.43854	0.34827	0.54258	0.37528		0.66144
Km 36 1976	0.61675	0.61805	0.62437	0.47298	0.67076	0.50485	0.53961	

TABLE II: C-values (comparison of the stations two by two). The superior right part gives the species approach whereas the inferior left side gives the class approach.

km 31 32	km 32 33	km 33 34	km 34 35	km 35 36
3.2000	7.11111	8.75757	26.56097	3.27272

TABLE III: C-values (comparison of neighbour stations two by two)