CHAPTER 1

THE MACROBENTHOS OF AN IMPORTANT WINTERING AREA OF THE COMMON SCOTER (*MELANITTA NIGRA*)

Steven Degraer [*], Magda Vincx [*], Patrick Meire [**] and Henk Offringa [**]

[*] University of Gent, Department of Biology, Marine Biology Section
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium

[**] Institute of Nature Conservation
Kliniekstraat 25, B-1070 Brussel, Belgium

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ABSTRACT

In October 1994, 39 macrobenthic samples, divided over two areas, were taken on the western Belgian Coastal Banks. The two areas could not be clearly divided concerning their macrobenthic communities. TWINSPAN, Bray-Curtis Group-Averaging Cluster Analysis, and CCA revealed five coherent communities, linked with typical sedimentological factors: (1) the *Barnea candida* community in a very compact muddy sediment (median 14 µm), (2) a second community characterized by the presence of spat of *Mytilus edulis*, with a medium sandy sediment (median 456 µm), (3) the *Lanice conchilega* community inhabiting a fine sandy sediment (median 211 µm), (4) the *Nephtys cirrosa-Echinocardium cordatum* community in a coarser fine sandy sediment (median 242 µm), and (5), closely related to the latter, the *N. cirrosa* community also occurring in a fine sandy sediment (median 224 µm). Only the *L. conchilega* community belongs to the diverse transition zone. The other four communities seem to be part of the heterogeneous, species-poor coastal zone associations. No open sea communities have been detected in the area.

On the western Coastal Banks, only the *L. conchilega* community, because of the high numbers of *Abra alba, Tellina fabula*, and *Spisula subtruncata*, can be interesting as feeding grounds for the common scoter (*Melanitta nigra* (Aves: Mergini)). Comparison of the spatial distribution of the wintering common scoters and the *L. conchilega* community revealed no direct similarity. The factors possibly causing this dissimilarity have been discussed.

INTRODUCTION

On the Belgian Continental Platform, several sandbank systems occur: (1) the Hinderbanks, about 35 – 60 km offshore, (2) the Zeelandbanks, some 15 – 30 km offshore, (3) the Flemish Banks, about 10 – 30 km offshore of the western Belgian coast, and (4) the Coastal Banks, parallel to the coastline and typical for the coastal zone between Oostende and De Panne.

These Coastal Banks are composed of a combination of (1) a subtidal extension of the sandy beaches and (2) a series of shallow (< 8 m) sandbanks parallel to the coast. The latter can be subtidal as well as intertidal with mobile sandripples of different scales (De Moor, 1986; Ashley, 1990; Van Lancker, 1993). The sandbanks may be separated by swales. Being shallow and having a highly variable and diverse topography, currents can change drastically within only tens of meters because of the compression of the water column (Van Veen, 1936). This implies a large variety of sediments (Bastin, 1974; Buchanan, 1984; Houthuys, 1989), with patchy distribution over the area. Regarding this very heterogeneous topography and the ensuring very diverse, patchy sediment texture, the macrobenthic communities, due to the close relation between the benthos and the sediments, will also be patchy distributed. So far, the benthos along the western Belgian coast has been poorly studied (Govaere, 1978; Govaere *et al.*, 1980; Van Steen, 1978; Van Assche and Lowagie, 1991).

The area of the western Belgian Coastal Banks is an important wintering area for the common scoters (*Melanitta nigra*) (Maertens *et al.*, 1988, 1990), reflecting its ecological importance. The seaducks, whose diet consists of macrobenthos, mainly bivalves (Madsen, 1954; Glutz von Blotzheim and Bauer, 1980; Nilsson, 1972; Cramp and Simmons, 1977; Van Steen, 1978; Meissner and Bräger, 1990; Durinck *et al.*, 1993), winter mainly on the Coastal Banks in front of Oostende (Stroombank and Balandbank) and/or in front of De Panne-Koksijde (Potje, Broersbank and Den Oever) (Maertens *et al.*, 1988, 1990). The RAMSAR convention (Kuijken, 1972; Skov *et al.*, 1994, 1995) has therefore put the area of the western Coastal Banks under an international preservation convention. The western Belgian Coastal Banks were also put in the list of Belgian areas for the EC Bird Directive 79/4099/EEC (Van Vessem and Kuijken, 1986) and EC Habitat Directive 92/43/EEC (Anonymous, 1992a). The area was skipped for the EC Bird Directive, but is still under consideration for the EC Habitat Directive.

Ecological information on the food resource of the common scoter will provide additional information: (1) on the potential distribution of the seaducks and (2) on food resource itself, the macrobenthos, as a component of the sandbank ecosystem. At this moment it is not clear to what extent the feeding grounds of the seaducks are linked with their wintering distribution.

In this paper the structural characteristics of the macrobenthic communities along the western Belgian coast will be investigated in relation to the granulometric characteristics of the sediments and will be correlated with the spatial distribution of the wintering common scoters. This knowledge should be of importance to the management of the coast. Indeed, large scale dredging on the sandbanks is planned within the framework of coastal defence. This could affect scoter populations in a very negative way, not at least by damaging their food supply.

MATERIALS AND METHODS

SAMPLING SITE

The sampling area (Figure 1) covers the Stroombank and Balandbank, separated from the beach by a deep trench (area 1), and Potje, Broersbank and part of Den Oever, directly adjacent to the beach (area 2). These are the most important wintering places for the common scoter.

In October 1994, 39 macrobenthic samples were taken. In area 1, 20 stations cover the different geomorphological formations: the southern and northern flanks (4 respectively 6 stations), and the top of the sandbanks (10 stations). As area 2 is geomorphologically more differentiated, the 19 stations were placed in a grid covering the whole area.

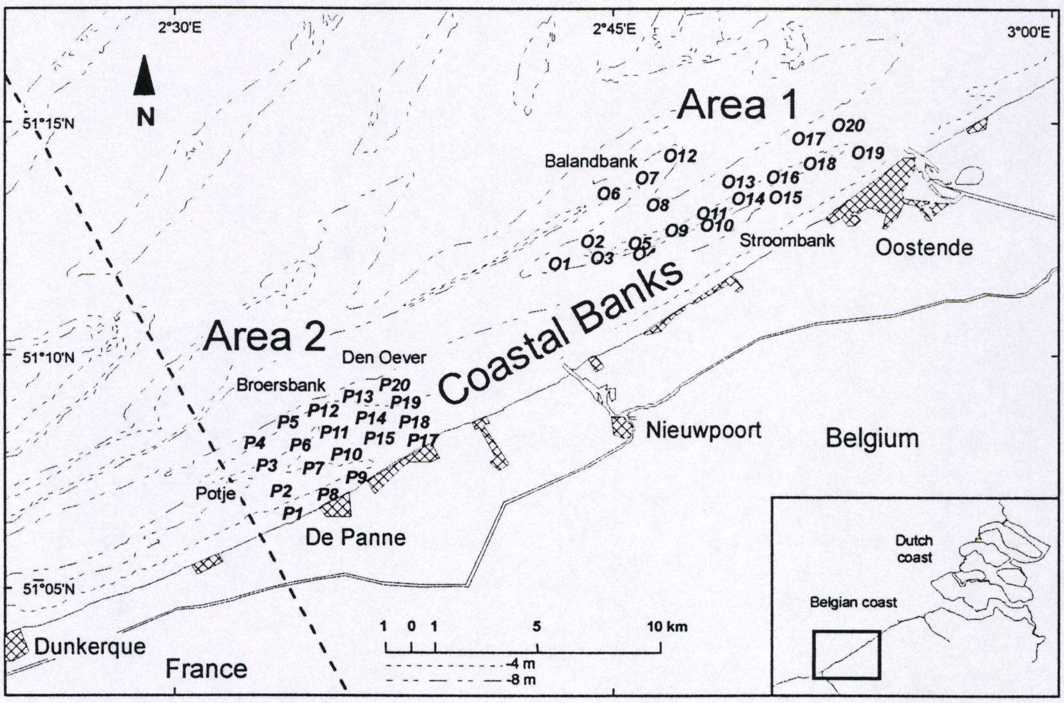

Figure 1. Geographical view on the western Coastal Banks, divided in area 1 and area 2; with indication of the 39 sampling sites.

SAMPLING METHOD

Samples were taken with a Van Veen grab (sampling surface area: 0.12 m^2) and sieved on board over a 1 mm sieve before fixation. The residual was preserved in a buffered 8% formaldehyde solution. Samples were decanted, stained with Bengal rose and the residuals were sorted under stereomicroscope. All the individuals were identified up to species level, except the oligochaetes.

ENVIRONMENTAL PARAMETERS

Water depth was recorded while sampling and standardized to mean low water spring (MLWS). The grain size analysis of a subsample was measured with a Coulter particle size analyser.

DATA ANALYSIS

To identify groups of similar stations, the density data were subjected to a Two-Way INdicator SPecies Analysis (TWINSPAN), with cutlevels: 0, 9, and 40 ind m^{-2}, a TWINSPAN on the presence/absence data (Hill, 1979) and, after fourth root transformation, to a Bray-Curtis group-average Cluster Analysis (van Tongeren, 1987) and a Canonical Correspondence Analysis (CCA) (Ter Braak, 1988).

The station groupings, resulting from the multivariate analyses, analysis were characterized by their typical species composition, diversity indices (Hill numbers: N_0, N_1 and N_{inf} and Shannon-Wiener diversity index, H') (Hill, 1973; Shannon and Weaver, 1949) and the measured environmental variables.

Statistical differences for biotic and abiotic variables between groups were analyzed by the Kruskal-Wallis test ($p < 0.05$). Significant differences were further analyzed by *a posteriori* multiple comparisons (Conover, 1971).

RESULTS

The number of species per station varied between three and 29 species, with a mode of four species (Figure 2A). About 47 % of the 71 identified species belongs to the Polychaeta, 20 % to the Bivalvia, 14 % to the Amphipoda, 6 % to the Decapoda, and another 11% are belonging to the remaining taxa (Figure 2B). The total density varied between 58 and 8350 ind m^{-2} with a mode of 100 – 200 ind m^{-2}; 18 of the 37 stations had densities from 100 – 400 ind m^{-2} (Figure 2C).

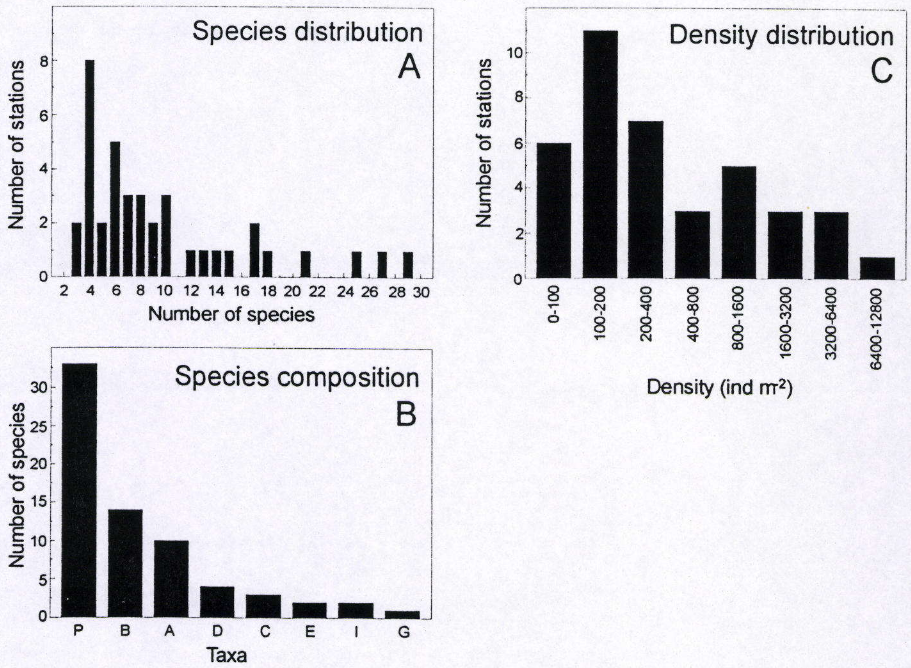

Figure 2. (A) Species distribution, (B) species composition (P, Polychaeta; B, Bivalvia; A, Amphipoda; D, Decapoda; C, Cumacea; E, Echinodermata; I, Isopoda; G, Gastropoda), and (C) density distribution of the 39 stations.

MULTIVARIATE ANALYSES

In the different multivariate analyses, the same stations were always grouped together, except for O13, O18 and P15 (Figure 3). Station O13 was placed in group 2 in three of the four analyses. The stations O18 and P15 showed no preferences for a group and were kept out of further analyses.

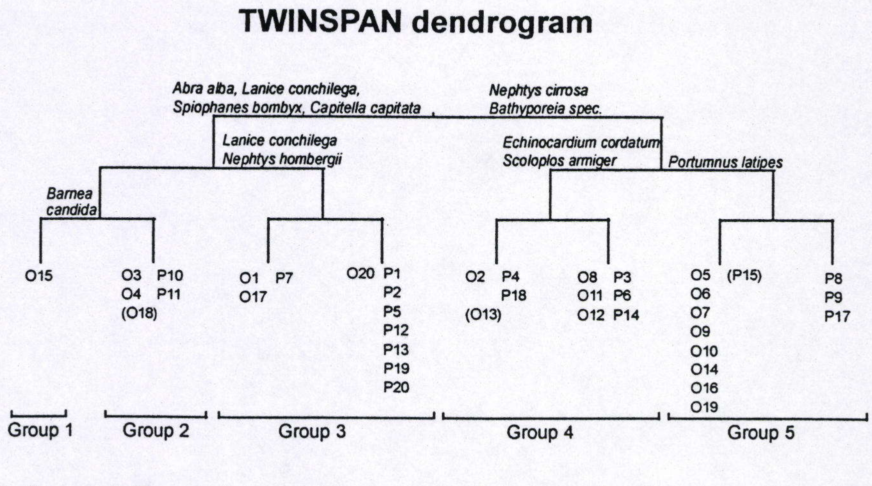

Figure 3. Presentation of the graphical result of one multivariate technique: TWINSPAN dendrogram of the presence/absence data; with indication of the five groups and their indicator species.

SPECIES COMPOSITION

The ten most dominant species differ between the five groups as do their relative importance within groups (Table 1). In group 1, only *Barnea candida* (Linnaeus, 1758) occurs in quite high densities. The second group is dominated by *Microphthalmus similis* (Bobretzky, 1870) and spat of *Mytilus edulis* (Linnaeus, 1758). *Magelona papillicornis* (F. Müller, 1858), *Eumida sanguinea* (Oersted, 1843), *Lanice conchilega* (Pallas, 1766), *Abra alba* (S. Wood, 1802), and *Tellina fabula* (Gronovius, 1781) are well represented in group 3. Group 4 has high densities of *M. papillicornis* and *Nephtys cirrosa* (Ehlers, 1868). Group 5 also has *M. papillicornis* and *N. cirrosa* as most dominant species.

Group 1 Species	$N.m^{-2}$	%	Group 2 Species	$N.m^{-2}$	%	Group 3 Species	$N.m^{-2}$	%
B. candida	117	100	*M. similis*	237	60	*M. papillicornis*	1392	64
Ensis sp.	33	100	spat *M. edulis*	118	100	*E. sanguinea*	344	82
N. longissima	25	100	*N. cirrosa*	28	100	*L. conchilega*	228	64
N. succinea	25	100	*H. augeneri*	20	60	*A. alba*	139	91
G. capitata	25	100	Oligochaeta	15	20	*T. fabula*	104	64
Oligochaeta	17	100	*Ensis* sp.	10	40	*P. typicus*	69	64
E. longa	17	100	*S. armiger*	7	60	*Ensis* sp.	62	82
U. deltaura	8	100	*G. capitata*	7	40	*N. hombergii*	61	82
Bivalvia indet.	8	100	*S. subtruncata*	7	40	*S. subtruncata*	48	55
A. Mucosa	8	100	*O. limacina*	3	20	*C. capitata*	41	73

Group 4 Species	$N.m^{-2}$	%	Group 5 Species	$N.m^{-2}$	%
M. papillicornis	72	77	*M. papillicornis*	125	75
N. cirrosa	70	100	*N. cirrosa*	93	100
E. cordatum	21	77	*Ensis* sp.	21	17
Bathyporeia sp.	16	66	*D. vittatus*	11	25
S. armiger	7	55	*Bathyporeia* sp.	7	50
P. altamarinus	6	55	*N. hombergii*	7	33
P. batei	5	22	*P. latipes*	7	42
D. bradyi	5	33	*U. poseidonis*	4	25
Ensis sp.	4	33	*E. sanguinea*	4	8
U. poseidonis	4	33	*D. bradyi*	2	25

Table 1. The ten most abundant species per group with indication of the density ($N.m^{-2}$) and the percentage of occurrence in the stations of the different groups (%).

The abundances of the indicator species of the TWINSPAN, presence/absence and absolute densities, were compared statistically in between groups (Table 2). Group 1 cannot be compared statistically with the other groups (N = 1), but the presence of *B. candida*, which occurs only in group 1 is likely to be typical for that kind of environment. Group 2 is put apart by the abundance of juvenile specimens of *M. edulis*. Group 3 differs from the other groups by the abundance of *A. alba* and *L. conchilega*. *Nephtys cirrosa* and *Echinocardium cordatum* (Pennant, 1777) are typical for group 4, and group 5 cannot be separated statistically by any TWINSPAN indicator, but possesses the highest number of *N. cirrosa*.

	Group 1	Group 2	Group 3	Group 4	Group 5	H	p
Barnea candida	117	0	0	0	0	---	---
Mytilus edulis spat	0	118	5	0	0	28.682	<0,0001
Abra alba	0	2	139	0	0	27.861	<0,0001
Lanice conchilega	0	0	228	0	0	25.813	<0,0001
Nephtys cirrosa	0	28	25	70	93	14.365	0,0025
Echinocardium cordatum	0	0	2	21	0	18.968	0,0003

Table 2. Densities (ind m^{-2}) of the differentiating species, with indication of the test statistic (H) of the Kruskal-Wallis test together with the p-level for differences between group 2, 3, 4, and 5.

Thirteen species of bivalves were found in the whole area: *Abra alba*, *Barnea candida*, *Donax vittatus*, *Ensis* sp., *Macoma balthica*, *Mactra corallina*, *Montacuta ferruginosa*, *Mytilus edulis*, *Spisula subtruncata*, *S. solida*, *Tellina fabula*, *T. tenuis*, and *Venerupis pullastra*. Group 1 is characterized by *B. candida* and *Ensis* spp. Group 2 has only high densities of *M. edulis* spat. *Abra alba, T. fabula, Spisula subtruncata, Ensis* spp., and *Montacuta ferruginosa* are reaching high densities in group 3. Group 4 does not have a typical bivalve species and no bivalve species has a density higher than 5 ind m^{-2}. Group 5 is also poor concerning bivalves, but *Donax vittatus* and *Ensis* spp. are found in low numbers. *Tellina tenuis, Macoma balthica, Spisula solida, Mactra corallina*, and *Venerupis pullastra* are only occurring in low densities (maximal 11 ind m^{-2}).

	Group 1	Group 2	Group 3	Group 4	Group 5
Exclusieve species	3	3	23	4	1
Total number of species	10	21	54	24	15
N_0	10	8	18	8	5
N_1	6.8	5.0	6.8	5.2	3.2
N_2	4.9	4.2	4.4	4.0	2.5
N_{inf}	2.6	2.7	2.3	2.6	1.7
H'	1.9	1.6	1.7	1.6	1.1

Table 3. The number of exclusive species per group; the total number of species per group and different diversity indices of the five groups: (1) Hill numbers (N_0, N_1, N_2 and N_{inf},) and (2) Shannon-Wiener diversity index (H').

DIVERSITY

Table 3 is indicating different diversity indices. Each group is characterized by some exclusive species. Group 3 has 23 exclusive species in a total of 54 species. On a total of only ten species found, group 1 has 3 exclusive ones. N_0, which gives the group average of the number of species per station, indicates a very high number for group 3 (18 spp.). The other groups are having a N_0 varying from five (group 5) to ten (group 1). Taking into account the rest of the Hill numbers, group 1 is the most diverse group, followed by group 3.

ENVIRONMENTAL VARIABLES AND GEOGRAPHICAL DISTRIBUTION

As group 1 is composed of only one station, statistical comparisons with other groups is impossible. However, the relatively great depth (8.2 m), low median grain size (14 µm), and high volume percentage of silt (63 %), differentiate group 1 from the other groups.

	Group 1	Group 2	Group 3	Group 4	Group 5	p-level
Depth	8,2	4,8	5,7	4,8	3,8	0,3698
Median	14	456	211	242	224	0,0005
MM-ratio	1,2	1,0	0,9	1,0	1,0	0,0393
% Mud	18	0	1	0	0	0,0004
% Silt	63	0	3	0	0	0,0004
% Very fine sand	8	1	4	1	3	0,0007
% Fine sand	6	9	65	57	63	0,0019
% Medium sand	4	54	22	43	33	0,0063
% Coarse sand	1	36	5	1	1	0,0010
% Gravel	0	11	0	0	0	<0,0001
Area 1 : Area 2	1:0	3:2	3:8	4:5	8:3	—

Table 4. Average value of the measured environmental variables per group, with indication of the p-level of the Kruskal-Wallis test for differences between group 2, 3, 4, and 5, and the geographical distribution of the number of stations of the five groups over area1 and area2. Depth = meter under MLWS; median = median grain size (µm); MM-ratio = sediment mean/median ratio; different sediment fractions in volume percentages; percentage gravel in mass percentage.

Statistical differences between the other four groups (Table 4) were found for: median grain size, volume percentage clay (<4 µm), silt (4 – 63 µm), very fine sand (63 – 125 µm), medium sand (250 – 500 µm) and coarse sand (500 – 1000 µm), and mass percentage of gravel (>1000 µm). Depth, mean-median ratio, and volume percentage fine sand (125 – 250 µm) showed no differences. Most of the stations in group 3 (eight stations) occur in area 2, with only three stations in area 1. In all the other groups, there are more stations in area 1 (groups 1 and 5) or about the same number of stations in the two areas (groups 2 and 4). The results of the Kruskal-Wallis *a posteriori* tests on the differentiating environmental variables between the groups 2, 3, 4, and 5 are given in Table 5. In summary, group 1 has a typical very fine sediment, group 2 is characterized by a medium sandy sediment, group 3 by fine sandy sediments, and, the very similar, groups 4 and 5 by slightly coarser fine sandy sediments.

	Group 2	Group 3	Group 4	Group 5
Group 2	---			
Group 3	1234567	---		
Group 4	167	12345	---	
Group 5	14567	234	no differences	---

Table 5. Environmental variables indicating statistical differences between groups with an a-posteriori test after a negative Kruskal-Wallis test; 1, median grain size; 2, mud; 3, silt; 4, very fine sand; 5, medium sand; 6, coarse sand; and 7, gravel content of the sediment.

DISCUSSION

MACROBENTHIC COMMUNITIES

Govaere *et al.* (1980) described three macrobenthic communities occurring in the Southern Bight of the North Sea: (1) a very diverse open sea community, (2) a rather diverse transition zone community, where the following species are numerically dominant: *Lanice conchilega, Nephtys cirrosa, Spiophanes bombyx, Magelona papillicornis, Pectinaria koreni* (Malmgren, 1865), *Anaitides mucosa* (Oersted, 1843), *Tellina fabula, Eumida sanguinea*, and *Ophelia limacina* (Rathke, 1843), and (3) a species-poor, heterogeneous coastal zone community, dominated by *P. koreni, Macoma balthica, Nephtys hombergii* (Savigny, 1818), and *Abra alba*.

The presented study here, in the shallow subtidal part of the western Belgian coast, detected five macrobenthic communities, all characterized by a series of typical species and specific values of some environmental factors. As this study only results from an autumn campaign, differences with the communities described in Govaere *et al.* (1980), resulting from several campaigns, spread over several years, are expected (McIntyre *et al.*, 1982).

As *B. candida* (besides *Ensis* spp. the only bivalve species in group 1) is exclusively found in group 1, this group can be defined as the *B. candida* community. This rather diverse community occurs in a muddy (median grain size: 14 µm), deeper lying (8.2 m) sediment, containing high numbers of *B. candida* (117 ind m^{-2}). The species composition of this community does not resemble any of the three communities described in Govaere *et al.* (1980). However, due to the heterogeneous character of the coastal zone, with a typical deposition of fine sediments and a low number of species, the *B. candida* community possibly belongs to the coastal zone community complex. The very fine sediments, in contradiction to the generally high dynamic sandbanks with a consequently coarser sediment, and the depth indicate that this community is part of the communities occurring in the trenches in between, rather than on, the sandbanks. As this study aimed to sample the communities of the sandbanks, only one station belonging to the *B. candida* community has been encountered.

Group 2 could be differentiated by means of the presence of juvenile *Mytilus edulis*: the '*M. edulis*' community. This community is situated on top of the Broersbank (area 2) and along the top of the Stroombank (area 1). The very coarse sediments, with an average median grain size of 456 µm, imply high hydrodynamic forces. The community is characterized by a low diversity. Except for the juvenile *M. edulis* specimens, no other bivalves occurred in high densities. Due to the low diversity and low number of species, this community could also be part of the coastal zone community complex. Because of the absence of adult specimens of *M. edulis*, this bivalve may not be a typical species over all the seasons. The juvenile specimens can attach to the coarse sediment particles, but when they grow the chance of being washed out increases, as adult *M. edulis* attach firmly to hard substrata.

A fine sandy sediment (median 211 µm) with typically high densities of *A. alba* and *L. conchilega* and a very high diversity are characteristic elements for group 3, defined as the *L. conchilega* community. This community contains the highest densities of bivalves. The *L. conchilega* community coincides very well with the transition zone community (Govaere *et al.*, 1980). In fact the transition zone reaches the coast in front of De Panne and the *L. conchilega* community, in this study, is typical for the sandbank area at this place: eight of the 11 stations of the association are situated in area 2, only three transition zone stations can be found in area 1.

The groups 4 and 5, which are very similar, are occurring in a slightly coarse fine sandy sediment (median grain size: respectively 242 and 224 µm), with both a quite low diversity and low numbers of bivalves. *Echinocardium cordatum* and *Nephtys cirrosa* are reaching high densities, respectively 21 and 70 ind m^{-2}, and are characteristic for group 4: the *N. cirrosa-E. cordatum* community. The fifth group contains only high numbers of *N. cirrosa* (93 ind m^{-2}) and can thus be defined as the *N. cirrosa* community. These two communities both have a low diversity and can also be considered as a type of the coastal zone community complex.

Some studies on the macrobenthos of the nearby, but deeper lying, Flemish and Zeeland Banks have been carried out (Rappé, 1978; Meheus, 1981; De Rijcke, 1982; Vanosmael *et al.*, 1982). Generally these sandbanks have a typical open sea community, with affinities to the transition zone. The communities are relatively species-poor in comparison to the surrounding areas (Rappé, 1978) and no relation between the most abundant species of these Flemish and Zeeland Banks on the one hand and these of the Coastal Banks (this study) on the other hand could be detected (Table 6). The lack of high densities of bivalves is also in contrast with the Coastal Bank communities or at least with the *L. conchilega* community. Craeymeersch *et al.* (1990a) described for the Voordelta area (the Netherlands), a shallow, sandy, subtidal marine area, five communities, related with typical abiotic parameters, of which the sedimentology seemed to be the most important (Craeymeersch *et al.*, 1990b). Generally, the macrobenthos of the Voordelta area has higher densities (500-15000 ind m^{-2}) and higher number of species (55-120 spp.) in comparison with the five communities of this study. Yet, a clear similarity between the median grain size of the richest communities of Craeymeersch *et al.* (1990a), namely 180 – 220 µm, and the median grain size of the rich *L. conchilega* community (average 211 µm) can be noticed. Biologically seen, among the most abundant species are also *S. bombyx, L. conchilega, A. alba, Spio filicornis,* and *Mysella bidentata*. *Spisula subtruncata* occurs in high densities, but the lack of high densities of this bivalve species in the *L. conchilega* community is discussed below.

Zeelandbanks	Flemish Banks
Spisula elliptica	*Ophelia borealis*
Nephtys cirrosa	*Hesionura augeneri*
Ophelia borealis	Oligochaeta
Nephtys longosetosa	*Bathyporeia elegans*
Nephtys caeca	*Nephtys cirrosa*
Scolelepis bonnieri	*Spio filicornis*
Bathyporeia guillamsoniana	*Eteone longa*
Thia scutellata	*Bathyporeia guillamsoniana*
Eteone longa	*Nephtys hombergii*

Table 8. The most abundant macrobenthic species of other sandbank ecosystems on the B.C.P. The species list of the Zeelandbanks is based on the species lists of samples from the Thornton Bank and Gootebank; the list of the Flemish banks is based on samples from the Oostdijck, Buiten Ratel and Kwintebank (Meheus, 1981).

Van Steen (1978) surveyed area 2, with special attention to the bivalves. As only a selective part of the western Coastal Banks, mainly Potje, was sampled, the sediment analyses all resulted in a fine sandy sediment (median grain size: 170 – 240 µm). Yet, the high densities of *A. alba*, *T. fabula*, and *L. conchilega*, show a clear relationship with the *L. conchilega* community described here.

Sandbank systems are abiotically extremely diverse and a depth difference of 0.5 m in a shallow area affects the hydrodynamics very much. Consequently, extremely diverse hydrodynamics are expected. Because of the linkage between hydrodynamics and sedimentology (Gullentops *et al.*, 1977; Buchanan, 1984), even within some tens of metres completely different types of sediment can be encountered, each with their own typical macrobenthic community. However, as the 39 stations (without the exceptional *B. candida* community) are only divided into four consistent communities, it is unlikely that a new community will be found when taking more samples in the same area.

Since the dynamics of the benthic system are a reflection of the distribution of residual and tidal currents and the load of suspended materials, the basic composition and distribution of the respective communities and their spatial distribution will remain stable (within the natural variability due to erratic recruitment and mortality) as long as the currents and the amount of suspended material carried will not change drastically (Govaere *et al.*, 1980). A comparison of the geomorphology and sedimentology of area 2 between 1973 (Bastin, 1974) and 1994 (this study) reveals no substantial differences. This implies no drastic changes in hydrodynamic regime and, consequently, an over years rather constant spatial variation of the macrobenthic communities, even for a very high dynamic region such as the western Coastal Banks. No reasons could be found to presume a different situation in area 1.

FOOD AVAILABILITY FOR THE COMMON SCOTER

In total 13 bivalve species are found in this study. Yet, for the common scoter, not all bivalves in any density are a potential food resource: (1) the bivalves have to occur in a fairly high density, so the scoter is likely to find a bivalve specimen while diving, (2) the bivalve specimens cannot be too big for swallowing or too small, which make it energetically unfavourable diving for, and (3) may not be digging to deep, which make it unlikely to be found (Leopold, 1995; Leopold *et al.*, 1995). Of the 13 species, only *D. vittatus, A. alba, T. fabula, T. tenuis, M. balthica, S. subtruncata,* and *B. candida* are likely to be eaten by the wintering common scoters. Thus, the common scoters are expected to feed on the *L. conchilega* community, with fairly high densities of *A. alba, T. fabula*, and *S. subtruncata*, and to a lesser extent on the *B. candida* community. Although, morphologically seen, *B. candida* is a potential food resource for the common scoter, the bivalve lives in a very compact muddy sediment (clay) and it is doubtful the common scoter could find these bivalves.

While studying the bivalves in area just east of area 2, Van Assche and Lowagie (1991) encountered a community with very high densities of *S. subtruncata* (up to over 500 ind m^{-2}), *M. balthica* (up to 500 ind m^{-2}), *T. fabula*, and *A. alba*. This community would probably also act as a very important food resource for seaducks, but this community has not been detected in this study. Possibly, due to their irregular recruitment, the bivalve populations disappeared by: (1) natural mortality, (2) maybe predation by the common scoters, and (3) the lack of recruitment in the area for several years. Concerning *S. subtruncata*, the high number of individuals found in February 1991 (Van Assche and Lowagie, 1991) were probably all recruits from 1989 or earlier (personal observation from maximal shell length) and the present study reveals few individuals which were at least recruited in 1993, but the low densities are giving the idea that recruitment has taken place even earlier. Maybe, between 1990 and 1994, there has been even no recruitment at all, which could explain the extreme low densities of *S. subtruncata* in comparison with 1991. Unfortunately, between 1990 and 1994 no more macrobenthic samples have been taken in the area to prove this idea.

The expected similarity between the spatial distribution of the macrobenthos (Nilsson, 1972), more specifically the *L. conchilega* community, and the wintering scoters (Table 7), as discussed above, cannot be detected. Most of the scoters are staying in area 1, whereas the highest densities of bivalves (*L. conchilega* community) are mostly found in area 2. Obviously there exist some problems when linking both spatial distributions. A first problem is the difference in scales used. The macrobenthic species are, in comparison to the ducks, very sessile: one sampling campaign for the macrobenthos reveals already a detailed pattern, which normally is quite stable in time. As seaducks are a lot more mobile, for instance by flying and drifting (Winter, 1993) their spatial distribution can change significantly, even within some hours. Consequently, four seaduck counts during one winter half year do not necessarily show a detailed, temporal stable spatial pattern. It gives an idea about the total number in a large area, rather than their distribution over the area. This fact implies problems linking both distributions. Secondly, groups of the seaduck can be found on places where it is too deep to dive for food (pers. comm. H. Offringa) and research, trying to link the spatial distribution of the common scoter with the macrobenthos in the Netherlands, revealed an excess of *Spisula* banks: not all *Spisula* banks found possess constantly a group of common scoters feeding on them (Leopold, 1995). These two facts create the idea that the common scoter does not always have to select the best feeding grounds. Sometimes 'sub-optimal' or even 'bad' feeding places can be preferred. This can also be concluded from the presence of the scoters during winter 1994-1995 in area 1. What exactly or what combination of factors is determining the ducks' spatial distribution is not known at this moment. Possibly a combination of food availability and the lack of disturbance, by fishing activities for instance (Leopold and Land, 1996), determines their spatial distribution.

	13.11.94	31.12.94	12.02.95	04.03.95
Area1	52	1187	1366	184
Area 2	67	72	165	0
Total	343	1294	1585	188

Table 9. The distribution of the common scoter at the Belgian coast during winter 1995-1995, with distinction between area 1 and area 2 (H. Offringa, unpublished data).

Still the protection of areas as wintering place for the common scoter is important. As tranquillity zones, e.g. marine protected areas, can be safeguarded against anthropogenic influences, such as shellfish fisheries and sand extraction, the establishment of these areas, rich in bivalves, will have a positive influence on and may even attract the common scoter. Even if the tranquillity zone is not visited by the common scoter every year, the area can act as a refuge in times of food shortage or disturbance.

The monitoring of the macrobenthos in these areas allows estimates of potential productivity of renewable resources and is thus a major component in determining sustainable levels of use, for instance in the case the shellfish fisheries (Agardy, 1994).