Meded. Werkgr. Tert. Kwart. Geol.	vol. 16 nr. 1	pp. 17 - 54	6 tab., 4 fig., 5 pl.	Rotterdam, maart 1979

THE SUBBOREAL COASTAL BARRIERS AT LEIDSCHENDAM, WITH A DESCRIPTION OF THE FAUNAS (PROVINCE OF ZUID-HOLLAND, THE NETHERLANDS)

by

J. G. M. Raven
Leidschendam.

Raven, J. G. M. The subboreal coastal barriers at Leidschendam, with a description of the faunas (province of Zuid-Holland, The Netherlands). - Meded. Werkgr. Tert. Kwart. Geol., 16 (1): 17 - 54, 6 tab., 4 fig., 5 pl. Rotterdam, March 1979.

A lithological and palaeontological description of the coastal barrier deposits and the clayey deposits on the beach plain in the region of Leidschendam is given and the palaeoecology is discussed. Special attention is paid to the juvenile shells of several molluscs; some systematical notes are added.

J. G. M. Raven, Pr. J. W. Frisolaan 229, 2263 CG Leidschendam, The Netherlands.

Contents:

SAMENVATTING

Bij Leidschendam zijn onlangs een aantal tijdelijke ontsluitingen geweest in de eerste (meest landwaarts gelegen) strandwal en de strandvlakte tussen de eerste en tweede strandwal. In deze vlakte bleken twee smallere (secundaire) wallen te liggen. Vooral de secundaire rug in de Leidschendamse wijk Duivenvoorde is uitgebreid onderzocht (tekstfig. 1 - 3).

In het onderzochte gebied hebben de strandwallen een asymmetrische vorm met een lange, vlakke zeewaartse helling en een korte, steilere, landwaartse helling (tekstfig. 2). In de wallen valt vooral het naar boven grover worden van de sedimenten op. In Leidschendam was over 2,5 m een overgang te zien van kleiig zeer fijn zand naar grof zand. De oorzaak hiervan ligt in de sorterende werking van de golfbeweging op de vlakke helling aan de zeezijde van de barrière. De grofste sedimenten worden het meest landwaarts afgezet en door het uitbouwen van de kust overdekken zij de fijnere sedimenten.

De gevonden fossielen (tabel 1) zijn vrijwel alle getransporteerd, maar er is wel een onderscheid te maken tussen ver en minder ver getransporteerde exemplaren. Slechts weinig soorten leefden in het door een lage barrière afgeschermde gebied, bewoners van het harde zandwad en dicht bij de kust levende soorten komen hier voor (tabel 2). De verder uit de kust levende soorten spoelden slechts zeer incidenteel aan (tabel 5). Vrij veel zoetwatersoorten werden gevonden (tabel 3), de meest juveniele schelpjes zijn vrij ver getransporteerd en afkomstig uit de rustige delen van de zuidelijke rivieren. Daarnaast worden nog fossielen gevonden die uit oudere afzettingen afkomstig zijn, vooral brakwatersoorten (tabel 4).

Met behulp van deze gegevens kan een beschrijving van het afzettingsmilieu worden gegeven. Het meeste materiaal is afgezet op een brede, flauw hellende zandige strandvlakte. Deze vlakte lag onder gemiddeld hoogwaterniveau terwijl enkele delen boven laagwaterniveau lagen. Een onderzeese rug schermde het gebied af zodat slechts fijne sedimenten vanuit zee inspoelden. Omdat de rug zich langzaam landwaarts verplaatste en tenslotte samenviel met de kust traden af en toe perioden op met sterkere golf- en stromingsinvloeden zodat grover materiaal kon worden afgezet. Spoedig werd dan weer een nieuwe rug gevormd.

Na het hoger worden van deze rug werd het gebied verder afgeschermd. Op de laaggelegen strandvlakten wordt dan kleiig sediment afgezet dat het gebied bereikt via de monding van de Rijn. In het brakke milieu leefde een soortenarme fauna.

De chloriniteit (= gehalte Cl^- ionen) van de sedimentatiemilieu's kan bepaald worden uit het gemiddeld aantal ribben van *Cerastoderma edule*. De strandwallen blijken afgezet te zijn in een milieu met een iets lagere chloriniteit dan nu voor de huidige kust voorkomt (tabel 6). In de jongere klei zien we een hoger aantal ribben wat op een verhoging van het zoutgehalte wijst. Dit is in tegenspraak met de andere gegevens. Een mogelijke verklaring wordt gevonden in de toegenomen isolatie van het gebied, waardoor geen genetisch materiaal kon worden uitgewisseld met andere populaties zodat het aantal ribben genetisch vastligt binnen de populatie.

In een systematisch deel wordt nog extra aandacht besteed aan enkele mollusken, vooral aan de juveniele schelpjes (plaat 1 - 4). De leefpositie van de Tellinacea wordt behandeld; een soort neemt in verschillende milieu's soms een verschillende leefpositie aan; waarschijnlijk is dit afhankelijk van de waterbeweging en de sedimentatiesnelheid. De nomenclatuur van de brakwatervorm van *Littorina rudis* wordt uitvoerig behandeld.

INTRODUCTION

During the last decennia several important studies on Holocene deposits in the Netherlands were published, a large number of which dealt with the coastal barriers in the western part of the country (Jelgersma, 1961; Pons et al., 1963; van Straaten, 1965; Eisma, 1968; Jelgersma et al., 1970; Edelman, 1974). These studies mainly treated sedimentological, palaeobotanical and archaeological subjects. Also the fauna was studied, e.g. the material from the borings described by van Straaten was studied by the State Geological Survey (Spaink, 1963), but the results were never published. Van Straaten (1965) published some results when he compared the fossil mollusc fauna of the coastal barriers with recent faunas. A problem in the study of these fossil faunas is that because of the relative poorness in fossils usually large samples are necessary to obtain a good survey of the fauna.

In this paper an attempt is made to describe the lithology and the fauna from a restricted area of the coastal barriers. The study was possible because many exposures were made in the coastal barrier deposits at Leidschendam during the last years (text-fig. 1) and that enough time was available to visit these exposures frequently (e.g. the exposures at Duivenvoorde were visited during a month, twice a day). Before these exposures were dug, a series of auger-borings (edelman type) were made in the upper metres of the barriers (text-fig. 1). Supplemented with literature data this resulted in a fairly complete survey of the Holocene coastal barrier complex in this area.

THE COASTAL BARRIERS

Coastal barriers are ridges along open sea, rising from the sea floor to above low tide level. The material composing the subaqueous parts was deposited either in the open sea itself, or in the tidal inlets which became filled up completely and did no longer interrupt the continuity of the shoreline (van Straaten, 1963, p. 167).

Lithology

In this paper the barriers will be referred to according to their position (text-fig. 1). The innermost barrier will be indicated as first barrier. At the sea-side of this barrier lie two smaller ridges, the first and second secondary barrier respectively. At the sea-side of these barriers lies the second barrier.

Form and internal structure of the second secondary barrier have been studied in the Duivenvoorde district (see text-fig. 2). At the sea-side the barrier is sloping one to seven degrees. At the land-side the slopes are steeper, to about ten degrees. Therefore, and because the part of the beach plain at the sea-side lies lower, the slope at the sea-side is longer. The slope is also more regular, which is caused by wave action that passed from the sea-side over the barrier, which was lying partly above mean sea level, depositing its sediments on the land-side of the barrier. The same outline can be observed in the other barriers. The top of the barriers is always affected by wind action. The internal structures were hardly visible because of the good sorting of the sands and because of the short time of exposure of each section. Thinly laminated sets with a dip of 4 - 15 degrees in landward direction are the most usual structures.

The most remarkable feature in the coastal barriers is the coarsening upwards of the sediments. This was described by van Straaten (1965) and is confirmed in the present study. In the upper two or three metres of the barriers usually a sequence as in section d4 (see below) was measured. Sometimes the lower layers were more clayey. At the sea-side of the second secondary barrier a local shell bed completes the coarsening upwards sequence (text-fig. 2 and 3 and section d5). This bed consists of coarse sand and rounded fragments of shells, mainly *Macoma balthica*, also some well-preserved shells were found. The bed has a thickness of ten cm, an extension of three metres and could be demonstrated for some tens of metres along the sea-side of the barrier. The coarsening upwards of the sediment is caused by the sorting effect of the sea on the low angle slope at the sea-side of the barrier. The coarsest sediments accumulate at the land-side and by the effect of the prograding coast they cover the finer sediments.

The colour of shells and sediments was changed by iron-combinations under oxidizing or reducing conditions. The dark brown sands are coloured by humus. The variety of colours is caused by differences in permeability of the sediments. The coarser sands are well aerated and saturated, iron hydroxides formed coatings around the grains resulting in a yellowish brown colour of the sediment. The finer grained and more clayey sands are much less aerated and saturated, which caused stagnation of the water. This results in reducing conditions causing bluish-grey coloured iron sulfides. Van Straaten (1965, pp. 57 - 63) studied these processes in detail. In the clay the situation is different. Sometimes the shells have the same colour as the sediment but frequently the shells only lost their original colour and remain white. Therefore shells from the clay can be separated easily from specimens deposited in sand.

The influence of eolian action on the barriers was overestimated by Jelgersma et al. (1970, fig. 3). who regard the upper five m of the first barrier as eolian deposits. In exposure h (text-fig. 1) the sediments from 1.50 m – N.A.P. and deeper are obviously deposited in marine environments. The fine-grained sand is somewhat clayey and contains large shells, up to four cm in diameter.

Text-fig. 1. Geological map of Leidschendam. ⟶

From south-east to north-west: the first barrier, the two secondary barriers and the second barrier. Geology after Jelgersma et al. (1970), Tesch (1925) and the present study.

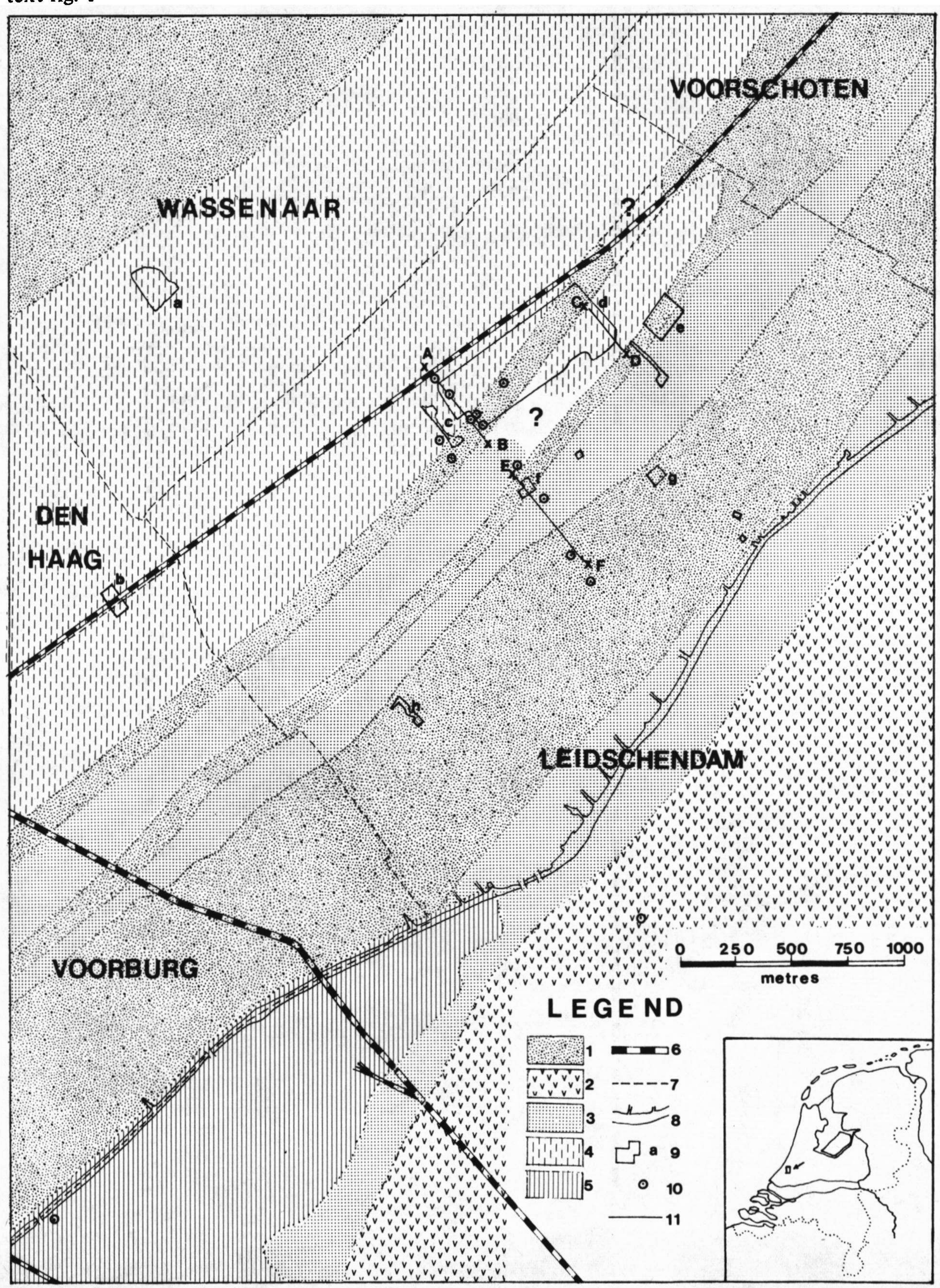
1. coastal barrier sand; 2. Holland Peat on clayey Calais Deposits; 3. Holland Peat on coastal barrier sand; 4. Holland Peat on clay on coastal barrier sand; 5. Dunkirk I Deposits; 6. railways; 7. municipal boundaries; 8. Rijn-Schie-Canal or Vliet; 9. temporary exposures (1963 - 1978): a. pond at Persijnlaan. Wassenaar (1966); b. construction-pit near railway-station Mariahoeve, Den Haag and Voorburg (1972, 1977); c. pond near Duivenvoorde, Leidschendam (1972); d. excavations at Duivenvoorde-district, Leidschendam (1977 - 1978); e. socker-field near Schakenbosch, Leidschendam (1977); f. Vlaardingen Culture-excavation at Prinsenhof, Leidschendam (1963); g. construction-pit at the Veurse Achterweg, Leidschendam (1978); h. pond near the P.T.T.-laboratory, Leidschendam (1978); 10. edelman-borings (1976 - 1977); 11. section (text-fig. 2).

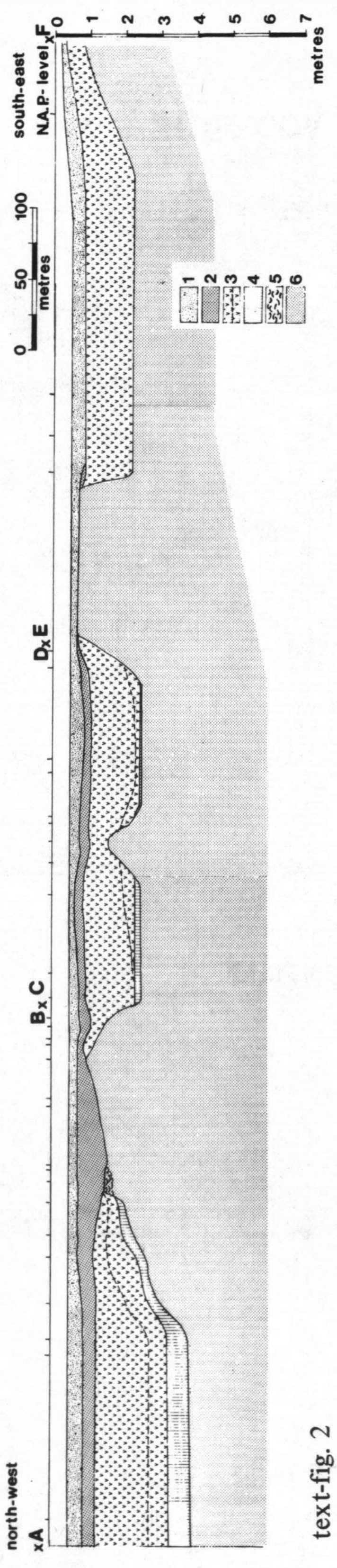
Tekstfig. 1. Geologische kaart van Leidschendam.

Van zuidoost naar noordwest: de eerste strandwal, de twee secundaire strandwallen en de tweede strandwal. Geologie naar Jelgersma et al. (1970), Tesch (1925) en de huidige studie.

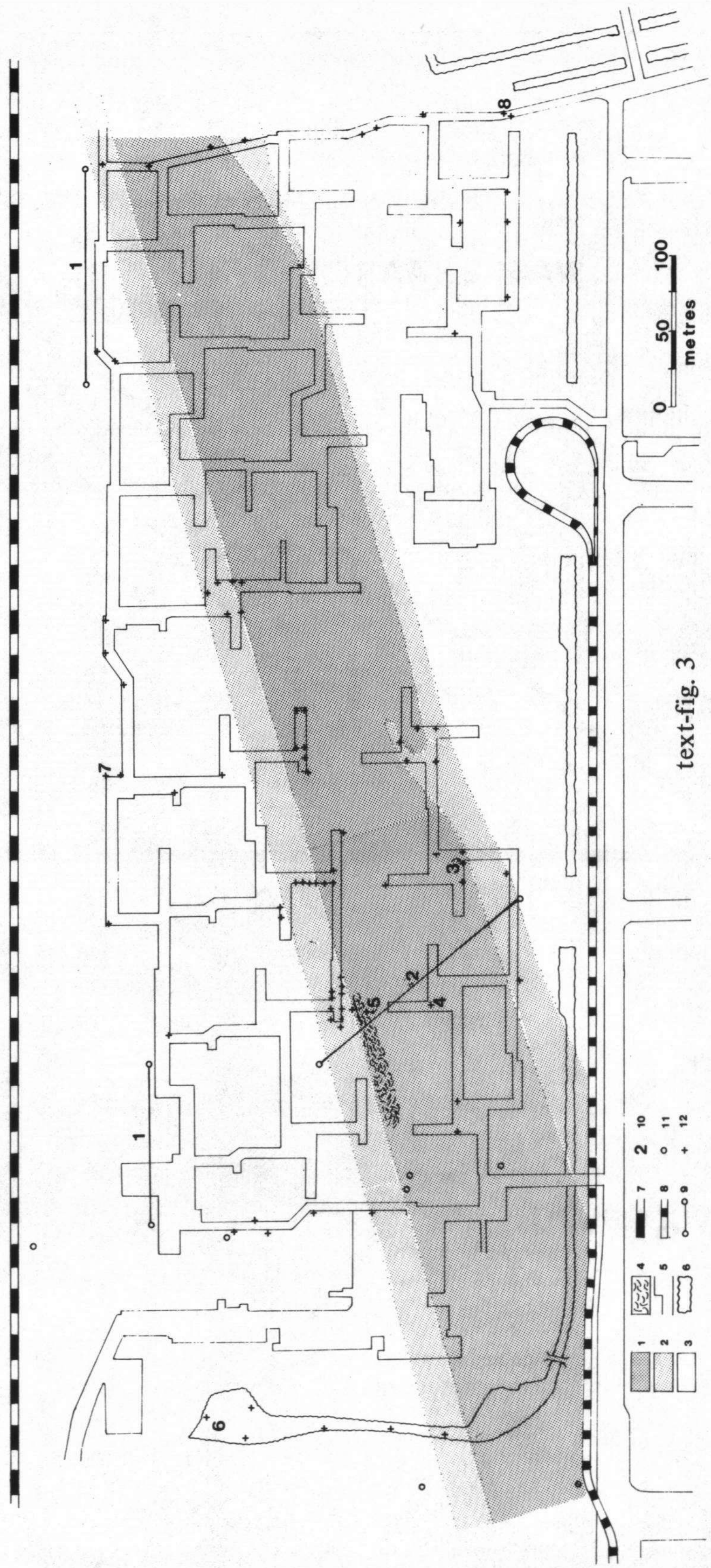
1. strandwal-zanden; 2. Hollandveen op kleiige Afzettingen van Calais; 3. Hollandveen op strandwal-zanden; 4. Hollandveen op klei op strandwal-zanden; 5. Afzettingen van Duinkerke I; 6. spoorwegen; 7. gemeentegrenzen; 8. Rijn-Schiekanaal of Vliet; 9. tijdelijke ontsluitingen (1963 - 1978): a. vijver aan de Persijnlaan, Wassenaar (1966); b. bouwput nabij station Mariahoeve, Den Haag en Voorburg (1972, 1977); c. vijver bij Duivenvoorde, Leidschendam (1972); d. ontsluitingen in de wijk Duivenvoorde, Leidschendam (1977 - 1978); e. voetbalveld bij Schakenbosch, Leidschendam (1977); f. Vlaardingen Cultuur opgraving in Prinsenhof, Leidschendam (1963); g. bouwput aan de Veurse Achterweg, Leidschendam (1978); h. vijver bij het P.T.T.-laboratorium, Leidschendam (1978); 10. edelman-boringen (1976 - 1977); 11. profiel (tekstfig. 2).

text-fig. 1


VOORSCHOTEN
WASSENAAR
DEN
HAAG
LEIDSCHENDAM
VOORBURG
0 250 500 750 1000
metres
LEGEND
1
2
3
4
5
6
7
8
9
10
11



text-fig. 2



text-fig. 3

Some sections in the second secondary barrier:

- On the sea-side of the barrier (text-fig. 3, d5).

0.00 - ± 0.25 m	- dark brown, humose sand.
± 0.25 - 0.65 m	- yellowish-brown, medium-grained sand with roots.
0.65 - 0.87 m	- greyish-green, medium-grained sand with roots.
0.87 - 1.01 m	- dark brown, coarse sand with humose streaks and a clay pebble.
1.01 - 1.05 m	- light grey, medium-grained sand.
1.05 - 1.28 m	- shell bed with coarse, light grey sand. The shells are broken and rounded, mainly *Macoma balthica*.
1.28 - (1.85) m	- light grey, medium-grained sand with some thin shell lenses and low angle crossbedding.

- At the middle of the barrier (text-fig. 3, d4).

0.00 - 0.23 m	- brown, very humose sand with roots of trees and shrubs.
0.23 - 0.38 m	- dark brown humus.
0.38 - 0.80 m	- yellowish-brown, medium-grained sand with roots and with crossbedding (angles of 3 - 15° in several directions).
0.80 - 1.54 m	- light grey, medium-grained sand with roots, finely laminated, landward dip of 4 - 5°.
1.54 - 1.75 m	- dark grey or bluish-grey, fine-grained sand.
1.75 - 1.95 m	- dark grey or bluish-grey, fine-grained sand with thin lenses of plant remains or shell-grit, ostracods, foraminifera and some larger shells (*Cerastoderma glaucum, Spisula subtruncata, Scrobicularia plana*).
1.95 - (2.00) m	- dark grey or bluish-grey, fine-grained sand.

- On the land-side of the barrier (text-fig. 3, the cross below point d4).

0.00 - ± 0.45 m	- brownish-grey, humose sand.
± 0.45 - 0.67 m	- yellowish-brown, medium-grained sand.
0.67 - 0.93 m	- black forest peat.
0.93 - 1.14 m	- dark grey humose sand with rounded pieces of peat and with roots in life position.
1.14 - 1.41 m	- yellowish-grey sand.
1.41 - 1.98 m	- light grey sand with some shells (*Macoma balthica, Cerastoderma glaucum*).
1.98 - (2.11) m	- bluish-grey sand.

Text-fig. 2. Composite section through the coastal barriers near Duivenvoorde (position see text-fig. 1).
1. humose sand, disturbed; 2. eolian sand; 3. Holland Peat, lower part reed peat, upper part forest peat; 4. clay; 5. shell bed; 6. coastal barrier sand.

Tekstfig. 2. Samengesteld profiel door de strandwallen bij Duivenvoorde (ligging zie tekstfig. 1).
1. humeus zand, gestoord; 2. eolisch zand; 3. Hollandveen, onder rietveen, boven bosveen; 4. klei; 5. schelpenbank; 6. strandwalzand.

Text-fig. 3. The Duivenvoorde-district (position see text-fig. 1, d).
1. highest part of the coastal barrier; 2. slope of the barrier, covered with clay and peat; 3. peat; 4. shell bed; 5. roads including footpaths; 6. ponds and channels; 7. railway; 8. tramway; 9. series of wash-borings; 10. fossil-samples; 11. edelman-boring; 12; measured section.

Tekstfig. 3. De wijk Duivenvoorde (ligging zie tekstfig. 1 bij d).
1. hoogste deel van de strandwal; 2. helling van de strandwal, bedekt met klei en veen; 3. veen; 4. schelpenbank; 5. wegen inclusief voetpaden; 6. vijvers en sloten; 7. spoorweg; 8. trambaan; 9. series spoelboringen; 10. fossielmonsters; 11. edelman-boring; 12. gemeten secties.

Fauna

Only the upper parts of the barrier deposits could be studied and sampled in exposures. Wash-borings supplied material from greater depths below surface. In total several hundred kg of sediment were sieved. The fossil content of the deposits is low and therefore large samples had to be studied to obtain a reliable survey of the fauna. There are only slight differences in composition of the fauna from each sample (see table 1 and the chapter Survey of the collected samples).

It is quite difficult to interprete a fossil fauna but I tried to classify the fossils in several groups. 'Autochthonous' and allochthonous faunas are distinguished although in fact all specimens were transported. As 'autochthonous' is regarded the fauna that lived 'close to' the sampled area and which was transported to the studied shore over a short distance only.

Van Voorthuysen (1960) described a recent tidal flat and estuarium environment. He found that a large part of the fauna consists of allochthonous species. In a littoral-lagoonal environment the microfauna may easily be reworked from other ecological zones or from older deposits while the macrofauna usually will be found in situ. As is observed in the present study reworking of nearby deposits may result in deposition of many allochthonous macrofossils. In open sea small molluscs with thin shells are transported easier than larger molluscs with thicker shells (Eisma, 1968). Juvenile shells and larvae may be transported over long distances as is also the case in foraminifera, ostracods and other micro-organisms. The sea-urchin *Echinocardium cordatum* is very fragile and entire specimens will be found only within two km from the population. Spines of this species, however, may be transported very far, and sometimes they accumulate 50 km from a population (Schäfer, 1962, pp. 544 - 545). The bivalve *Chamelea gallina striatula* (Da Costa, 1778) has a thick shell and therefore it is only transported over short distances (Schäfer, 1962; Raven, 1978). Schäfer describes a beach three km from a population where the shells are found only very occasionally. On a beach eight km from this population the species is almost absent. During transport the shells of bivalves may be subjected to sorting effects by which a majority of left or right valves reach a certain location (Lever et al., 1964). Such a sorting can be used to distinguish autochthonous and allochthonous species but large quantities of specimens of transported shells are required.

1. The 'autochthonous' fauna. The species usually occur in large numbers of individuals with a high percentage of juvenile specimens. Such a domination of juvenile shells alone can not be used as a prove for an autochthonous assemblage (Lever, 1977). The bivalves often occur as double-valved specimens, especially in the finest fractions. The preservation is good because the specimens were transported over a very short distance. The fauna is poor in species (see table 2).

Table 2. The 'autochthonous fauna of the coastal barriers.
Tabel 2. De 'autochthone' fauna van de strandwallen.

Foraminiferida	Mollusca	*Littorina littorea*
Cibicides lobatulus	*Mytilus edulis*	*Peringia ulvae*
Elphidium crispum (?)	*Mysella bidentata*	*Rissoa inconspicua*
Elphidium excavatum	* *Tellimya ferruginosa*	* *Chrysallida decussata*
Elphidium waddense	*Cerastoderma edule* type 2	
Elphidium williamsoni	* *Spisula subtruncata*	Ostracoda
Globulina gibba (?)	* *Angulus fabulus*	*Cyprideis torosa*
Guttulina lactea	* *Angulus tenuis*	*Pontocythere elongata*
Nonion depressulum	*Macoma balthica*	*Urocythereis distinguenda*
Protelphidium anglicum	*Abra alba*	
Streblus batavus	*Barnea candida*	
Streblus catesbyanus	*Zirfaea crispata*	

Table 1. The fauna from the coastal barriers (sample a, d1, d2, d3, d4, d5, e, g and h), the section at Mariahoeve (sample b) and the clayey deposits on the beach plains (sample d6, d7 and d8) (see text-fig. 1 and 3 for sample localities). To the right the samples from the younger sediments.
The material was counted as follows: < one specimen = 1; > one to three specimens = 2; > three to ten specimens = 3; > 10 to 40 specimens = 4; > 40 to 100 specimens = 5; > 100 to 350 specimens = 6; > 350 specimens = 7.
Two valves of bivalve molluscs were counted as one specimen. The following abbreviations were used: a = mainly adult specimens; j = mainly juvenile specimens; ja = more juvenile than adult specimens; d = double valved specimens; f = only fragments; o = operculum; x = present but not counted, an indication is placed between brackets when it applies to a part of the material.

Tabel 1. De fauna van de strandwallen (monster a, d1, d2, d3, d4, d5, e, g en h), de sectie in Mariahoeve (monster b) en de kleiige afzettingen in de strandvlakten (monster d6, d7 en d8) (zie tekstfig. 1 en 3 voor de ligging van de monsterplaatsen). Naar rechts de monsters uit de jongere sedimenten.
Het materiaal werd als volgt geteld: < één exemplaar = 1; > één tot drie exemplaren = 2; > drie tot tien exemplaren = 3; > 10 tot 40 exemplaren = 4; > 40 tot 100 exemplaren = 5; > 100 tot 350 exemplaren = 6; > 350 exemplaren = 7.
Twee kleppen van tweekleppige mollusken zijn geteld als één exemplaar. De volgende afkortingen zijn gebruikt: a = vooral volwassen exemplaren; j = vooral juveniele exemplaren; ja = meer juveniele dan volwassen exemplaren; d = doubletten; f = slechts fragmenten; o = operculum; x = aanwezig maar niet geteld, wanneer een letter tussen haakjes is geplaatst geldt het gegeven slechts voor een gedeelte van het materiaal.

	a	h	g	d1	d2	e	d5	d4	d3	b	d8	d7	d6	
PLANTS														
diatoms										x				
seeds of higher plants	x				x	x		x	x	x				
ANIMALS														
Phylum Protozoa														
Classis Sarcodina														
Cibicides lobatulus (Walker & Jacob, 1798)								3						
Elphidiella arctica (Parker & Jones, 1864)								7						
Elphidiononion incertum (Cushman, 1948)								8						
Elphidium crispum (Linné, 1767)								4						
Elphidium excavatum (Terquem, 1875)								3						
Elphidium waddense van Voorthuysen, 1951								4						
Elphidium williamsoni Haynes, 1973								4						%
Globulina gibba d'Orbigny, 1826								2						
Guttulina lactea (Walker & Jacob, 1798)								1						
Nonion depressulum (Walker & Jacob, 1798)								4						
Nonionella sp.								1						
Protelphidium anglicum Murray, 1965								0,1						
Streblus batavus Hofker, 1951								46	99,6					
Streblus catesbyanus (d'Orbigny, 1839)								3	0,4					
Streblus viennensis (d'Orbigny)								12						

	a	h	g	d1	d2	e	d5	d4	d3	b	d8	d7	d6
Phylum Parazoa = Porifera = Spongiida													
sponge needles										x			
Cliona celata Grant, 1826 (bore-holes)		x	x				x						
Phylum Cnidaria													
Classis Hydrozoa													
Hydractinia echinata (Fleming, 1828) (colonies)									1			1	
Phylum Polyzoa = Bryozoa = Ectoprocta (colonies)	x								x	x			
Phylum Mollusca													
Classis Bivalvia													
Nucula sp.								1jd					
Nuculacea gen. and sp. indet								1jd					
Mytilus edulis Linné, 1758	4aj(f)	2af	2af	5aj(f)	4ja(f)	3j	4af	4ajf	4af	4ja(d)		3j	
Aequipecten opercularis (Linné, 1758)				1j	3j				1jf	1j			
Pododesmus (Heteranomia) squamula (Linné, 1758)					2j								
Ostrea edulis Linné, 1758	2aj				3j,1af	1j							
Semierycina (Semierycina) nitida (Turton, 1822)					1a								
Mysella (Mysella) bidentata (Montagu, 1803)	4aj(d)		3j(d)	4aj(d)	5aj(d)		1a	4ja(d)	4aj(d)	4aj(d)		3ja	
Tellimya ferruginosa (Montagu, 1808)	1j			3aj	4j	1j			1a	1j		1f	
Altenaeum nortoni Spaink, 1972								1a					
Cerastoderma edule (Linné, 1758)	6aj	4a	4a	5ja	5ja	3j	4ja	1a	5aj	5aj(d)		2a	2a
Cerastoderma glaucum (Poiret, 1789)	5aj	3a		4aj	4aj	1j		4ja(f)	4a	4aj	1j	3ja	4ajd
Laevicardium (Laevicardium) crassum (Gmelin, 1791)				1j									
Mactra (Mactra) corallina cinerea Montagu, 1803	3a(f)			2a	2af		1af		2af	3a(f)			
Spisula (Spisula) elliptica (Brown, 1827)	2aj				3ja								
Spisula (Spisula) solida (Linné, 1758)		1a	1a		1a								
Spisula (Spisula) subtruncata (Da Costa, 1778)	7a	3ja(f)	2a	6ja	7ja	6ja	4ja	7j(d)	7ja	6ja(d)	3a(d)	5ja(d)	3a(d)
Solen marginatus Pulteney, 1799				1j	3j								
Phaxas (Phaxas) pellucidus (Pennant, 1777)					1j					1j			
Angulus (Fabulina) fabulus (Gmelin, 1791)	2ja			2j	3j			4j	2j	3j		2j	
Angulus (Macomangulus) tenuis (Da Costa, 1778)	4aj	2j		4ja	4ja	3ja		6j(d)	4ja	4ja		1j	
Macoma (Macoma) balthica (Linné, 1758)	6a	4a(d)	4a	5a(d)	5aj	4aj	5a	3aj	5a(d)	6aj(d)	4a(d)	4aj(d)	3a(d)
Donax (Cuneus) vittatus (Da Costa, 1778)	2a(f)							1j					
Scrobicularia plana (Da Costa, 1778)	4af	1af	1af	3a(f)	4ja	2a(f)	5af	2af	3a(f)	6aj(d)	4ad	6ajd	6ad
Abra (Abra) alba (Wood, 1802)	3aj			2a(f)	5ja	3aj			2a(f)	3aj		1j	
Pisidium (Neopisidium) moitessierianum Paladilhe, 1866	1a				2aj			3j	3a	3a			
Pisidium (Rivulina) henslowanum (Sheppard, 1823)					3a								
Pisidium (Rivulina) nitidum Jenyns, 1832					1a				1a	1(?)			

	a	h	g	d1	d2	e	d5	d4	d3	b	d8	d7	d6
Pisidium (Rivulina) supinum Schmidt, 1850	1a				2aj			3j	2j	1a			
Sphaerium (Cyrenastrum) solidum Normand, 1844	1j				1j					1a			
Venerupis senegalensis (Gmelin,1791)	1af												
Mya (Mya) truncata Linné, 1758		1j		1j	3j			3j	2j	2j		1j	
Barnea (Barnea) candida (Linné, 1758)	4af	3a(f)	3af	4aj(f)	4aj(f)	3ja	4af	3aj(f)	4af	4ja(f)		2jf	
Zirfaea crispata (Linné, 1758)	3ajf	3af	3af		3j		2af			3a			
Bivalvia gen. et sp. indet.													
Classis Gastropoda													
Theodoxus (Theodoxus) fluviatilis (Linné, 1758)	3aj(f)	1a		3a(f)	3a(f)			3j(f)	2jf	1a		1j	
Valvata (Cincinna) piscinalis piscinalis (Müller, 1774)	3a				3j	3j	1af	4j	3j	3ja(f)		1j	
Valvata (Valvata) cristata Müller, 1774								3j		1j		1j	
Littorina (Algaroda) littorea (Linné, 1758)	4a(f)				1j		1af	1j	3aj(f)				1a
Littorina (Littorinivaga) rudis (Maton, 1797) f. *tenebrosa* Montagu	4aj(f)			2a(f)	3j(f)		1j	4ja(f)	3j(f)	3j(f)			
Hydrobia (Hydrobia) ventrosa (Montagu, 1803)	3aj			3ja	4ja	2j		5ja	4ja	3ja	3a	2a	5a
Peringia ulvae (Pennant, 1777)	6aj			5aj	6aj	4ja	5a	7ja	6aj	7aj	6aj	6a	
Bithynia (Bithynia) leachi (Sheppard, 1832)	1o	2o					1o	3o	2o	3o			
Bithynia (Bithynia) tentaculata (Linné, 1758)	4o	3o		2o	4o		3o	5o,3j	3o	2o			1a
Turboella (Turboella) inconspicua (Alder, 1844)										2a			
Epitonium (Clathrus) clathrus (Linné, 1758)					1jf				1j	1j			
Euspira catena (Da Costa, 1778)	3a(f)	1af	2af				1af	1j	1a	1af		1a	
Euspira poliana (Della Chiaje, 1830)	3ja(f)				2ja			1j	1j	1j			
Buccinum undatum Linné, 1758	1af						1a	1jf				1a	
Hinia (Hinia) reticulata (Linné, 1758)	2af							1jf	2ajf				
Chrysallida (Pyrgulina) decussata (Montagu, 1803)	3a				4a	1a		5ja	4a	3a			
Retusa (Retusa) obtusa (Montagu, 1803)	1a				2af			2af	2a	1a			
Acroloxus lacustris (Linné, 1758)						1a							
Galba (Galba) truncatula (Müller, 1774)					2j(f)				1j			2j	
Lymnaea stagnalis (Linné, 1758)												1a	
Stagnicola (Stagnicola) palustris (Müller, 1774)					1j								
Ancylus (Ancylus) fluviatilis (Müller, 1774)	1a				3j	1j		2j					
Ferrissia wautieri (Mirolli, 1960)					2j								
Anisus sp.	3j												
Armiger crista (Linné, 1758)								4aj					
Hippeutis complanatus (Linné, 1758)								1j					
Planorbarius corneus (Linné, 1758)												1j	
Segmentina nitida (Müller, 1774)							1a	1j					
Physa (Physa) fontinalis (Linné, 1758)										1f			
Succinaeidae gen. et sp. indet.	2jf				2j(f)				1j	2j(f)		2j	

	a	h	g	d1	d2	e	d5	d4	d3	b	d8	d7	d6	
Milacidae/Limacidae gen. et sp. indet. (shell)								1						
Trichia (Trichia) hispida (Linné, 1758)												1j		
Cepaea (Cepaea) nemoralis (Linné, 1758)					1af					1a				
Phylum Annelida														
Classis Polychaeta														
Nereis sp. 1 (large jaws)							1		1					
Nereis sp. 2 (small jaw)									1					
Pectinaria koreni (Malmgren, 1865) (arenaceous tubes)				3	4							1f		
Phylum Arthropoda														
Subphylum Crustacea														
Classis Ostracoda														
Candona neglecta Sars, 1887					49									
Cyprideis torosa (Jones, 1850)					50	95		86	86					
Erpetocypris reptans (Baird, 1835)					1									
Ilyocypris gibba (Ramdohr, 1808)								1						%
Pontocythere elongata (Brady, 1868)						5		12	13					
Pterygocythereis sp.									0,5					
Urocythereis distinguenda (Neviani, 1928)								1	0,5					
Classis Cirripedia														
Balanus balanoides (Linné) (skeleton fragments)	4			4	4				2	3				
Classis Decapoda														
Pagurus bernhardus (Linné, 1758) (inhabited shells)									1			1		
Carcinus maenas (Linné, 1758) (pincer)	1													
Cancer pagurus Linné, 1758 (pincer)	1													
Subphylum Uniramia														
Coleoptera gen. et sp. indet. (thorax)								1f		1		1f		
Phylum Echinodermata														
Classis Echinoidea														
Psammechinus miliaris (Gmelin, 1791) (skeleton)										1af				
Echinocyamus pusillus (Müller, 1774) (skeleton)	4a			2ja	4ja	3j				3aj				
Echinocardium cordatum (Pennant, 1777) (skeleton & spines)				4f	5f	3f	3f		5f	4f		3f		
Phylum Chordata														
Classis Pisces														
bony fish scales and skeleton fragments					3				2	3		1f		
Merlangius merlangus (Linné, 1758) (otolith)							1							

Most of the foraminifera species actually live in brackish environments and tolerate salinities of 1 - 32 °/oo. Many of the species are common on the beach near Kijkduin where they live near-shore (Hofker, 1977). The ostracods are also euryhaline species typical for a lagoonal environment with freshwater influx. Some specimens of *Cyprideis torosa* (in sample d1, d2 and d4) show knobs on both valves, caused by a decrease in salinity (Mr J. J. Lobenstein, pers. comm.).

The mollusc fauna is characterized by a large number of tidal flat species. Therefore a comparison with the fauna of such an environment was made. Van Straaten (1956) and van der Heide (1960) listed typical tidal flat species. Not all species mentioned by them were found in the fossil fauna at Leidschendam. Some species were introduced only in recent time in our country. Other species do not occur because the necessary substratum was not available.

In the fauna some mollusc species occur which are not known as tidal flat species. These species, marked with * in table 2, live in open marine environments: *Spisula subtruncata*, the most common species of the fauna, *Angulus fabulus, Angulus tenuis* and *Tellimya ferruginosa* live near-shore, preferring fine sand (Tebble, 1966), while *Chrysallida decussata* lives below low water-level on a sandy bottom, with or without a thin cover of silt (Sliggers, 1969). But most of the open marine species common on the North Sea beaches do not occur in the fauna or are much rarer. *Euspira poliana, Laevicardium crassum, Mactra corallina cinerea, Ensis*-species, *Donax vittatus* and *Mya truncata* live further from the coast (Eisma, 1966) but even *Chamelea gallina striatula* living also in the breaker-zone was not found.

A few species from the fossil fauna are much less common in the recent faunas. *Macoma balthica* and *Angulus tenuis* live in muddy sediments which nowadays cover smaller areas in the Netherlands than during the Subboreal (van Straaten, 1965 and own observations). *Barnea candida* and *Zirfaea crispata* have lost the competitive struggle with *Petricola (Petricolaria) pholadiformis* Lamarck, 1818 which was introduced this century from the eastern coast of North America.

2) The allochthonous fauna can be divided into three groups:

– Species washed in from fresh water or terrestrial environments (see table 3).

Mollusca

Pisidium moitessierianum
Pisidium henslowanum
Pisidum nitidum
Pisidum supinum
Sphaerium solidum
Theodoxus fluviatilis
Valvata piscinalis
Valvata cristata
Bithynia leachi
Bithynia tentaculata
Acroloxus lacustris
Galba truncatula
Stagnicola palustris
Ancylus fluviatilis
Ferrissia wautieri
Anisus sp.
Armiger crista
Hippeutis complanatus
Segmentina nitida
Succineidae gen. et sp. indet.
Milacidae/Limacidae gen. et sp. indet.
Cepaea nemoralis

Ostracoda

Candona neglecta
Erpetocypris reptans
Iliocypris gibba

Table 3. Species originating from fresh water or terrestrial environments.
Tabel 3. Soorten afkomstig uit terrestrische en zoetwatermilieu's.

Most of the mollusc species actually live in stagnant water with a rich vegetation, some of the species tolerate slightly brackish water. The species of Pisidiidae prefer current water and often occur in brooks or rivers, they do not tolerate brackish water (Kuiper, in Janssen & de Vogel, 1965; van Benthem Jutting, 1933, 1943). Usually the specimens are small and/or juvenile which makes it very probable that they were transported over long distances. As the studied area is situated north of the mouth of the river Meuse it is probable that the shells were brought in by longshore current from that river. Furthermore it is possible that a part of the material was reworked from older fresh-water deposits.

– Species reworked from older deposits (see table 4).

Foraminiferida

Elphidiella arctica
Nonionella sp.

Mollusca

Semierycina nitida
Altenaeum nortoni
Cerastoderma edule type 1
Cerastoderma glaucum
Scrobicularia plana
Littorina rudis forma *tenebrosa*
Hydrobia ventrosa
Retusa obtusa

Ostracoda

Pterygocytereis sp.

Table 4. Species reworked from older deposits.
Tabel 4. Soorten geremanieerd uit oudere afzettingen.

The fossils show obvious traces of transport, often they are broken, bivalves occur as single valves only and relatively very few juvenile specimens are found. For the greater part the molluscs originate from sediments deposited in a brackish water environment. The bivalve *Semierycina nitida* is known to occur in Eemian-deposits. The foraminifer *Elphidiella arctica* is a typical cold water species known from Early Quaternary marine sediments (Icenian/Amstelian) and does not occur in the recent fauna (van Voorthuysen, 1960a, p. 243).

– Species washed in from open sea (see table 5).

Mollusca

Nucula sp. (juv. specimen only)
Nuculacea gen. et sp. indet. (juv. specimen)
Aequipecten opercularis (juv. specimens)
Pododesmus squamula (juv. specimens)
Ostrea edulis (mainly juv. specimens)
Laevicardium crassum (juv. specimen)
Mactra corallina cinerea (adult)
Spisula elliptica (adult)
Spisula solida (adult)
Solen marginatus (juv. specimens)
Phaxas pellucidus (juv. specimens)
Donax vittatus
Venerupis senegalensis (adult)
Mya truncata (juv. specimens)
Epitonium clathrus (juv. specimens)
Euspira catena
Euspira poliana
Hinia reticulata (adult)
and most other invertebrates listed in table 1 (not in table 2 - 4).

Table 5. Species washed in from open sea.
Tabel 5. Soorten ingespoeld uit open zee.

The species only occur in small numbers, sometimes not more than one specimen was found. The (very) juvenile specimens washed in as larvae which died soon afterward, the adult specimens or fragments washed in as empty shells.

In his reports on the macrofossils from the borings of van Straaten (1965) Spaink (1963) mentioned some species which were not found during the present study. His results on the Echinodermata are of interest here because some of the species were disregarded by me. Spaink identified skeleton parts of Ophiuroidea and Asteroidea, of which *Ophiura texturata* Lamarck and *Asterias rubens* Linné are rather common, whereas only very few parts of *Ophiotrix fragilis* (Åbildgaard) and *Astropecten irregularis* (Pennant) were found.

Conclusions

The lithology and the fauna indicate the environment of a wide, slightly sloping, sandy beach plain. This plain is lying below mean high tide level and partly above mean low tide level, because the surface shows some low ridges and swales, some of which contained water even at low tide. A submarine ridge protected the area from high waves so that only fine sand and few animals from open marine environments washed in. The barrier migrated landwards and ultimately reached the shore. During a short time the area was fully exposed to waves and currents depositing coarser sand and worn shell fragments. Soon a new barrier originated, sheltering the area once again. The sediment was supplied by the river Meuse and by reworking from Holocene and Pleistocene deposits. Bioturbation was slight because the environment was unfavourable for most burrowing animals (e.g. *Arenicola marina* Linné, preferably living in more silty sediments). The water had a salinity slightly lower than near the present North Sea coast, as can be concluded from the composition of the fauna and the number of ribs in *Cerastoderma edule* (see the chapter on the chlorinity of the depositional environment).

A comparable environment existed at the sea-side of the second barrier at the time that the first phase of barrier formation had ended and before the second phase began (Jelgersma et al., 1970, p. 197).

THE SECTION AT MARIAHOEVE, DEN HAAG

South of the watershed at Mariahoeve (text-fig. 1, b) the following section was measured:

surface level 0.90 m - N.A.P.

0.90 - 2.38 m	- dark brown forest peat with trunks of alder and other trees.
2.38 - 2.46 m	- light brown reed peat, at the base a thin dark streak of gyttja.
2.46 - 2.72 m	- spotty clay, with some very thin (less than two mm) lenses of sand at the base.
2.72 - 2.88 m	- fine-grained sand, alternating with clay. Upwards more and thicker clay layers (sand layers 4 - 24 mm, clay layers 1 - 8 mm). Few fossils.
2.88 - 3.12 m	- fine-grained sand with few very thin clay layers. Some burrows. Few fossils.
3.12 - 3.50 m	- clay with some thin sand lenses and streaks of plant remains or shell-grit (thickness 1 - 3 mm). Some pieces of wood, a shell of the terrestrial snail *Cepaea nemoralis* and some sandy burrows. In the clay shells of *Scrobicularia plana* and juvenile specimens of *Macoma balthica* may be found in life position.
3.50 - 5.50 m	- fine sand with clay pebbles and some clayey burrows. Shells mainly concentrated in lenses.
5.50 - 6.50 m	- sandy clay.
6.50 - (6.70) m	- very fine-grained sand.

The colours of the sand and clay are bluish-grey or grey. Roots originating from the peat penetrate the sediment. In the upper 0.70 m (2.46 - ± 3.12 m) many roots of reed, trees and shrubs are present, deeper (± 3.12 - ± 4.00 m) dispersed roots are found. The clay layer of 3.12 - 3.50 m could be traced laterally for some metres until it was cut-off by erosion.

This section may be compared with boring VI of van Straaten (1965). In that paper the basal clay deposit was interpreted as a tidel channel on which tidal flat deposits were formed. According to van Straaten (1965, p. 70, 73) these deposits were formed about three centuries after the second ridge had developed and immediately before the area became overgrown by peat.

The fauna of the sandy deposits of 3.50 - 5.50 m may be compared with the fauna of the barriers and beach plains (table 1). It is clear that these deposits were formed in an environment slightly sheltered from open sea, with about normal salinity and with rapid sedimentation (few burrows). Because the fauna is equivalent to that of the coastal barriers these deposits are no real tidal flat deposits. Some specimens of *Peringia ulvae* show a monstruosity caused by a change in the salinity, probably the fresh water influence increased slightly (see the chapter Remarks on some mollusc species).

Upwards in the sequence the influence of the sea diminishes. The alternating sand and clay layers at 2.72 - 2.88 m probably are marsh deposits. The upper clay layer (2.46 - 2.72 m) is comparable to the uppermost clay layer on the beach plain (see profile in the next chapter); it was most probably deposited at the same time.

THE CLAYEY DEPOSITS ON THE BEACH PLAINS

Lithology

Immediately after the formation of the second barrier the low beach plain area on its land-side became covered with sandy clay or clay. The material was supplied via the river mouths (Edelman, 1974, p. 24). These deposits were formed between the second secondary barrier and the second barrier and also, in a small area near Duivenvoorde, between the secondary barriers (text-fig. 1 and 2). The deposits wedge out against the barriers and towards the watershed which was situated at the place where the boundary between the municipalities of Leidschendam and Voorburg is situated now. The coastal barriers were mapped by Zagwijn (1965) and Jelgersma et al. (1970, pl. 1). The secondary barriers meet north of Duivenvoorde. Both papers suppose an opening of about 400 m in the Duivenvoorde district. From the present study it is clear that such an opening did not exist at Duivenvoorde. On 17th century maps a continuous barrier with low dunes on top of it is indicated. The presence of a road, crossing a swamp, constructed on the sand ridge shortly before that time also contradicts an opening. But the clays on both sides of the ridge are similar and in both cases the fauna suggests a northern origin. Therefore it seems probable that an opening did exist, but was situated north of the Duivenvoorde district and which was filled subsequently with eolian sediments (text-fig. 1).

A representative section was measured at location d7 (text-fig. 3):

surface level 0.50 m - N.A.P.
0.00 - 0.50 m - brown humose sand.
0.50 - 0.80 m - yellowish-brown, medium-grained sand.
0.80 - 2.30 m - dark brown forest peat with trunks.
2.30 - 2.80 m - light brown *Phragmites*-peat.
2.80 - 3.00 m - bluish-grey, heavy clay with roots of reed.
3.00 - 3.40 m - bluish-grey, sandy clay with *Scrobicularia plana* in life position, few roots of reed.
3.40 - (3.60) m - bluish-grey, fine-grained sand with some shells, few roots of reed.
The clayey sediments at 2.80 - 3.40 m are the deposits dealt with in this chapter.

The texture of the sediments is very monotonous. This can be explained by the fact that the area was situated near the watershed, reached only by the finest sediments. In the section the diminishing influence of the sea, caused by the completion of the second barrier, is very well visible. The only marine influence during the deposition of the clay came through the mouth of the river Rhine in the north.

Fauna

In the clay a fauna poor in species was found (table 1, d6, d7, d8). The fauna clearly lived in a protected environment, almost all specimens are autochthonous. The fauna shows much variation. From the north to the south the marine influence decreases rapidly, over only a few hundred metres the fauna changes from slightly brackish to brackish; the marine gastropod *Peringia ulvae* is replaced by the brackish-water species *Hydrobia ventrosa*, and *Cerastoderma glaucum* appears, the number of transported specimens diminishes. Also the water movement decreased: *P. ulvae* lives in strongly moved water, *H. ventrosa* and *Cerastoderma glaucum* on the contrary prefer stagnant water.

The fauna may be compared with an impoverished tidal flat fauna, but only species preferring mud and tolerating a brackish environment are present. The juvenile specimens of marine species were probably washed in or were reworked from the underlying marine deposits. *Euspira catena* and *Buccinum undatum* were transported by hermit crabs. Remarkable is the presence of *Spisula subtruncata*. Usually this species lives low in the intertidal zone or deeper, but occasionally it lives in brackish water to 12 °/oo Cl, it occurred for example in the former Zuiderzee. In such a brackish environment the specimens remain very small and occur in local concentrations (van Benthem Jutting, 1943, p. 302). At Leidschendam the shells were not transported: locally the species occurs in high numbers of juvenile and adult double-valved specimens. Some specimens reach normal size but the bulk of the material is much smaller.

THE CHLORINITY OF THE DEPOSITIONAL ENVIRONMENT ESTIMATED FROM THE NUMBER OF RIBS IN *CERASTODERMA EDULE*.

Eisma (1965) found a relation between the average number of ribs in *Cerastoderma edule* and chlorinity. Later it was accepted generally that two species of *Cerastoderma* occur in the Netherlands, viz. *C. edule* and *C. glaucum*. Therefore Eisma's graph had to be revised (Eisma et al., 1976; Koulman & Wolff, 1977); a relation was demonstrated only for *C. edule*.

To find an indication for the salt content I studied specimens of *C. edule* from several samples (table 6). All the valves belong to type 2 (see chapter Remarks on some mollusc species), they are autochthonous or transported over a short distance. The average number of ribs in the oldest deposit that was sampled is 24.4 which agrees with a chlorinity of about 17 °/oo (Koulman & Wolff, 1977, fig. 5) what is equivalent to a salinity of 30.7 °/oo. This value is slightly lower than the chlorinity along the present coast near Scheveningen (table 6; Tijssen, 1969, fig. 61). In the other samples from the barrier deposits the average number of ribs is slightly lower (table 6).

In the clayey deposits on the beach plains the average number of ribs is 25.5. This indicates an increase in chlorinity, but the composition of the fauna points to a decrease in salt content. An explanation may be found using the results of Koulman & Wolff (1977). They explain the absence of a correlation between the average number of ribs and chlorinity in *C. glaucum* by the ecology of the species: the animals live in isolated populations, in each of which the number of ribs is fixed genetically. At Leidschendam the clayey deposits were formed behind a barrier, while fresh water bordered the area on the other sides. It seems probable that the population of *C. edule* was isolated genetically so that the number of ribs became fixed within the population. The variation is very low, all (admittedly few) specimens have25 or 26 ribs. Another indication for isolation is the fact that only the form of *C. edule* that is typical for sandy environments occurs. Probably the number of ribs is only linked with chlorinity if exchange of genetical material with other populations is possible, thus it is essential to know whether a connection with open sea existed or not.

sample	r	n	m	o
a	24.4	20	25, 23	23 - 26
b	24.2	14	26 and 25	21 - 26
d3	24.2	50	25, 23 and 24	22 - 26
g +h	24.0	30	25 and 23	20 - 26
d6 +d7	25.5	9	26, 25	25 - 26
S1	22.7	11	23	20 - 25
S2	24.8	24	26, 25 and 24	22 - 28

Table 6. Average number of ribs for several samples of *Cerastoderma edule*. From the coastal barriers: a) Persijnlaan, Wassenaar; d3) Duivenvoore district, Leidschendam and g +h) the top of the first barrier; from the section at Mariahoeve, Den Haag (b); from the clayey deposits on the beach plain in the Duivenvoorde district (d6 +d7) and from the present North Sea: S1) the outer harbour of Scheveningen, recent, Dec. 1978; S2) beach between Scheveningen and Katwijk, recent, 1971 - 1975.
r = average number of ribs; n = number of specimens; m = most frequent numbers of ribs; o = range of variability.

Tabel 6. Gemiddeld aantal ribben in enkele monsters van *Cerastoderma edule*. Van de strandwallen: a) Persijnlaan, Wassenaar; d3) Duivenvoorde, Leidschendam en g +h) top van de eerste strandwal; van de sectie in Mariahoeve, Den Haag (b); van de kleiige afzettingen op de strandvlakten in de wijk Duivenvoorde (d6 +d7), en van de huidige Noordzee: S1) van de buitenhaven te Scheveningen, recent, dec. 1978; S2) strand tussen Scheveningen en Katwijk, recent, 1971 - 1975.
r = gemiddeld aantal ribben; n = aantal exemplaren; m = meest voorkomende aantallen ribben; o = spreiding.

HOLLAND PEAT

As the area became more isolated when the second barrier became higher no more clastic sediment was supplied. On the clayey deposits a thin layer of black organic mud (gyttja) was deposited on which peat growth started. In the brackish environment reed, *Phragmites australis* (Cav.) Trin. ex Steud., covered large areas, except for the territory between the first barrier and the first secondary barrier. This reed peat is light brown, stems and leaves were preserved very well and the roots are visible in the clayey and sandy deposits below.

When isolation from the sea was completed and the water had become fresh an extensive swamp forest came into existence. The most important trees were alder (*Alnus*) and later also birch (*Betula*). This resulted in a thick layer of dark brown or black forest peat in which red trunks are striking. Rarely remains of beetles may be found. A mollusc fauna was not preserved because of the low pH in the peat. When the area was reclaimed the thickness of the peat diminished by compaction. During peat formation several gullies cut through the area and transported sand from the barriers into the peat swamp, while on the other hand peat grew in gullies on the barriers.

Radiocarbon datings of the base of the peat were obtained from samples close to the studied area (Jelgersma, 1961, fig. 16). The results indicate that behind the first barrier peat growth started 4,350 ± 180 B.P. and behind the second barrier at 3,925 ± 180 B.P. It is important to keep in mind that there is a difference between 'radiocarbon age' and real age as is discussed in Jelgersma et al. (1970, p. 151).

YOUNGER DEPOSITS

From about 1,050 B.P. sand accumulated on the ridges in the area west of Leidschendam and formed the Younger Dunes. Sand was blown also to the east where it accumulated on the ridges or in the peat area where it formed one or more layers (text-fig. 2). On the barriers a soil has developed. In the sections in the chapter 'The coastal barriers' the horizons of a grey-brown podzolic (Pannekoek, 1973, p. 194) can be distinguished. In section 1 three horizons were present: the A_1-horizon with humose yellowish-brown and dark brown sand (0.00 - 0.65 m); the eluviation-horizon A_2 of greyish-green sand (0.65 - 0.87 m) and the illuviation-horizon B of dark brown sand (0.87 - 1.01 m). About 2,500 - 2,150 B.P. the clayey Dunkirk I-deposits were formed during a transgression. This clay covers a large area near the estuaria of the rivers but reaches only the south-eastern part of the area studied (text-fig. 1). Much data on these younger deposits and on the history of the studied area were given in Anonymous (1978).

STRATIGRAPHICAL POSITION OF THE DEPOSITS

All Holocene marine near-coast deposits in The Netherlands were grouped together in the Westland Formation introduced by Doppert et al. (1975, p. 47 - 48). No type-section was given, only stratotype areas were designed, what is rather unsatisfactory in my opinion. All the deposits discussed here belong to this formation, the barrier deposits were named 'Strandwalafzettingen' (Coastal Barrier Deposits) at the top of which the 'Oude Duin Afzettingen' (Older Dune Deposits) are found, the peat was named 'Hollandveen' (Holland Peat) which is covered by the 'Jonge Duin Afzettingen' (Younger Dune Deposits). The clayey deposits on the beach plains have not yet been named. Because of the great interregional variation in these deposits a study of a more extended area is required before an official lithological name is attributed.

SURVEY OF THE COLLECTED SAMPLES

In this chapter the data on the samples described in table 1 are given, with respectively the code used for the sample, location, reference to the figure where the location is indicated, coordinates of the Topographical Map of The Netherlands, 1:25.000, sheet 30G ('s Gravenhage), stratigraphical position, depth at which the sample was taken, quantity of sediment searched.

sample a, pond at Persijnlaan, Wassenaar, text-fig. 1, X = - 69,480, Y = - 5,230, Coastal Barrier Deposits (beach plain), 10 - 12 m - N.A.P., ± 25 l.

sample b, excavation near railway-station Mariahoeve, Den Haag, text-fig. 1, X = - 69,680, Y = - 6,580, Coastal Barrier Deposits (channel fill), 3.12 - 5.50 m - N.A.P., ± 40 l (including the data from a sample in the Rijksmuseum van Geologie en Mineralogie, Leiden).

sample d1 to d8, Duivenvoorde district Leidschendam, text-fig. 3.

sample d1, wash-borings, Coastal Barrier Deposits (beach plain), 2.5 - 6.0 m - N.A.P., ± 40 l.

sample d2, wash-borings, Coastal Barrier Deposits (second secondary barrier), 2.5 - 6.0 m - N.A.P., ± 50 l.

sample d3, X = - 67,860, Y = - 5,720, Coastal Barrier Deposits (beach plain), 2.25 - 2.40 m - N.A.P., ± 12 l.

sample d4, X = - 67,920, Y = - 5,740, Coastal Barrier Deposits (second secondary barrier), 2.30 - 3.30 m - N.A.P., ± 20 l.

sample d5, X = - 67,950, Y = - 5,715, Coastal Barrier Deposits (shell bed in the top of the second secondary barrier), 1.55 - 1.60 m - N.A.P., ± 3 l.

sample d6, X = - 68,250, Y = - 5,800, (clayey deposits on the beach plain), ± 3.5 m - N.A.P., collected visually.

sample d7, X = - 68,000, Y = - 5,540, (clayey deposits on the beach plain), 3.00 - 3,40 m - N.A.P., collected visually (including the data from a sample in the Rijksmuseum van Geologie en Mineralogie, Leiden).

sample d8, X = - 67,425, Y = - 5,460, (clayey deposits on the beach plain), 2.20 - 2.40 m - N.A.P., collected visually.

sample e, Schakenbosch, Leidschendam, X = - 67,275, Y = - 5,425, Coastal Barrier Deposits (first secondary barrier), 2.5 - 6.0 m - N.A.P., ± 3 l.

sample g, construction pit Veurse Achterweg, Leidschendam, X = - 67,250, Y = - 6,080, Coastal Barrier Deposits (top of the first barrier), 1.5 - 2.5 m - N.A.P., collected visually.

sample h, pond close to the P.T.T.-laboratory, Leidschendam, X = - 68,375, Y = - 7,140, Coastal Barrier Deposits (top of the first barrier), 2.0 - 2.5 m - N.A.P., collected visually.

REMARKS ON SOME MOLLUSCS

In this chapter attention is paid especially to the very juvenile shells of several mollusc species. Descriptions of the larval shells of most species are given in Lebour (1938), Werner (1939) and Thorson (1946). Sofar possible the nomenclature is according to Janssen (1975). All specimens, if not stated otherwise, are in the author's private collection.

Aequipecten opercularis (Linné, 1758) (Plate 1, fig. 1).

The valves have a different appearence because of the flatness of the right valve and the convexity of the left valve. The outline of the right valve is characterized by the extending anterior ear. The structure of the left valve is very characteristic: the shell has a smooth prodissoconch, the juvenile shell with a height between 0.1 and 1.2 mm shows microscopical punctation while ribs appear at the margin. When the shell becomes larger than 1.5 mm the punctation is replaced by a radial sculpture of small scales between the ribs (Plate, 1, fig. 1). The right valve does not possess a punctation and the surface is smooth until the ribs appear. The structure then becomes as on the left valve. Spaink (1973) compared the juvenile shells of this species with those of *Chlamys (Chlamys) varia* (Linné, 1758).

Pododesmus (Heteranomia) squamula (Linné, 1758) (Plate 1, fig. 3a - b)

The juvenile shell (left valve) of this species is smooth and has a silverish appearance. The outline is oval and regular. The muscle scars are visible below the umbo.

Ostrea edulis Linné, 1758 (Plate 1, fig. 9a - b)

The juvenile shell of *O. edulis* shows a remarkable globose prodissoconch on which very fine growth lines can be seen. The outline of the shell is irregular. The isolated muscle-scars are visible, the small Quenstedt muscle-scar below the umbo and the large posterior adductor muscle-scar in the middle of the valve. The hinge is similar as in the adult shell.

Altenaeum nortoni Spaink, 1972 (Plate 1, fig. 7)

Only one valve was found. It has a worn appearance and it seems probable that the shell was reworked from older deposits. Until now a single other valve was described from the Netherlands by Spaink (1972) who recorded a specimen from Eemian deposits near Brielle.

Cerastoderma edule (Linné, 1758) (Plate 5, fig. 1 - 4)

This species may be separated rather easily from *C. glaucum* with help of the characteristics given by van Urk (1973). The available material is rather variable but two types may be distinguished:

C. edule type 1 (Plate 5, fig. 1). This type agrees well with the cockles which actually live in the estuaries in the province of Zeeland. It is typical for muddy sediments (see Eikenboom, 1978, fig. 1a). The ribs are flat, especially in the middle of the valve, and the shell is shorter than that of type 2. Because of the shorter hinge-line the outline is slightly triangular.

C. edule type 2 (Plate 5, fig. 2a - b, 4). This type is the same as the cockles actually living along the Dutch coast in open sea. They prefer a sandy environment (see Eikenboom, 1978, fig. 1b). The shell is longer than high, the outline is oval. This type may become larger than type 1.

In the coastal barrier deposits type 1 was found as transported specimens. Type 2 becomes more common towards the top of the deposits and finally reaches the normal size. In the clayey deposits on the beach plain autochthonous valves of specimens of type 2 may be found.

Cerastoderma glaucum (Poiret, 1789) (Plate 5, fig. 5 - 8, 10 - 11)

The shells of this species are very variable, the material could not be separated in two easily recognizable types as in *C. edule*. In the lower part of the coastal barrier deposits a form occurs with a low number of ribs, the shells are very solid and small (usually up to a length of two or three cm) and the outline shows little variation (Pl. 5, fig. 5, 6). Rarely specimens occur with a very broad rib (Pl. 5, fig. 5). The origin of this feature lies in the larval stage but sometimes the mantle was damaged later on so that two normal ribs are joined. At the inner side of the shell these broad ribs may be seen as a broad interspace. In the higher part of the coastal barrier deposits shells occur with a higher number of ribs, a more fragile shell and a variable outline, often the shell is very asymmetrical (Pl. 5, fig. 7 - 8). In the clayey deposits on the beach plains autochthonous specimens of a very large form were found (up to 46 mm length) with a lower number of ribs, solid shells and a rather constant outline (Pl. 5, fig. 10a - b, 11).

Spisula (Spisula) subtruncata (Da Costa, 1778)

The hinge of juvenile specimens differs markedly from that of adult specimens. In the right valve (Pl. 1, fig. 8) the hinge shows very short lateral teeth and large cardinal teeth of which one is below the umbo and almost vertical, the other at the anterior side lies almost horizontally.

In the clayey deposits a very fragile form occurs. It is wedge-shaped at the posterior side like specimens found in Holocene brackish water deposits in the province of Noord Holland (pers. observ.) (Pl. 5, fig. 9).

Solen marginatus Pulteney, 1799 (Pl. 2, fig. 10, 11a - b)

It was rather difficult to decide whether the valves belong to *S. marginatus* or to an *Ensis* species. Because the left valves show only one cardinal tooth I suppose that they belong to *Solen. Ensis* has two cardinal teeth in the left valve. It is not impossible that the hinge of the studied specimens was damaged by transport. Therefore a comparison was made with a drawing of a very juvenile specimen of *Ensis (Ensis) siliqua* (Linné, 1758) given by Lebour (1938, fig. 1). *Ensis* has a much more rounded outline than the specimens found in the coastal barriers which also have a notch below the umbo. Therefore the specimens from the coastal barriers are identified as *S. marginatus.*

Phaxas (Phaxas) pellucidus (Pennant, 1777) (Pl. 3, fig. 1a - b)

The juvenile specimens of this species may be recognized easily by the rounded outline and the hinge of the right valve composed of a bifid lateral tooth and a cardinal tooth.

Macoma (Macoma) balthica (Linné, 1758) (Pl. 2, fig. 6)

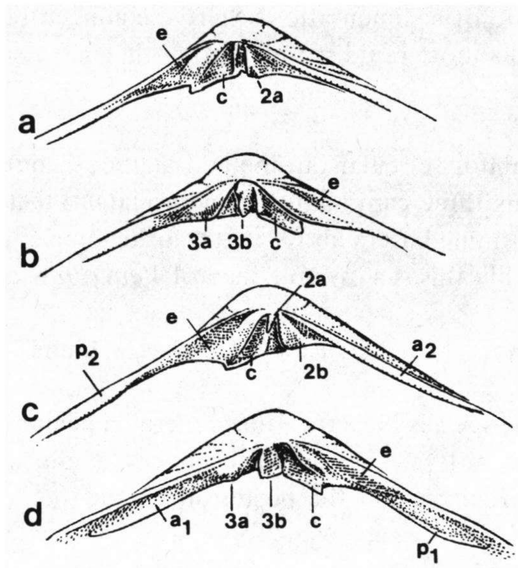
This species is a deposit-feeder preferring mud and muddy sand. The young specimens live in mud in the present Waddenzee, high in the intertidal zone. Later on they swarm off over the Waddenzee and the North Sea (Beukema in Meijer, 1974). In the studied area the same distribution was observed, juvenile specimens occur in the clay and the larger specimens were found in clay or muddy sand.

Angulus (Fabulina) fabulus (Gmelin, 1791), *Angulus (Macomangulus) tenuis* (Da Costa, 1778) and *Donax (Cuneus) vittatus* (Da Costa, 1778) (Pl. 2, fig. 7 - 9).

These species can be distinguished easily by means of the sculpture and the outline. The outer side of juvenile specimens of *Donax* is smooth while *Angulus* has concentric riblets. These concentric riblets are finer in *A. fabula*, on the right valve of this latter species diagonal striations are present. *A. tenuis* has a triangular outline, *Donax* has a more wedge-shaped outline and the posterior side is more rounded. *A. fabula* has a more elongate outline with a right angle between the ventral and posterior margin.

Abra (Abra) alba (Wood, 1802), *Abra (Abra) tenuis* (Montagu, 1803) and *Scrobicularia plana* (Da Costa, 1778) (Pl. 2, fig. 1 - 5, text-fig. 4)

The juvenile shells of *A. alba* are easily recognizable by means of their oval outline, whereas juvenile shells of *A. tenuis* and *S. plana* have a more triangular outline. It is more difficult to separate these two species. The outline of *A. tenuis* is more angular than that of *S. plana* and the shell is more convex. With the help of hinge-features the species can be separated easily. In the left valve *S. plana* has one cardinal tooth and no lateral teeth, the external ligament lies in a small groove at the posterior side of the umbo, below it lies the chondrophore of the internal ligament (text-fig. 4a); the left valve of *A. tenuis*, however, contains a large cardinal tooth, a very small cardinal above the chondrophore, usually this tooth is not mentioned in the literature but it was described by van der Mark (1967), and very weakly developed lateral teeth. In *A. tenuis* the external ligament is broader than in *S. plana*, the internal ligament is more slender (text-fig. 4c). In the right valves both *S. plana* and *A. tenuis* have two cardinal teeth, *A. tenuis* has two lateral teeth also (text-fig. 4b and d).



Text-fig. 4. Hinges of *Scrobicularia plana* (Da Costa, 1778) and *Abra (Abra) tenuis* (Montagu, 1803), x 59.
a) left valve of *S. plana*, b) right valve of *S. plana*, c) left valve of *A. tenuis*, coll. RGM 222.017, d) right valve of *A. tenuis*, coll. RGM 222.018, e = external ligament, c = chondrophore, 2a, 2b, 3a, 3b = cardinal tooth, a_1, a_2 = anterior lateral tooth, p_1, p_2 = posterior lateral tooth.

Tekstfig. 4. Sloten van *Scrobicularia plana* (Da Costa, 1778) en *Abra (Abra) tenuis* (Montagu, 1803), x 59.
a) linker klep van *S. plana*, b) rechter klep van *S.plana*, c) linker klep van *A. tenuis*, coll. RGM 222. 017, d) rechter klep van *A. tenuis*, coll. RGM 222.018, e = uitwendig ligament, c = chondrofoor, 2a, 2b, 3a, 3b = cardinale tand, a_1, a_2 = voorste laterale tand, p_1, p_2 = achterste laterale tand.

Scrobicularia plana is the most abundant species in the clayey deposits on the beach plains. Like in *Macoma* the animal has a considerable tolerance for water movements, composition of sediment and salinity. Both species are deposit feeders that prefer fine sand with mud. At the locations where *S. plana* was met in life position the shells always were situated vertically. In recent tidal flats (e.g. Burry's Inlet in Wales and the Oosterschelde in Zeeland, personal obs.) the shells show the same orientation. Therefore it is remarkable that Rasmussen (1973, p. 306) describes specimens from the Danish Isefjord lying on their side, when buried in the sediment. The animal may lie either on the left valve or on the right valve, but the shell is equivalve.

Many related species have comparable feeding customs and lie horizontally. When the animal always lies on its left valve the posterior end of the shell is curved to the right, e.g. in *Abra alba, Angulus fabulus* and *Angulus (Laciolina) incarnatus* (Linné, 1758) (Rasmussen, 1973, p. 305, and personal observations). When the animal always lies on its right valve the posterior end is curved to the left, e.g. in *Angulus tenuis* (Rasmussen, 1973, p. 310). Holme (1958, p. 268), however, observed *A.*

tenuis lying on its side at low water and in a vertical position at high tide. *Macoma balthica* lies on its left valve and therefore it has an inaequivalve shell (Rasmussen, 1973, p. 308) but in the coastal barrier deposits at Leidschendam the species is found in a vertical position which was also mentioned in literature (Stanley, 1970, pl. 35; Reineck & Singh, 1973, fig. 224; Cadée, 1978, pl. 1).

In the Danish Isefjord the deposit-feeders seem to lie on their sides, while in other environments some species live in a vertical position. A plausible explanation is given by a photograph in Reineck & Singh (1973, fig. 224) showing *Macoma balthica* in a vertical position in escape-burrows in an area with rapid sedimentation. It is possible that the animals live horizontally in an environment with quiet water and a low rate of sedimentation where the concentration of food is high, whereas in areas with moving water and a more rapid sedimentation the animals live in vertical position.

Veneracea gen. et sp. indet. (Pl. 1, fig. 5)

The juvenile shell has an almost circular outline and a smooth outer surface with faint growth lines. The (right) valve contains three cardinal teeth and no lateral teeth, the posterior tooth is very large, the ligament-groove lies immediately above it, the other two cardinal teeth are much smaller and lie below the umbo. Probably this is a juvenile shell of *Venerupis senegalensis.*

Mya (Arenomya) arenaria Linné, 1758, *Mya (Mya) truncata* Linné, 1758 and *Sphenia binghami* Turton, 1822 (Pl. 3, fig. 2 - 7)

The juvenile shells of these species have the same general appearance which makes it difficult to distinguish the species. In the right valve a concealed chondrophore lies beneath the umbo, the external ligament occupies a narrow zone at the posterior side of the umbo. Near the umbo a thick knob is present.

S. binghami has a sharp ridge running from the umbo towards the transition between the ventral and posterior margin. The umbo is protruding clearly and does not form a confluent line with the posterior dorsal margin as in *Mya*. Dorsal and ventral margins are straight and run parallel to each other. The outline of the shell is very variable.

In *M. truncata* a ridge runs from the umbo towards the transition between the ventral and posterior margin, in *M arenaria* this ridge is absent. The ventral margin is rounded in *M. arenaria* and almost straight in *M. truncata*. In *M. truncata* the ventral margin of the pallial line is confluent with the pallial sinus, in *M. arenaria* it is not confluent. In *M. arenaria* the umbo is more protruding than in *M. truncata.*

Littorina rudis (Maton, 1797) forma *tenebrosa* Montagu (Pl. 4, fig. 6)

In the Coastal Barrier Deposits small specimens of *Littorina*, reworked from brackish water deposits, were found. The shell is dark brown with a tesselate pattern of white spots. It is thin and fragile, the convex whorls are smooth or show faint spiral sculpture. It may become 7.5 mm high and 6.5 mm broad. It is the same form that occurs in recent and fossil brackish water environments in the northern and western part of the Netherlands. In such locations it is often found in very large numbers.

Van Benthem Jutting (1933) mentioned three subspecies of *Littorina saxatilis* from the Netherlands: *saxatilis* (Olivi, 1792), *rudis* (Maton, 1797) and *tenebrosa* (Montagu, 1803). The subspecies *rudis* is very common on exposed rocks along the entire coast, the other subspecies occur in brackish water in the province of Zeeland, on the North Sea islands and behind the 'Hondsbosse Zeewering' in the province of Noord Holland (van Benthem Jutting, 1933). The subspecies *tenebrosa* was not described in this paper, the drawing of *saxatilis* was taken from Dautzenberg & Fischer. Entrop

(1965) mentioned the same three subspecies and described them all, but the illustrated specimens (fig. 142 and 143) all belong to *rudis*.

From these publications it is not clear to which subspecies the material from the coastal barrier belongs. Therefore more Dutch material and several publications on material from outside the Netherlands were studied. *L. saxatilis* was described by Olivi from the (?brackish) lagoon of Venice (Italy). Shells from this location figured and described by James (1968, p. 147, Pl. 1, fig. 2) agree exactly with the Dutch brackish water specimens but James (1968) and Heller (1975) doubt the occurrence of *saxatilis* outside the Venice lagoon. This is caused by the fact that *L. saxatilis* occurs only in one location in the Mediterranean, the nearest population being that in Cadiz (Southern Spain) so that the population at the type locality seems to be isolated. Heller (1975) recognized four species in the British samples formerly always regarded as respresenting only one species (*L. saxatilis*). Because he knew nothing about the anatomy of the specimens from Venice he did not know which one of the four British species is *saxatilis* and therefore he used other names: *rudis* (Maton, 1797), *nigrolineata* Gray, 1839, *patula* Jeffreys, 1850 and *neglecta* Bean, 1844. Because the Dutch material agrees with the species *rudis* this name is used for the Dutch species too.

L. tenebrosa was described by Montagu (1803, p. 303 - 304; 1808, Pl. XX, fig. 4). The Dutch specimens agree with the description, the drawing however is indistinct. Fortuin (in prep.) will designate a lectotype but the data on the sample-location got lost. In his description Montagu wrote that the original material was found in the interidal zone on mud or rocks near high water mark. This environment is markedly differing from the environment where the Dutch brackish water form occurs. The morphology of the shell, however, is exactly the same so that the name *tenebrosa* may be used for both. James (1968) and Heller (1975) treated *tenebrosa* without having studied the material of Montagu, therefore their conclusions are dubious. Mr. A. W. Fortuin (pers. comm.) studied Dutch material of *L. rudis* and concluded that two ecological forms occur: *rudis* in the intertidal zone along the North Sea coast and *tenebrosa* in isolated brackish environments, an intermediate form lives on tidal flats. Because these are ecological forms the name for the Dutch brackish water specimens must be *Littorina rudis* forma *tenebrosa* Montagu, 1803.

Hydrobia (Hydrobia) ventrosa (Montagu, 1803) (Pl. 4, fig. 9)

This species has always been confused with *H. stagnorum* (Gmelin, 1791) which was described from the 'Kaasjeswater' at Zierikzee. Recently *H. ventrosa* was found there too. *H. ventrosa* has more convex whorls and a larger umbilicus than *H. stagnorum*. In the Netherlands *H. stagnorum* is known only from a few localities while *H. ventrosa* is common in brackish water in the northern and western part of the country (Bank et al., in prep.).

Peringia ulvae (Pennant, 1777) (Pl. 4, fig. 1 - 5)

This species is very variable. The material from Leidschendam was identified by Mr T. Meijer who recognized several forms that are mentioned below. The typical form (Pl. 4, fig. 1 - 3) has three flat upper whorls while the lower whorls are flat or moderately convex. Sometimes the last whorl is very convex (Pl. 4, fig. 4) which makes the shell look like *H. ventrosa*. The suture is shallow, only between the more convex lower whorls it is somewhat deeper. The aperture has an uninterrupted peristome which is pointed at the upper side. Sometimes larger specimens occur, they have more whorls and therefore become more slender (Pl. 4, fig. 1). There is also a small slender form (Pl. 4, fig. 5) that looks like *H. neglecta* Muus, 1963. In *H. neglecta* the maximum width of the shell lies closer to the top. The surface of *P. ulvae* usually is smooth but several specimens have a spiral sculpture (Pl. 4, fig. 1). At locations b and d8 specimens were found in which the upper part of the whorl shows a dent (Pl. 4, fig. 2) possibly caused by a change in salinity (Meijer, pers. comm.).

Turboella (Turboella) inconspicua (Alder, 1844) (Pl. 4, fig. 7)

Only two specimens were found, both at location b, showing the variability of the species: one is slender with weak ribs, the other one (Pl. 4, fig. 7) is broader and has pronounced ribs. Between the ribs fine spiral lines may be seen. The species is probably much more common than is thought until now, in Holocene deposits in the province of Zeeland the species is sometimes very common.

Euspira catena (Da Costa, 1778) and *Euspira poliana* (Della Chiaje, 1830) (Pl. 3, fig. 8 and 9)

Two very juvenile specimens are drawn. *E. catena* had a flat apex while in *E. poliana* it is more globose. In *E. poliana* the protoconch is smaller and the whorls are lying closer. The shells of *E. catena* usually were occupied by the hermit crab *Eupagurus bernhardus*, as is obvious from the cover of *Hydractinia echinata*, a hydrozoan living on shells occupied by hermit crabs, and from the wear and tear of the last whorl near the aperture.

Ancylus (Ancylus) fluviatilis (Müller, 1774) and *Ferrissia wautieri* (Mirolli, 1960) (Pl. 3, fig. 10, 11)

The latter species was only recently discovered in the Netherlands (van der Velde & Roelofs, 1977). It seems to be a common species as it has been found at several locations later on (several pers. comm.). Until now no fossil specimens have been described from the Netherlands. The very juvenile shells have a characteristic form, the shell is flat; the umbo lies in the centre, many fine radial grooves run to the margins. *Ancylus* has a more elevated form with the umbo curved to the back side of the shell, the radial ribs are broader and less in number.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the following persons: Mr J. J. Vermeulen (Santpoort Zuid), who draw the excellent illustrations of the molluscs, using a Wild M5 binocular with camera lucida device. Mr A. W. Janssen (RGM = Rijksmuseum van Geologie en Mineralogie, Leiden) critically read the manuscript, helped with some identifications (especially of the Pisidiidae) and placed his samples at my disposal. Mr J. J. Lobenstein (Leidschendam) and Dr J. Hofker (Den Haag) identified the foraminifera and ostracods. Mr T. Meijer (RGD = Rijks Geologische Dienst, Haarlem) identified the Hydrobiidae. Mr A. W. Fortuin (Leiden) and Dr E. Gittenberger (RMNH = Rijksmuseum van Natuurlijke Historie, Leiden) discussed with me the nomenclature of *Littorina*, Mr G. Spaink (RGD, Haarlem) placed his internal reports at my disposal, Dr P. A. M. Gaemers (Leiden) critically read the manuscript and Messrs H. Schiet and W. C. Laurijssen (both GMI = Geologisch en Mineralogisch Instituut, Leiden) prepared the photographs.

REFERENCES

Anonymous, 1978. Gemeente Leidschendam, bestemmingsplan landelijk gebied 1978. Toelichting en voorschriften, A - B. Delft (OD205 adviseurs voor planologie, architectuur en landschap B.V.).

Bank, R. A., L. J. M. Butot & E. Gittenberger, in prep. On the identity of Helix stagnorum Gmelin and Turbo ventrosus Montagu (Prosobranchia: Hydrobiidae) - Basteria, 43.

Cadée, C. G., 1978. Sediment-omwerking door depositfeeders. - Meded. Werkgr. Tert. Kwart. Geol., 15 (3): 85 - 100, 5 fig.

Doppert, J. W. C., G. H. J. Ruegg, W. J. van Staalduinen, W. H. Zagwijn & J. G. Zandstra, 1975. Formaties van het Kwartair en Boven-Tertiair in Nederland. In: W. H. Zagwijn & C. J. van Staalduinen (ed.), 1975. Toelichting bij geologische overzichtskaarten van Nederland. Haarlem (Rijks Geologische Dienst), pp. 11 - 56, 60 fig.

Edelman, T., 1974. Bijdrage tot de historische geografie van de Nederlandse kuststreek. Publikatie 14. Den Haag (Rijkswaterstaat, Directie waterhuishouding en waterbeweging).

Eikenboom, J. C. A., 1978. Cerastoderma glaucum (Bruguière) onze 'Brakwaterkokkel'. - Vita Marina, Tweekleppigen: 157 - 162, 3 fig., 1 tab.

Eisma, D., 1965. Shell-characteristics of Cardium edule L. as indicators of salinity. - Neth. J. Sea Res., 2: 493 - 540.

Eisma, D., 1966. The distribution of benthic marine molluscs off the main Dutch coast. - Neth. J. Sea Res., 3 (1): 107 - 163, 11 fig., 12 tab.

Eisma, D., 1968. Composition, origin and distribution of Dutch coastal sands between Hoek van Holland and the island of Vlieland. - Neth. J. Sea Res., 4 (2): 123 - 267.

Eisma, D., W. G. Mook & H. A. Das, 1976. Shell characteristics, isotopic composition and trace-element contents of some euryhaline molluscs as indicators of salinity. - Palaeogeogr., Palaeoclimatol., Palaeoecol., 19: 39 - 62.

Entrop, B., 1965. Schelpen vinden en herkennen (2 ed.). Zutphen (Thieme & Cie). 320 pp., 227 fig.

Fortuin, A. W., in prep. - Basteria.

Heide, S. van der, 1960. Einige Bemerkungen zur Molluskenfauna des Dollart-Ems-Gebietes. - Verh. Kon. Ned. Geol. Mijnb. Genootsch., (geol. serie), 19. Symposium Ems-Estuarium (Nordsee): 271 - 278, 4 tab.

Heller, J., 1975. The taxonomy of some British *Littorina* species, with notes on their reproduction (Mollusca: Prosobranchia). - Zool. J. Linn. Soc., 56: 131 - 152, 2 pl., 10 fig.

Hofker, J., 1977. The Foraminifera of Dutch tidal flats and salt marshes. - Neth. J. Sea Res., 11 (3/4): 223 - 296.

Holme, N. A., 1950. Population-dispersion in Tellina tenuis Da Costa. - J. mar. biol. Ass. U. K., 29: 267 - 280.

James, B. L., 1968. The characters and distribution of the subspecies and varieties of *Littorina saxatilis* (Olivi, 1792) in Britain. - Cah. Biol. mar., 9: 143 - 165.

Janssen, A. W., 1975. Systematische lijst van Nederlandse recente en fossiele mollusken. - Meded. Werkgr. Tert. Kwart. Geol., 12 (4). 115 - 170, 1 tab.

Janssen, A. W. & E. F. de Vogel, 1965. Zoetwatermollusken van Nederland. Amsterdam (Nederl. Jeugdb. Natuurst.). 160 pp., 14 fig., 17 pl.

Jelgersma, S., 1961. Holocene sealevel changes in The Netherlands (Diss. Leiden). - Meded. Geol. Stichting, (C-VI) 7, 50 pp., 5 fig., 5 encl.

Jelgersma, S., J. D. de Jong, W. H. Zagwijn & J. F. van Regteren Altena, 1970. The coastal dunes of the western Netherlands; geology, vegetational history and archeology. - Meded. Rijks Geol. Dienst, (N.S.), 21: 93 - 167, 39 fig., 10 pl.

Jutting, W. S. S. van Benthem, 1933. Fauna van Nederland, VII. Mollusca (I). A. Gastropoda Prosobranchia et Pulmonata. Leiden (Sijthoff). 387 pp.

Jutting, W. S. S. van Benthem, 1943. Fauna van Nederland, XII. Mollusca (I). C. Lamellibranchia. Leiden (Sijthoff). 477 pp.

Jutting, W. S. S. van Benthem, 1959. Ecology of brackish water Mollusca in the Netherlands. - Basteria, 23, suppl.: 77 - 99.

Jutting, W. S. S. van Benthem & H. Engel, 1936. Fauna van Nederland, VIII. Molluscs (I). B. Gastropoda Opisthobranchia, Amphineura et Scaphopoda. Leiden (Sijthoff). 106 pp.

Koulman, J. G. & W. J. Wolff, 1977. The Mollusca of the estuarine region of the rivers Rhine, Meuse and Scheldt in relation to the hydrography of the area. V. The Cardiidae. - Basteria, 41 (1-4): 21 - 32, 5 fig., 1 tab.

Lebour, M. V., 1938. Notes on the breeding of some lamellibranchs from Plymouth and their larvae. - J. marine biol. Ass., 23: 119 - 145.

Lever, J., 1977. Experimental malacology. In: A. C. van Bruggen (ed.), 1977. Malacology in the Netherlands. Leiden (Nederl. Malacol. Ver.): 33 - 42.

Lever, J., M. van den Bosch, H. Cook, T. van Dijk, A. J. H. Thiadens & R. Thijssen, 1964. Quantitative Beach Research, III. An experiment with artificial valves of Donax vittatus. - Neth. J. Sea Res., 2: 458 - 492.

Mark, D. van der, 1967. Voorlopige determinatie-tabel voor miocene Abra-soorten. Rotterdam (Werkgr. Tert. Kwart. Geol.) (not published).

Meijer, T., 1974. Verslag van de najaarsexcursie naar Texel. 27/29 september 1974. - Correspondentieblad Ned. Malacol. Ver., 160: 282 - 285, 1 pl.

Montagu, G., 1803 - 1808. Testacea Brittannica, or an account of all the shells hitherto discovered in Britain, I - II, XL + 606 pp., 16 pl., London, 1803; Suppl., V + 183 pp., pl. 17 - 30, London, 1808.

(continued at p. 54)

EXPLANATION OF PLATE 1

Fig. 1 *Aequipecten opercularis* (Linné, 1758)
Left valve, juv. Coastal Barrier Deposits (beach plain), sample d3, x 28.
Linker klep, juv. Strandwalafzettingen (strandvlakte), monster d3, x 28.

Fig. 2a - b Nuculacea gen. et sp. indet.
Right valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d4, x 43.
Rechter klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 43.

Fig. 3a - b *Pododesmus (Heteranomia) squamula* (Linné, 1758)
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 26.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 26.

Fig. 4a - b *Laevicardium (Laevicardium) crassum* (Gmelin, 1791)
Left valve, juv. Coastal Barrier Deposits (beach plain), sample d1, x 31.
Linker klep, juv. Strandwalafzettingen (strandvlakte), monster d1, x 31.

Fig. 5 Veneracea gen. et sp. indet.
Right valve, juv. Clayey deposits on the beach plain, sample d7, coll. RGM 222.013, x 46.
Rechter klep, juv. Kleiige afzettingen op de strandvlakte, monster d7, coll. RGM 222.013, x 46.

Fig. 6 *Semierycina (Semierycina) nitida* (Turton, 1822)
Left valve. Coastal Barrier Deposits (second secondary barrier), sample d2, x 23.
Linker klep. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 23.

Fig. 7 *Altenaeum nortoni* Spaink, 1972
Right valve. Coastal Barrier Deposits (second secondary barrier), sample d4, x 43.
Rechter klep. Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 43.

Fig. 8 *Spisula (Spisula) subtruncata* (Da Costa, 1778)
Right valve, juv. Coastal Barrier Deposits (beach plain), sample d3, x 32.
Rechter klep, juv. Strandwalafzettingen (strandvlakte), monster d3, x 32.

Fig. 9a - b *Ostrea edulis* Linné, 1758
Right valve, juv. Coastal Barrier Deposits (first secondary barrier), sample e, x 31.
Rechter klep, juv. Strandwalafzettingen (eerste secundaire strandwal), monster e, x 31.

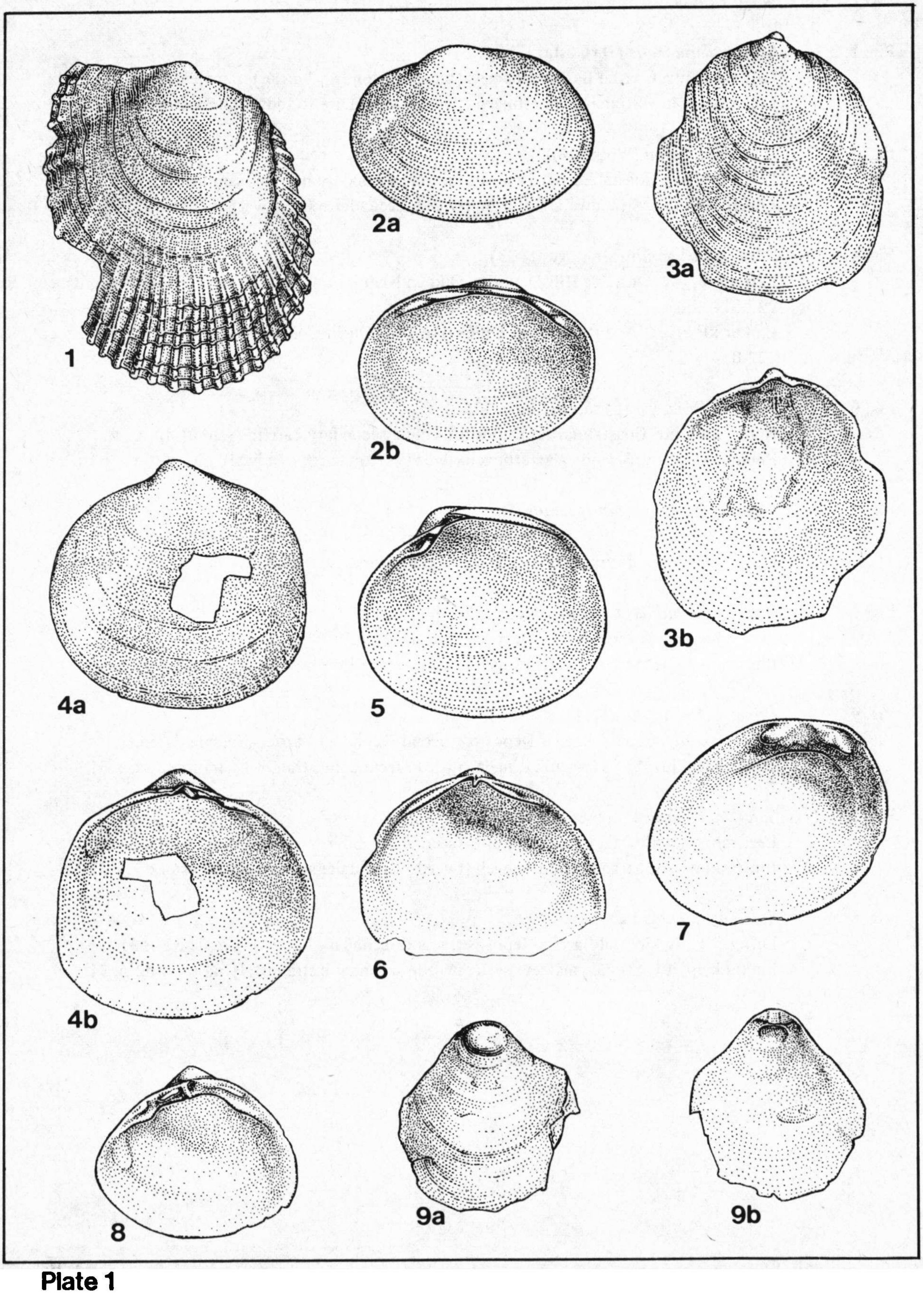


Plate 1

EXPLANATION OF PLATE 2

Fig. 1, 2 *Scrobicularia plana* (Da Costa, 1778)
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 26.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 26.

Fig. 3 *Abra (Abra) alba* (Wood, 1802)
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 27.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 27.

Fig. 4, 5 *Abra (Abra) tenuis* (Montagu, 1803)
Left valve, juv. Dunkirk IIIb Deposits, Oud en Nieuw Gastel (province of Noord Brabant), coll. RGM 222.014, x 27.
Linker klep, juv. Afzettingen van Duinkerke IIIb, Oud en Nieuw Gastel (Noord Brabant), coll. RGM 222.014, x 27.

Fig. 6 *Macoma (Macoma) balthica* (Linné, 1758)
Right valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 26.
Rechter klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 26.

Fig. 7 *Angulus (Macomangulus) tenuis* (Da Costa, 1778)
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d4, x 37.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 37.

Fig. 8 *Angulus (Fabulina) fabulus* (Gmelin, 1791)
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d4, x 40.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 40.

Fig. 9 *Donax (Cuneus) vittatus* (Da Costa, 1778)
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d4, x 31.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 31.

Fig. 10 *Solen marginatus* Pulteney, 1799
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 33.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 33.

Fig. 11a - b *Solen marginatus* Pulteney, 1799
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 31.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 31.

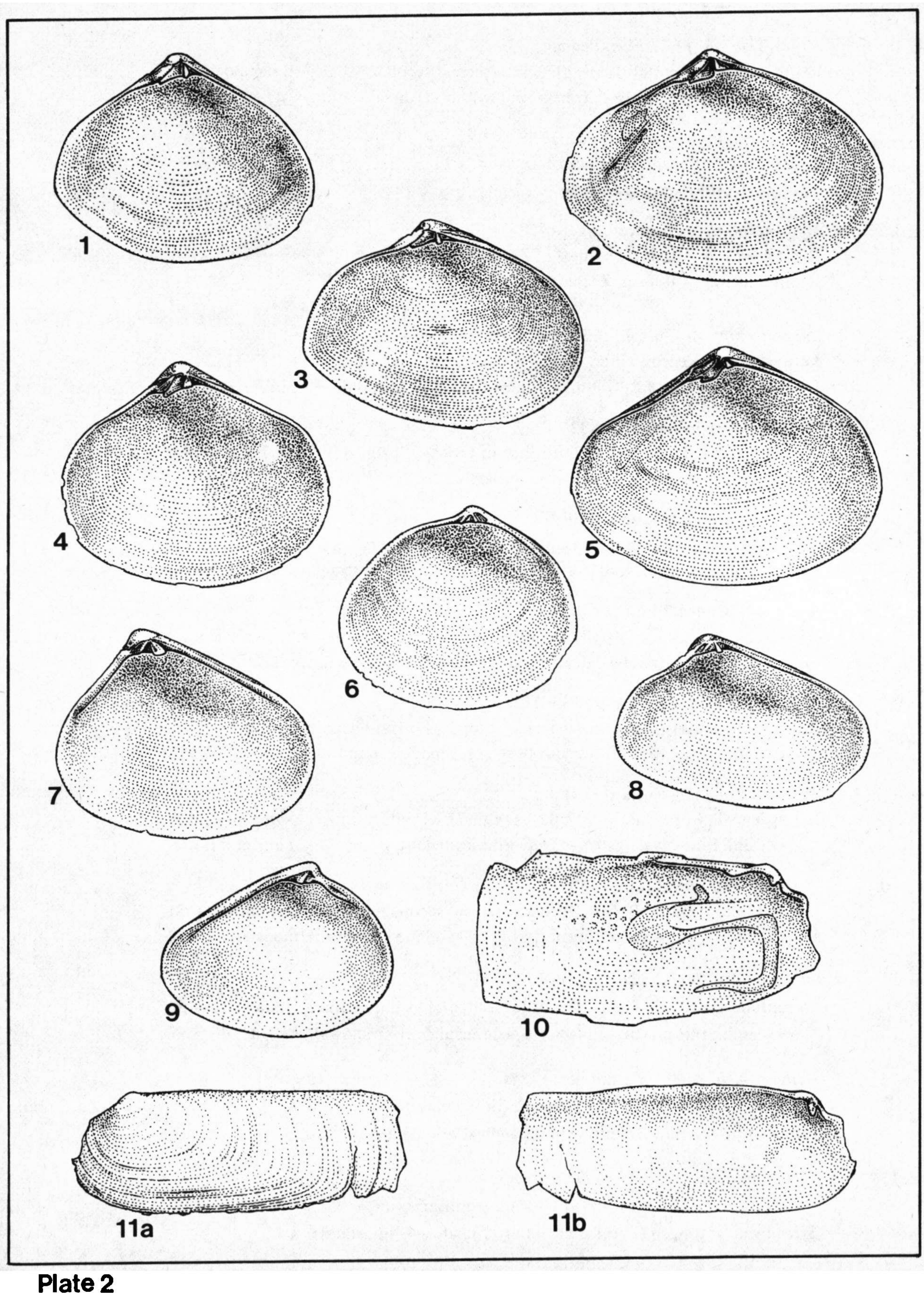


Plate 2

EXPLANATION OF PLATE 3

Fig. 1a - b *Phaxas (Phaxas) pellucidus* (Pennant, 1777)
Right valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 30.
Rechter klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 30.

Fig. 2 *Mya (Arenomya) arenaria* Linné, 1758
Left valve, juv. Recent, province of Zeeland, x 21.
Linker klep, juv. Recent, Zeeland, x 21.

Fig. 3 *Mya (Arenomya) arenaria* Linné, 1758
Right valve, juv. Recent, province of Zeeland, x 21.
Rechter klep, juv. Recent, Zeeland, x 21.

Fig. 4 *Sphenia binghami* Turton, 1822
Left valve, juv. Recent, Gijon, province of Oviedo, Spain, coll. RGM 222.015, x 22.
Linker klep, juv. Recent, Gijon, provincie Oviedo, Spanje, coll. RGM 222.015, x 22.

Fig. 5 *Sphenia binghami* Turton, 1822
Right valve, juv. Recent, Gijon, province of Oviedo, Spain, coll. RGM 222.016, x 22
Rechter klep, juv. Recent, Gijon, provincie Oviedo, Spanje, coll. RGM 222.016, x 22.

Fig. 6 *Mya (Mya) truncata* Linné, 1758
Left valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 57.
Linker klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 57.

Fig. 7 *Mya (Mya) truncata* Linné, 1758
Right valve, juv. Coastal Barrier Deposits (second secondary barrier), sample d2, x 57.
Rechter klep, juv. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 57

Fig. 8 *Euspira poliana* (Della Chiaje, 1830)
Juv. specimen. Coastal Barrier Deposits (second secondary barrier) sample d4, x 28.
Juv. exempl., Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 28.

Fig. 9 *Euspira catena* (Da Costa, 1778)
Juv. specimen. Coastal Barrier Deposits (second secondary barrier), sample d4, x 27.
Juv. exempl. Strandwalafzettingen (tweede secundaire strandwal), monster d4, x 27.

Fig. 10. *Ferrissia wautieri* (Mirolli, 1960)
Juv. specimen. Coastal Barrier Deposits (second secondary barrier), sample d2, x 31.
Juv. exempl. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 31.

Fig. 11 *Ancylus (Ancylus) fluviatilis* (Müller, 1774)
Juv. specimen. Coastal Barrier Deposits (second secondary barrier), sample d2, x 36.
Juv. exempl. Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 36.

Fig. 12 *Galba (Galba) truncatula* (Müller, 1774)
Juv. specimen. Coastal Barrier Deposits (beach plain), location d8, x 22.
Juv. exempl. Strandwalafzettingen (strandvlakte), locatie d8, x 22.

Fig. 13 *Segmentina nitida* (Müller, 1774)
Coastal Barrier Deposits (second secondary barrier), sample d5, x 17.
Strandwalafzettingen (tweede secundaire strandwal), monster d5, x 17.

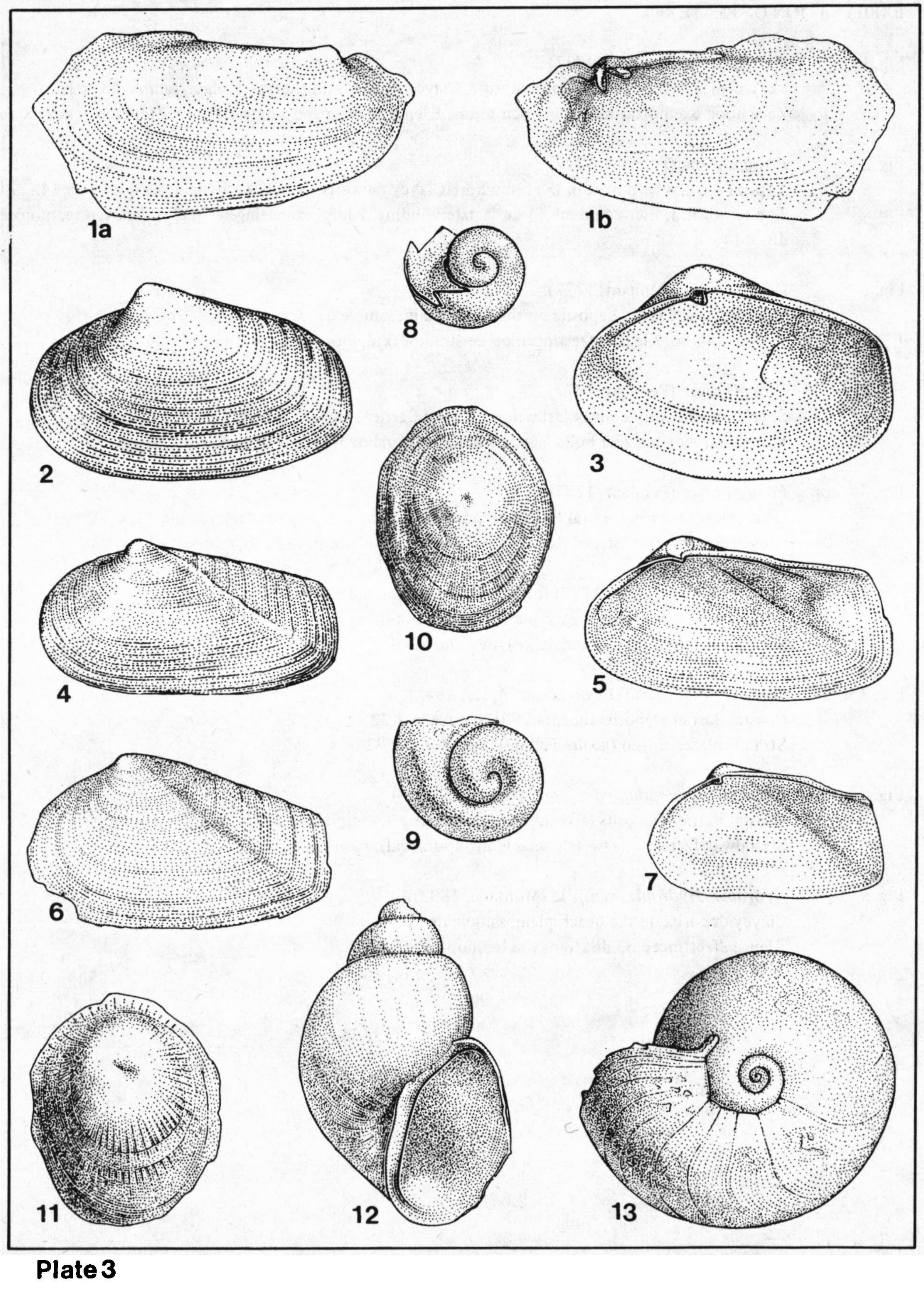


Plate 3

EXPLANATION OF PLATE 4

Fig. 1 *Peringia ulvae* (Pennant, 1777)
Very high specimen with spiral sculpture. Clayey deposits on the beach plain, sample d8, x 14.
Zeer hoog exemplaar met spiraalsculptuur. Kleiige afzettingen op de strandvlakte, monster d8, x 14.

Fig. 2 *Peringia ulvae* (Pennant, 1777)
Typical form, with a dent in the last whorl. Clayey deposits on the beach plain, sample d8, x 14.
Typische vorm, met een deuk in de laatste winding. Kleiige afzettingen op de strandvlakte, monster d8, x 14.

Fig. 3 *Peringia ulvae* (Pennant, 1777)
Typical form. Clayey deposits on the beach plain, sample d8, x 14.
Typische vorm. Kleiige afzettingen op de strandvlakte, monster d8, x 14.

Fig. 4 *Peringia ulvae* (Pennant, 1777)
Specimen with very convex last whorl. Coastal Barrier Deposits (beach plain), sample a, x 9.
Exemplaar met een zeer bolle laatste winding. Strandafzettingen (strandvlakte), monster a, x 9.

Fig. 5 *Peringia ulvae* (Pennant, 1777)
Small, slender form. Coastal Barrier Deposits (second secondary barrier), sample d2, x 32.
Kleine, slanke vorm. Strandafzettingen (tweede secundaire strandwal), monster d2, x 32.

Fig. 6 *Littorina rudis* (Maton, 1797) forma *tenebrosa* Montagu
Coastal Barrier Deposits (beach plain), sample a, x 8.
Strandwalafzettingen (strandvlakte), monster a, x 8.

Fig. 7 *Turboella (Turboella) inconspicua* (Alder, 1844)
Coastal Barrier Deposits (channel fill), sample b, x 32.
Strandwalafzettingen (geulopvulling), monster b, x 32.

Fig. 8 *Chrysallida (Pyrgulina) decussata* (Montagu, 1803)
Coastal Barrier Deposits (second secondary barrier), sample d2, x 27.
Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 27.

Fig. 9 *Hydrobia (Hydrobia) ventrosa* (Montagu, 1803)
Clayey deposits on the beach plain, sample d6, x 28.
Kleiige afzettingen op de strandvlakte, monster d6, x 28.

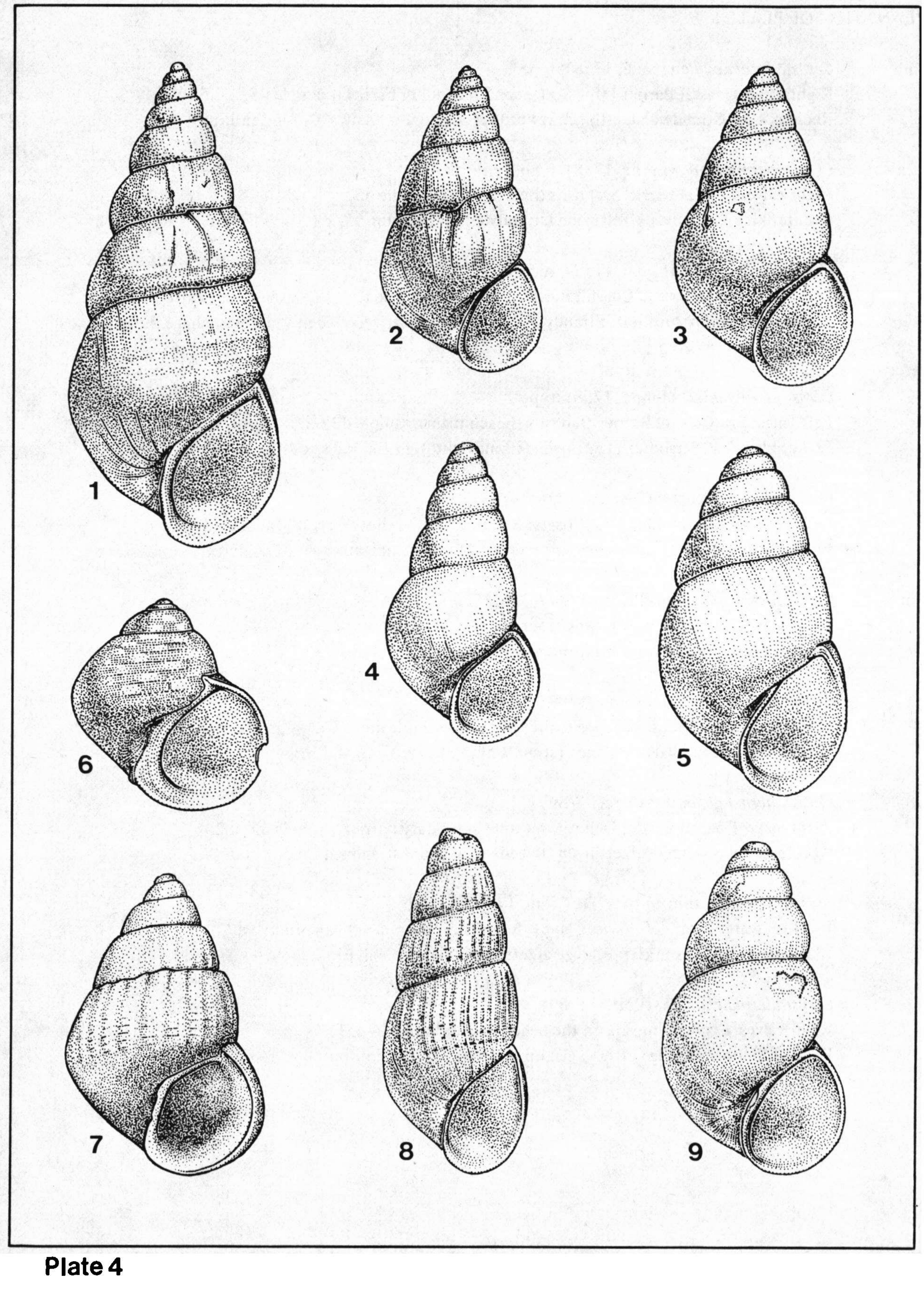


Plate 4

EXPLANATION OF PLATE 5

Fig. 1 *Cerastoderma edule* (Linné, 1758), type 1
Right valve. Coastal Barrier Deposits (second secondary barrier), sample d5, x 1.5.
Rechter klep. Strandwalafzettingen (tweede secundaire strandwal), monster d5, x 1,5.

Fig. 2a - b *Cerastoderma edule* (Linné, 1758), type 2
Right valve. Coastal Barrier Deposits (beach plain), sample d5, x 1.
Rechter klep. Strandwalafzettingen (strandvlakte), monster d5, x 1.

Fig. 3 *Cerastoderma edule* (Linné, 1758), type 1
Left valve, monstruosity. Coastal Barrier Deposits, pond south of Leidsenhage, Leidschendam, x 2.
Linker klep, monstruositeit. Strandwalafzettingen, vijver ten zuiden van Leidsenhage, Leidschendam, x 2.

Fig. 4 *Cerastoderma edule* (Linné, 1758), type 2
Left valve, juv. Coastal Barrier Deposits (beach plain), sample d3, x 2.
Linker klep, juv. Strandwalafzettingen (strandvlakte), monster d3, x 2.

Fig. 5 *Cerastoderma glaucum* (Poiret, 1789)
Left valve with two joined ribs. Coastal Barrier Deposits (beach plain), sample d3, x 2.
Linker klep met twee samengegroeide ribben. Strandwalafzettingen (strandvlakte), monster d3, x 2

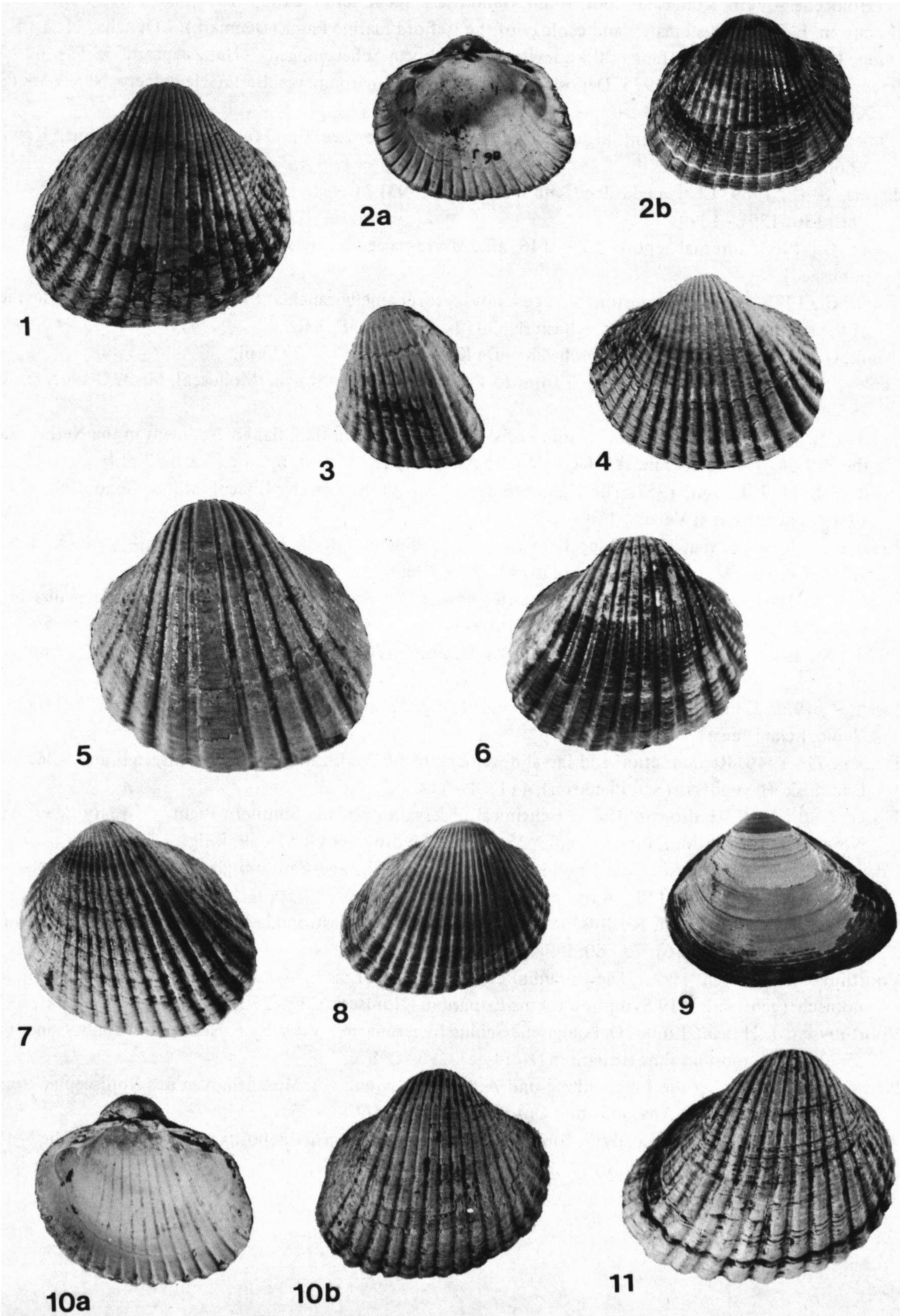
Fig. 6 *Cerastoderma glaucum* (Poiret, 1789)
Right valve. Coastal Barrier Deposits (beach plain), sample a, x 2.
Rechter klep. Strandwalafzettingen (strandvlakte), monster a, x 2.

Fig. 7 *Cerastoderma glaucum* (Poiret, 1789)
Left valve. Coastal Barrier Deposits (beach plain), sample d3, x 2.
Linker klep. Strandwalafzettingen (strandvlakte), monster d3, x 2.

Fig. 8 *Cerastoderma glaucum* (Poiret, 1789)
Right valve. Coastal Barrier Deposits (second secondary barrier), sample d2, x 2.
Rechter klep, Strandwalafzettingen (tweede secundaire strandwal), monster d2, x 2.

Fig. 9 *Spisula (Spisula) subtruncata* (Da Costa, 1778)
Brackish water form, left valve. Clayey deposits on the beach plain, sample d7, x 2.
Brakwatervorm, linker klep. Kleiige afzettingen op de strandvlakte, monster d7, x 2.

Fig. 10a-b, 11 *Cerastoderma glaucum* (Poiret, 1789)
Right valves. Clayey deposits on the beach plain, sample d6, x 1.
Rechter kleppen. Kleiige afzettingen op de strandvlakte, monster d6, x 1.


1
2a
2b
3
4
5
6
7
8
9
10a
10b
11

Pannekoek, A. J. (ed.), 1973. Algemene Geologie. Groningen (Tjeenk Willink). XV +533 pp.

Pons, L. J., S. Jelgersma, A. J. Wiggers & J. D. de Jong, 1963. Evolution of the Netherlands coastal area during the Holocene. - Verh. Kon. Ned. Geol. Mijnb. Genootsch., (geol. serie), 21 (2): 197 - 208, 3 fig., 9 encl.

Rasmussen, E., 1973. Systematics and ecology of the Isefjord marine fauna (Denmark). - Ophelia, 11: 1 - 507.

Raven, J. G. M., 1978. Een fauna 20 kilometer westelijk van Scheveningen. - Het Zeepaard, 38 (3): 62 - 71, 9 fig.

Reineck, H.-E. & I. B. Singh, 1975. Depositional sedimentary environments. Berlin, Heidelberg, New York (Springer) XVI +439 pp., 579 fig., 23 tab.

Schäfer, W., 1962. Aktuo-Paläontologie nach Studien in der Nordsee. Frankfurt am Main (Waldeman Kramer), VIII +666 pp., 277 fig., 36 pl.

Sliggers, B. C., 1969. Chrysallida decussata (Montagu, 1803) in Nederland. - Correspondentieblad Ned. Malacol. Ver., 130: 1397 - 1399.

Spaink, G., 1963. Internal reports 139 - 146, afd. Macro-palaeontologie. Haarlem (Rijks Geologische Dienst) (not published).

Spaink, G., 1972. Altenaeum nortoni nov. gen. nov. spec. (Lamellibranchia: Condylocardiidae) from the Pleistocene of the southern North Sea Basin. - Basteria, 36 (2-5): 143 - 148, 2 fig.

Spaink, G., 1973. Juveniele molluskenschalen. - De Kreukel, 9 (6): 78 - 79, 3 pl.

Stanley, S. M., 1970. Relation of shell form to life habits of the Bivalvia (Mollusca). Mem. Geol. Soc. Am., 125, 296 pp.

Straaten, L. M. J. U. van, 1956. Composition of shell beds formed in tidal flat environment in the Netherlands and in the Bay of Arcachon (France). - Geol. Mijnbouw, (N.S.) 18: 209 - 226, 2 fig., 5 tab., 2 pl.

Straaten, L. M. J. U. van, 1957. The Holocene deposits. - Verh. Kon. Ned. Geol. Mijnb. Genootsch., (geol. serie), 17 The excavation at Velzen: 158 - 183.

Straaten, L. M. J. U. van, 1963. Aspects of Holocene sedimentation in The Netherlands. - Verh. Kon. Ned. Geol. Mijnb. Genootsch., (geol. serie), 21 (1): 149 - 172, 7 fig.

Straaten, L. M. J. U. van, 1965. Coastal barrier deposits in South- and North-Holland, in particular in the areas around Scheveningen and IJmuiden. - Meded. Geol. Stichting, (N.S.), 17: 41 - 75, 26 fig., 4 tab., 5 pl.

Tebble, N., 1976. British bivalve seashells (2 ed.). Edinburgh (Her Majesty's Stationary Office), 212 pp., 110 fig., 5 pl.

Tesch, P., 1925. Geologische kaart van Nederland, 1:50.000, sheet 30, 's Gravenhage, Kwartblad IV, Haarlem (Rijks Geologische Dienst).

Thorson, G., 1946. Reproduction and larval development of Danish marine bottom invertebrates. - Meddr. Komm. Dan. Fisk. Havunders., (Ser. Plankton), 4 (1): 1 - 523.

Tijssen, S. B., 1969. Hydrographical and chemical observations in the Southern Bight, February, May, August and November, 1968. - Ann. Biol. Copenh., 25, (Part 1. Hydrography): 51 - 59, 7 fig.

Urk, R. M. van, 1973. Systematical notes on Cardium edule L. and Cardium glaucum Brug. in the Netherlands. - Basteria, 37 (5/6): 95 - 112, 14 fig.

Velde, G. van der & J. G. M. Roelofs, 1977. Ferrissia wautieri (Gastropoda, Basommatophora), nieuw voor Nederland. - Basteria, 41 (5/6): 73 - 80, 2 fig., 2 tab.

Voorthuysen, J. H. van, 1960a. Die Foraminiferen des Dollart-Ems-Estuarium. - Verh. Kon. Ned. Geol. Mijnb. Genootsch. (geol. serie), 19 Symposium Ems-Estuarium (Nordsee): 237 - 270, 11 pl.

Voorthuysen, J. H. van, 1960b. Oekologische Schlussfolgerungen. - Verh. Kon. Ned. Geol. Mijnb. Genootsch. (geol. serie). 19 Symposium Ems-Estuarium (Nordsee): 293 - 298.

Werner, B., 1939. Ueber die Entwicklung und Artunterscheidung von Muschellarven des Nordseeplanktons. - Zool. Jahrbücher, (Abt. 2.), Anatomie und Ontogenie der Tiere, 66: 1 - 55.

Zagwijn, W. H., 1965. Pollen-analytic correlations in the coastal-barrier deposits near The Hague (The Netherlands). - Meded. Geol. Stichting, (N.S.) 17: 83 - 88, 2 fig., 2 encl.