A STUDY OF MARINE MIOCENE FAUNAS IN THE "ACHTERHOEK" (NETHERLANDS, PROVINCE OF GELDERLAND), PART 1

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Summary

A brief historical review of the stratigraphy is given. Indicated is what was understood as "Hemmoor Stufe" and "Reinbek Stufe", of the latter the subdivision in "Unterstufen" is given. The basal strata of the Upper Miocene may have been deposited on a very shallow flat, causing the strandings of many whales. At the base of the miocene deposits in the region studied always a layer with rounded phosphorites and worn shark-teeth is found. Arguments for regarding Hemmoor and Reinbek Stufe as different facies of the same transgression are given by Boekschoten (1969b). A survey is given of the research of the Miocene in the Achterhoek and adjacent parts. A recent research of the differences between biocoenosis and thanatocoenosis of the Ria de Arosa (Spain) is dealt with; transport of dead material is mentioned. In addition the mistakes caused by the drilling - methods used are given. An analysis is given of the several proposed methods for counting molluscs. The method used for this research is given with arguments concerning the deviations. Indicated is the accuracy of the counting. The apex of a gastropod shell counts for one specimen, the umbo of a bivalve shell for half a specimen. Species for which another part is regarded as characteristic are mentioned, complete with the reasons. A counting-table is given for possible later statistic treatment.

Samenvatting

Een uitgebreid historisch overzicht over de stratigrafie wordt gevonden bij Thiele 1941, Sorgenfrei 1958 en Anderson 1964. Een overzicht wordt gegeven over het gebruikelijke onderscheid tussen Hemmoor Stufe en Reinbek Stufe, van de laatste wordt ook de verdeling in "Unterstufen" behandeld. De basis van het Boven-Mioceen kan zeer ondiep afgezet zijn (complete walvisskeletten), andere argumenten spreken voor een afzetting in dieper water. Onafhankelijk van de Stufe wordt aan de basis van het Mioceen een laag zwarte gerolde fosforieten gevonden. Boekschoten (1969b) is de eerste die argumenteert dat Hemmoor Stufe en Reinbek Stufe facies zijn van dezelfde transgressie. Hij stelt vast dat de op gidsfossielen gebaseerde "Stufen" in andere gebieden niet dezelfde ouderdom behoeven te hebben. Er wordt een overzicht gegeven van de belangrijkste punten in het onderzoek van het Mioceen in de Achterhoek en omgeving, zoals de kennis van Staring (1860), de boringen in de Peel tot 1918, de bewerking van deze boringen, en een gedetailleerd verslag van de resultaten van de Werkgroep voor Tertiaire en Kwartaire Geologie, zoals de ontdekking en de interpretatie van belangrijke lagen en ontsluitingen (Ticheloven, Dingden, Miste etc.). Vrij diep wordt ingegaan op een recent onderzoek over de biocoenosen en thanatocoenosen in de Ria de Arosa (Spanje) van Cadée (1968). Deze onderscheidt aan de hand van de mollusken een marginale zone tot de diepte waar de beweging van de golven nog invloed uitoefent, hieronder is een fauna aanwezig die sterk verschilt van die erboven. Transport van ondiep naar diep water is mogelijk met losgeraakt wier, de schelpen zijn dan niet afgerold. Deze getransporteerde schelpen nemen echter niet meer dan 1% van de totale fauna in beslag. Andere manieren van transport zijn in dieper water te verwaarlozen. Verschillen tussen de biocoenose en de thanatocoenose worden behandeld in verband met fluctuaties in de biocoenose. Van de thanatocoenose wordt opgegeven waardoor deze kan afwijken van de biocoenose. Bij het werken met schelpmateriaal uit boringen komt hierbij nog de onnauwkeurigheid door boorfouten. Een overzicht wordt gegeven over de methoden voor het tellen van mollusken, welke in de Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie werden voorgesteld. De methode van Van der Mark (1967) werd globaal gevolgd. De verschillende gewichtsbepalingen werden niet uitgevoerd in verband met de afwijkingen door de boormethoden veroorzaakt. De verschillende boormethoden worden behandeld en de mate van verontreiniging van de monsters wordt aangegeven. De nauwkeurigheid waarmede de schelpmonsters werden behandeld voor het tellen is aangegeven. Van de horens en de tweekleppigen werd de top beschouwd als karakteristiek. De uitzonderingen waarbij een ander karakteristiek deel werd geteld, worden geargumenteerd gegeven. Er wordt een voorbeeld gegeven van een telstaat, zodat later eventueel statistische gegevens aan deze tellingen kunnen worden ontleend.

INTRODUCTION AND ACKNOWLEDGEMENTS

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This work was started because of the need for detailed knowledge of the miocene deposits in the Achterhoek. The results of this research may be a great help for the general stratigraphic work of the Werkgroep voor Tertiaire en Kwartaire Geologie. It was also intended as a check of the method for counting molluscs as proposed by Van der Mark (1967), because at that time it was not known whether this method was useful for distinguishing strata of different age.

GENERAL HISTORY OF STRATIGRAPHIC INTERPRETATIONS OF THE MIOCENE DEPOSITS

Historic reviews of the classifications and interpretation of the strata are given by Thiele 1941, Sorgenfrei 1958, and Anderson 1964, a detailed subdivision in "Stufen" and "Unterstufen" can be found in Anderson 1961b. These subdivisions are based on molluscan faunas and especially on the occurrence of certain guide-fossils, which do not occur in other beds and on the phylogeny of certain groups (Gripp 1961c). The Hemmoor Stufe and the Reinbek Stufe are rarely found in one section; usually thay are found in different localities, so that the mutual relation had to be interpretated by means of correlation.

Hemmoor Stufe

This is a stratum with glauconitic sand and quartzsand varying from fine to rather coarse, and containing a molluscan fauna with a large amount of gastropod species. These molluscs indicate a sediment formed in shallow water. Foraminifera show in their fauna also a great amount of shallow-water species, indicating no influence of brackish water (Hilterman 1961, Indans 1962). The ostracods too suggest by their thick-walled specimens that the water cannot have been very deep (Bassiouni 1961). The species of deep-sea fish occurring in this stratum can be washed in, the remainder of the fish-fauna are indicating too a shallow water environment (Weiler 1961). Moreover, an alternation of marine sediments and terrestrial deposits can be found occasionally. Boekschoten (1969a) has a deviating opinion. He says that the Hemmoor of Winterswijk-Miste (Netherlands) must have been deposited in a rather deep sea in a non-deposit area, with regards to the many planktonic foraminifera.

Reinbek Stufe

- Laag van Ticheloven (Formation of Ticheloven)

This stratum consists of fine quartzsand with varying content of glauconite and mica. The molluscan fauna shows a rather large amount of bivalves. Most arguments are for a forming in rather shallow water (Janssen 1967).

- Dingdener Schichten (Formation of Dingden)

1. Dingden Feinsand. Sandy clays or clayey sands, with a very low percentage of mica. Indications are for deposition in rather deep water (Janssen 1967).
2. Dingden Glimmerton. Sandy clays with a varying content of mica and a rather poor molluscan fauna which is an impoverished fauna of the underlying layer. The foraminifera show gradual changes of various species (Drooger & Felix 1961) and indicate wide marine flats with a depth between 20 and 70 m.

Upper Miocene, divided in several "Stufen".

At the base of the upper-miocene beds many rests of whales and sharks have been found. The subdivision in "Stufen" is based on the evolution of molluscs (Hinsch 1952). There is little alteration in the sediments, which are merely sandy clays with high percentages of mica. Molluscs are very scarce or even absent. Arguments are found for a rather deep deposition environment, but the presence of complete skeletons of whales suggests that some parts may have been very shallow muddy flats, where whales could not orientate and stranded in masses, so attracting sharks. (Information of G. Kortenbout van der Sluijs)

General remarks

The base of the miocene deposits in the region studied can consist of the beds of the Reinbek Stufe as well as those of the Hemmoor Stufe. At the base subsequently a layer of black, hard, rounded phosphorites and worn shark-teeth of probably under-miocene age is found, a rest of sediments that have been eroded completely. There is a remarkable uniformity in interpretation among most of the authors regarding the succession of the layers. Sorgenfrei (1963, l.c. Boekschoten 1969b) was the first to doubt the justness of the neogene stratigraphy. This was studied by Boekschoten (1969b), who states that the "Stufen" have a rather weak litho-stratigraphy- and biostratigraphy-base, when only a few species are used to distinguish the "Stufen", and especially when these species are restricted to specific habitats. There is a considerable chance that layers correlated in this way do not represent the same time-interval. He also remarks that "Hemmoor", which represents shallow water, is found more landinwards, and that the "Reinbek" sediments that were deposited in deep water are found more towards the centre of the basin. Below the Reinbek beds one usually finds Oligocene, rarely Hemmoor. The easiest way to explain this is to regard the Hemmoor sediments as the shallow-water deposits, the Reinbek sediments as the deeper-water deposits of the same transgression. Boekschoten emphatically states that although the Reinbek and Hemmoor deposits are of the same age in the Lower Rhine area, this is not obligatory the case in other localities, and he gives an example that the Hemmoor and Reinbek of Wulksfelde and Langenhorn (Northern Germany) are younger than those of the Lower Rhine area.

RESEARCH IN THE "ACHTERHOEK" AND ADJACENT PARTS

The first more serious records of miocene outcrops in the region of the Achterhoek date back to 1860, when Staring gives a survey of the known localities. Most of these localities are claypits of brickworks, situated on two parallel morphological elevations, running about north-south. He states that it is possible that they may be two parts of the same formation, only secondarily separated by for instance erosion by a river (which indeed seems to be the case). These elevations range from about Ootmarsum in the north to Dingden in the south. Some differences between the various localities are mentioned, but they are not classified in a system. The known localities rich in fossils were De Giffel near Meddo and Dieter near Rekken, the latter with the fossil-horizont just lying below the surface and very badly preserved. Other localities are rather poor in fossils; mentioned are Mallem, Oldenkotte, Swilbroek, Winterswijk and Miste, and a few molluscan names are given. Staring (1860) also indicates that in several localities shark-teeth and concretions, sometimes containing impressions of shells are found. An enumeration of the species found in Rekken and De Giffel is given: 60 gastropods, 2 scaphopods and 27 bivalves were known at that time. He states that the sediments were not deposited in shallow water, as in muddy flats, but in a deeper sea, with so little movement that silt and clay could settle down. The climatic conditions in that time were those of southern Europe nowadays. All the Miocene of the Achterhoek is reckoned by him to the upper half of the Miocene. In Limburg (southern Netherlands) only continental Miocene was known to him.

In the beginning of the 20th century several borings were brought down in the Peel (a region in the province of Brabant, Netherlands). A general account of this region was given by Molengraaf & Waterschoot van der Gracht (1913). At the base Middle-Miocene is found, approximately up to 60 m thick, to the north up to 27 m thick. On top of this the "Glimmerton" (not: Dingden Glimmerton, the word is used in a sedimentological sence here) is up to 125 m thick. The Miocene of Winterswijk and Nijmegen must be situated between that of the Peel and the Upper-Miocene. The shallow miocene sea was situated in a region with a slowly sinking bottom, but it was filled up with sediments at the same rate. The depth was probably nowhere over 70 m. To the north-west the sinking is greater, so the sediments are thicker here. The borings discussed by these authors were made by means of wash-drilling and sampling was not very accurate, because of the used drilling-mud and the depths could not be measured exactly. Lots of shells were collected on sieves, but they were put together from considerably long trajects. (Waterschoot van der Gracht 1918). In later years some publications on the material from these Peel-borings have been published, one of them dealing with the stratigraphy by means of the foraminifera (Ten Dam & Reinhold 1942). According to them the basal layers have a fauna that is more or less related to that of the Hemmoor Stufe of northern Germany. On top of this there is a layer without any molluscs, containing a foraminiferal fauna that resembles much that of Winterswijk and Dingden. Other publications on molluscs from these borings are purely systematic works and do not give any new stratigraphic point of view.

The miocene deposits of the German Lower Rhine area are dealt with by Anderson 1958. The transgression here is said to have started in the south-west (only Hemmoor Stufe is found here), the area more to the north-east is reached much later during the Reinbek Stufe. The speed of the transgression is said to have been very slow.

Spaink (1959) gives an enumeration of species known from various localities. He also states that the Miocene of the Peel belongs to the Hemmoor Stufe, but that in some of the borings Upper-Miocene containing molluscs is also present. The Miocene of the eastern Netherlands (Achterhoek-region) belongs to the Dingdener Stufe (= Reinbek Stufe), according to guide-fossils.

Indans 1962 published a paper on the foraminifera of the German Lower Rhine area. According to her opinion only in one of the borings both Hemmoor Stufe and Reinbek Stufe are present. She gives a detailed map with the contents of the borings indicated.

In 1963 the Werkgroep voor Tertiaire en Kwartaire Geologie was initiated and the study of the Achterhoek-region was started. The results are published in this periodical. Van den Bosch (1964c) gave an account of the previously known localities, combined with some details on the separate localities. He also treated the correlation of the Dutch Miocene with Germany and Belgium. Based on shark-teeth he drew conclusions about the connections with seas differing from those given by Anderson (Van den Bosch 1964b). The region north of Winterswijk is continental in the beginning of the Miocene, afterwards it is inundated. During the Middle Miocene it is again continental. Janssen (1966a) mentions the occurrence of a sandy layer in Dingden below the clay in which pits were dug for collecting-purposes. He says that when correlating the fauna of Ticheloven with upper part of the Anversien, there must be a gap between the Reinbek-Stufe and the Hemmoor-Stufe. Van den Bosch (1966b) gives a standard profile of the Miocene of the eastern Netherlands: the base consists of fine sands, deposited on a transgressive conglomerate of black rounded phosphorites and shark-teeth. There are also soft unworn phosphorites which later appeared to belong to a certain stratum. On top of this dark clays are found, containing comparatively few shells, especially at the base. The fauna is in accordance with that of the Reinbek Stufe; several species are mentioned. On top of these strata a layer with vertebrates and shark-teeth is found. The water is supposed to be rather deep and the transgression was thought to be at its peak. The strata on top of these show regressive impression, with sands containing molluscs and brachiopods in abundance. Parts of fish-skeletons are also found.

The investigations of the Werkgroep voor Tertiaire en Kwartaire Geologie did reveal so much information about the Miocene that revision of the stratigraphy given by Janssen 1966a was necessary (Van den Bosch 1966b). A deep boring at Dingden was made. The lithological description was done by Van den Bosch 1966c; Janssen 1966b gives a detailed survey of the differences in the fauna from the basal layers to the top. The samples wereanalysed quantitatively; used is the system of Cadée 1966. Janssen states that there is a boundary at 8,50 m below surface, but at closer examination of his graphs it appears that all distinct changes in the fauna are restricted to very few species, while the other species only change gradually and slowly and that in this way several layers can be distinguished, which do not have a very sharp boundary. Important is the sandy basal layer, because it had already been found in the Netherlands in several places. Some species are mentioned that are restricted to this layer. A detailed research of the miocene strata in the neighbourhood of Winterswijk-Stemerdink, which has been started in 1963 is still in progress, as is illustrated by a paper of Cadée (1967). Van den Bosch (1967) revised the classification of Janssen (1966a), on account of some Belgian miocene deposits. The gap mentioned by Janssen is partly filled up by the basal layer, present in Dingden.

The knowledge of the lithostratigraphy of the Upper-Miocene is enlarged by some borings that are situated rather east in the Achterhoek (Van den Bosch 1967c). Besides of a systematical treatment of the molluscs of Dingden Janssen (1967) gives an account of the gradual differences in the fauna just as in his paper of 1966. The basal layer is named "Laag van Ticheloven", after the type - locality in the Netherlands (community of Eibergen), where it occurred not overlain by younger tertiairy strata. The sandy layer of the Formation of Dingden should not be named "Bislicher Schichten", because the profile of the type-locality of the latter has not been analysed, so that it is unknown with what part of the Dingden-section it could be correlated.

A detailed survey of the knowledge of the various layers in the Miocene is given by Van den Bosch (1967d), localities are indicated. In 1968, in some handborings in the neighbourhood of Winterswijk - Miste, a sandy layer with a typical Hemmoor fauna was discovered by H.G.Kolstee (Van den Bosch 1968). This layer of about 2.5 m was sampled by means of a digging-machine. At the top a layer of soft phosphorites is found,At the bottom a layer of black, hard, rewashed phosphorites. The section could not be studied in detail, because of the loose sediments, nor could any sample been taken. Anonymus (1968) mentions that in Ootmarsum a fauna was discovered in soft phosphorites, containing Venus scalaris and Haustator eryna (molluscs), so that its age must be between Hemmoor and Laag van Ticheloven. Boekschoten 1969 gives a list of foraminifera found in the Hemmoor deposits of Winterswijk - Miste. He states that no difference could be stated in age with for example the foraminifera in Dingden (a rather wide conception !). Planktonic elements are rather frequent, so that the depth of the sea is estimated to have been deeper than that of Dingden, which is 20 - 70 m according to Drooger & Felix 1961. He thought that these deposits were formed on top of hills in a rather deep sea, in a so called non deposit area, the molluscs needing only a bottom of rather course sediment.

Van den Bosch 1969a gives a survey of the results obtained in the years 1968 and 1969. The succession of the layers is dealt with in detail. Important species and other features are mentioned. The given situation of the "Hemmoor Stufe" of Winterswijk - Miste below the "Laag van Ticheloven" is a mere interpretation: in the Achterhoek this is nowhere demonstrated. On the drawings of the transects it can clearly be seen that the layers of the oligocene deposits (and also of the Miocene) dip to the west, and their thickness remains the same. Where they come to the surface they are obliquely cut off, which indicates that an unknown part has disappeared by erosion.

An interesting report on the underground of the surroundings of Winterswijk - Stemerdink is given by Van den Bosch 1970. He states that after the Oligocene the upper-oligocene deposits are eroded, and also that about 30 m of Rupelclay has disappeared. Only at a few places some of these deposits have not disappeared. At the base of the Miocene worn shark-teeth of lower-miocene age are found. It is not known whether this erosion has taken place before or after the Lower - Miocene. Miocene sedimentation has taken place in the whole area. Since the beginning of the Pliocene the bottom was elevated and at most places the Miocene is eroded. Only in the neighbourhood of Stemerdink a strong bottom-sinking was in progress on a salt-dome, so that the tertiairy sediments were not removed. The layers in this area are thicker than usual, since the bottom also sank and the pit was filled up by sedimentation.

STUDIES ON RECENT MOLLUSCAN BIOCOENOSES AND THANATOCOENOSES, BASED MAINLY ON CADEE (1968)

General

A zonation, based on molluscs and other assemblages can be distinguished. In bays as well as in the open ocean there is a marginal zone, divided into a shallow and a deep subzone. In the marginal shallow subzone only sand can be deposited. In the marginal deep subzone muddy sediments can settle as well, because of the decreased watermovements. The existance of the marginal zone seems to be originated by the watermovement caused by waves providing a good oxigen content. The lower margin of this zone is more or less in correspondence with the thermocline in the summer. In sheltered bays the marginal zone extends to 3 - 5 m depths, in exposed parts as the open ocean the lower margin is found at about 20 m depths. The differentiation of the shallow and the deep marginal zones is based on biocoenoses and thanatocoenoses. There is no sharp boundary, but a gradual change in relative frequencies of species. In the central bay and probably also on the shelf a part can be distinguished were very fine material is deposited. Remarkable here is a rather sharp boundary to the marginal zone.

Transport of shells

In the marginal zone there is a transport along the coast, the different biocoenoses are mixed and one thanatocoenosis is formed. In this respect it is not mentioned whether the thanatocoenosis consists of much worn shell-material. Within the marginal zone there is a transport of shells towards the coast. In the Ria de Arosa (Spain) this zone extends to a depth of about 5 m, in the Kattegat this zone should be 12 m, in exposed area like Iceland and the Faeroes this belt is about 15 m (Johanson 1901, l.c. Cadée 1968). A remarkable mechanism of transport towards deeper water is mentioned: shells of species only living in the marginal zone are found in the deeper parts without having been worn. The mean of transport is suggested to be floating algae. More distant from the coast the number of these shells is lower. The transport within the central bay is negligible, except for the influence of shells from the marginal zone, which take about 1% of the total number. Even in the English Channel transport of shells seems to be absent (Habe 1956, l.c. Cadée 1968); Cadée also states: "This absence of transport along the bottom and the quantitatively not very important admixture of shells from the marginal zone are very promising for paleontologists working with fossil faunas".

In the oceanic shelf-zone strong water-movements occur, so in deeper parts there usually has been no deposition of silt and clay. Certainly it must also be kept in mind that it is possible that most of the fine material is trapped in the bays. The thanatocoenosis consists of autochthonous species, but many shallow-water species too are found here, possibly due to recent transport and probably not to eustatic movements in geological times. This is only true for species that live on the sediment, species that live in the sediment do not show this effect.

Differences between thanatocoenosis and biocoenosis

Samples taken from the thanatocoenosis show little differences among one another, whereas the differences in samples from biocoenoses are usually striking, not only within one year in close localities, but also in the same spot in several consecutive years. The distribution of the species usually is at random, sometimes patchy; variations in distribution occur seasonally, yearly and on long term. As a thanatocoenosis is an accumulation of all autochthonous species in a longer time, a good agreement with the living fauna is not probable, although long-term differences can be noted if there is a reasonable sedimentation. Important influences on the thanatocoenosis as given by Cadée are:

- transport
- mixing with autochthonous, relatively young fossils
- selective removal by predators
- differences in rate of shell-production
- differences in mechanical destruction
- differential solubility of shells

In addition to the second point I want to mention the burrowing species; in a changing fauna they are found in association with species with which they never lived together.

Differences within the zones

The marginal zone shows a lot of differentiation in various micro-habitats, due to factors like density of algae, exposure, type of sediment etc. This will certainly influence the composition of the fauna which shows a large variation in ecology. In the thanatocoenosis, as is stated already, these differences are usually suppressed. The conditions in the central bay are rather uniform. As there is a gradual increase from the exposed outer part of the bay towards the more tranquil inland part, there are differences in the fauna, not only qualitatively but also quantitatively. The fauna of the outer bay seems to be typical for the muddy shelf. In the oceanic zone there seems to be a fair transport of fauna-elements from nearby rocks, also a great number of species is found only livingin shallow water. The correlation with the living fauna is rather poor, but the species that live in the sediment do agree better, although differences do remain.

From the foregoing it will be clear that if one wants to draw conclusions from thanatocoenoses, one must keep in mind that not a survey is given of the fauna that lived on the actual spot, but that individuals can be washed in from other zones in the neighbourhood (if any !), and that its quantitative composition can be different from that of the actual living fauna. The fauna that is found is not a reflection of the species that lived on the spot at the same moment, but an accumulation of faunulae of different years, seasons and micro-habitats.

Besides, in fossil thanatocoenoses from core-samples one has to be aware of contamination from higher levels, while the methods of taking samples are usually not accurate enough to obtain samples with a core lenght less of half a meter, so that in one sample also the factor of a change within that interval will influence the composition of the fauna. Nevertheless, it is the only way to get some information concerning the fossil faunae, so we have to except all these disadventages.

COUNTING OF MOLLUSCS

In 1964 a uniform method for comparing molluscan faunas was badley needed and the editor of this very journal asked their menbers to develop a normalised system for the counting of molluscs. The first one to react to this was Van der Mark (1965). He took 1,8 liter of sieved shells as a standard unit, and counted the total number of species, ignoring the common and larger species; from the remaining specimens he only took the entire ones. Of two very common species he only counted the specimens of 0,6 liter shell material and this number he converted into the number of 1,8 liter. The results he gave in a list, in which of each sample the total number of each species is given.

Cadée (1966) responds to Van der Mark. He gives a review of the authors who also researched mollusc-faunas quantitatively, and he states that uniformity is needed. The most important points he brought to attention are:

- all material above 2 mm should be counted, everything below that size should not be counted, but only qualitatively be mentioned as "additional fauna".
- a gastropod shell counts for one specimen, one valve of a bivalve counts for half a specimen. Fragments are estimated at their size. Fragments of hinges and axes of gastropods can also be counted. Another possibility is

to take the weight of all fragments of a species and divide this weight by the average weight of one specimen.

- count 200 specimens at a maximum. The weight os the indeterminable fragments should be estimated in relation to the determinable part.
- calculate the percentages of the species.

Van der Mark (1966) critisizes Cadée. He states that never is estimated how many fragments of larger species are found in the fractions under 2 mm and that these fragments could influence the totsl percentages of the species. It should be stated which part of a molluscs is really characteristic. He mentioned in which way systematic errors can be avoided. Janssen (1966c) immediately critisizes this paper, but not all his remarks seem to the point.

At the same time the important work of Janssen (1966b) was published, in which the results of counting molluscs from a boring in Dingden are given. The method used is that of Cadée; graphs are given of those species that have a percentage of more than 2% in one or more samples. He also gave the variation of the total number of species of bivalves, gastropods and scaphopods, and the total number of specimens of these groups in relation to the depths below surface level.

A standard-method is given by Van der Mark (1967). Important differences with the method of Cadée are-

- all specimens above 1 mm are counted
- at least 200, preferable 500 specimens are counted. Characteristic fragments count for 1 (gastropods) or ½ (bivalves)
- different weights should be executed

Additional important remarks are those concerning: a) not counting material from accumulations of transported shell-material, b) the advantages of a 1 mm sieve over a 2 mm sieve, c) about the reliability of the obtained figures. An example of fragmentation as a source for deviations is given. His calculations on correlation are hardly applicable, because he does not explain his formulae and symbols.

METHODS FOR OBTAINING THE SAMPLES

The samples were obtained by several drilling-methods. With each boring the applicated method is mentioned.

1. Edelman drill. A rather undisturbed more or less kneaded sample is obtained from the auger. No casing is used, each sample comes in contact with the overlying layers, so that the outside must be removed to avoid contamination. The auger is attached to rods of which the length is exactly known.

2. Bailer sampler. Simultaneously with the bailer a casing is let into the hole. By way of bumping with the sharp underside of the bailer on the bottom of the hole the sediment is loosened. The bailer also works like a plunger each time when it is hauled and even very fine bottom material comes up in lumps, so that there is no influence of sediment or micro-fossils of overlying strata when the sample is caught in a rather coarse sieve. Coarser material does not stick together and is mixed up with micro-fossils of overlying sediments. The shell-material brought upin this way is in excellent condition. For macro-fossils as used in this investigation this method is rather good.

3. Wash-boring. A rod with a head consisting of one or more chissels, through which water circulates, rotates in the bottom. To prevent the borehole, which does not bear a casing, from collapsing a drilling-mud is added to the boring-water. This drilling mud, by means of high specific gravity and impregnation of the wall of the hole prevents material from higher levels to fall down in the sample. This drilling-mud also incorporates the sediment in lumps. In contrast to what is often alleged it appears from the counting of the samples that mixing with material from higher levels is negligible if a suiting drilling-mud is used and if the samples are taken with care. (This is demonstrated in a boring where two drilling-methods are used and where there is no discrepancy in the percentages). The drilling-mud circulates through a mudpit, in which microfossils and sediments are suspended. To prevent these microfossils from being collected the sample is caught in a sieve, so that the liquid containing contamination flows off to the pit and an almost clean sample is achieved. This has proved to give good results, even for micro-fossils (ostracods), enclosed in the lumps of sediment. (Literature: Van den Bosch 1966e, 1967a).

METHOD USED FOR STUDY OF SAMPLES

A portion of each sample is kept separate for lithologic studies, the remainder is washed on a 1 mm standard sieve. Large residues are carefully homogenised and so much is removed that a sufficient small quantity is attained. Homogenising is necessary because a sorting to weight and size is achieved by decantation. With small residues less than 500 specimens this is not necessary, because the whole sample will be counted. The residue is spread into a small, shallow tray, attention is to be paid that there is no sorting (small gastropod shells are wont to roll to the sides). The tray is searched from one side to another and characteristic parts of molluscs are sorted out. Also non-molluscs, concretions, pyrite etc. are kept apart, but not used for this investigation.

As characteristic parts of molluscs are taken: the apex of gastropods and the umbo of bivalves. Each gastropod counts for one specimen, each valve of a bivalve for one half. Exceptions were made for several species:

- Pectinidae : two separate "ears" count for half a specimen
- Corbula gibba : the innerside of the shell is counted, because the outerside easily splits off, the umbo of this part being rather fragile
- Thracia ventricosa : all parts with the thickened hinge-part were counted
- Cochlodesma praetenue : all parts with the chondrophore were counted
- Scaphopoda : all fragments are sorted out, the maximum number of specimens is estimated from the diameter of the fragments
- Ringicula buccinea : the thickened outer lip was counted

Of each sample so many specimens were counted that 100 specimens were achieved, included characteristic parts that could not be determined. The number of each species then represents its percentage. This procedure is repeated five times for each sample (if the sample was large enough !). Often large differences for the same species appear in the detailed countings of a sample, but in general the method of counting only 100 specimens is useful for routine-controls to determine the place of a certain layer by means of its fauna-contents in relation to already known profiles. As an example of deviation in numbers in one sample when counting, a complete list is given of the counting of 500 specimens. It can be used for calculations to control the reliability of the results, given in part 2 (see page 73).

COUNTING-METHOD USED

As a basis I have used the method of Van der Mark (1967) with a few alternations. As t he samples are sometimes caught in a sieve, so that only lumps of sediment and all the shell-material are caught and sometimes the whole sample is put in a bucket to settle down, it is useless to determine the percentage of the weight of the shells as compared to the residue. Another factor that will influence the relation is the rust which comes off the casing.

The results of such an investigation can only be a rough survey of the more common species, for the less abundant species are in this respect of minor importance. The number of the more abundant species is also an approximation of the real number in the total fauna. In this respect it is of no importance that

rare species are not counted. That very small specimens are not counted is regrettable, but their number in the material below 1 mm is rather small, while the advantage in time is considerable. Furthermore, when counting a not-sieved sample, the differences in size will influence the accuracy of the countings to such an extend that the data will be much less reliable. When using the method of counting only characteristic parts, the advantage is that it is much less time-consuming, while one is consequent with all species. The results can be compared more properly. Of less frequent species there are also less characteristic fragments, so that the change to spot them does not compare unfavourably that of other species of which only the characteristic parts are taken. The method of taking all fragments and estimating the minimum number of less common species can be critisized, because in this case more attention is paid to the species that are of minor importance, while one is not consequent, because of the more common species only the characteristic parts are counted and one arrives at a too low number especially for these more important species. Moreover, only of a part of the species the fragments can be identified.
When comparing the results of several samples of one boring with one another, one should keep in mind that while the other species remain the same, an absolute increase of one species gives an absolute decrease of the other species from one layer in relation to the other. In the graphs the increase of one species is somewhat flattered, although, because of the great number of species this does not play such an important role. With broken or very eroded material all parts of the molluscs will become less identifiable, so that this will influence both methods.

REVISION OF THE NOMENCLATURE OF THE SPECIES DEALT WITH IN THIS INVESTIGATION (FRIENDLY DONE BY A. W. JANSSEN, LEIDEN)

Introductory remarks

If instead of a speciesname the abbreviation "sp." is used, several species are usually meant. A note of interrogation (?) before the name of a genus means that it is doubtful whether the species belongs to that particular genus. The epithet determination is not questionnable. Remarks to several species are listed at the end of the enumeration of species, numbers between brackets after the speciesname referring to this remarks.

Species occurring in the analysed samples

Bivalvia

Nucula (s.lat.) sp.
Nuculana (Saccella) westendorpi (Nyst 1839)
Portlandia (Portlandia) curvirostris (Lehmann 1885)
Portlandia (Yoldiella) pygmaea pygmaea (Münster 1837)
Portlandia (Yoldiella) sp. ? n.
Yoldia (Yoldia) glaberrima (Münster 1837)
Bathyarca pectunculoides (Scacchi 1834)
Anadara (Anadara) diluvii (Lamarck 1805)
Limopsis (Limopsis) aurita (Brocchi 1814)
Limopsis (Pectunculina) retifera Semper 1861
Limopsis (Pectunculina) lamellata (Lehmann 1893)
Glycymeris (Glycymeris) lunulata baldii Glibert & Van de Poel 1965
Arcoperna sericea (Bronn 1831)
Modiolula phaseolina (Philippi 1844)
Korobkovia woodi (Nyst 1861)
Aequipecten angelonii (Stefani & Pantanelli 1880) s.lat.
Pseudamussium lilli (Push 1837)
Pododesmus (Heteranomia) squamula (Linné 1758)
Limaria (Limatulella) loscombii (Sowerby 1820)
Limea (Limea) aff. strigillata (Brocchi 1814) (note 1)
Limatula sulcata (Brown 1827)
Limidae sp.
Cavilucina droueti (Nyst 1861)
Lucinoma borealis (Linné 1767)
Thyasira (Thyasira) sp. (note 2)
Diplodonta (Diplodonta) rotundata (Montagu 1803)
Erycinidae sp.
Lepton transversarium Cossmann 1895
? Tellimya aff. coarctata (Wood 1850) (note 3)
Spaniorinus cimbricus (Kautsky 1925)
Anisodonta duvergieri Cossmann & Peyrot 1909
Cyclocardia (Cyclocardia) chamaeformis (Sowerby 1825)
Erycinella chavani (Glibert 1945)
Astarte (Astarte) gracilis (Münster 1835) s. lat. (note 4)
Astarte (Astarte) radiata Nyst & Westendorp 1839
Astarte (Astarte) kickxi Nyst 1835
Astarte (? Astarte) waeli Glibert 1945
Goodallia (Goodallia) angulata (Lehmann 1885)
Goodallia (? Goodallia) laevigata (Münster 1835) subsp. n.
Parvicardium straeleni (Glibert 1945)
Parvicardium aff. scabrum (Philippi 1844)
Nemocardium (Nemocardium) cyprium (Brocchi 1814) (note 5)
Laevicardium (? Laevicardium) dingdense Lehmann 1885 (note 5)
Spisula (Spisula) sp. (note 6)
Phaxas (Phaxas) pellucidus (Pennant 1777)
Ensis sp.
Angulus (Moerella) aff. donacilla (Wood 1857) (note 7)
Angulus (Peronaea) fallax (Lehmann 1893)
Macoma (? Psammacoma) elliptica (Brocchi 1814)
Gari (Psammobia) affinis (Dujardin 1837)
Abra (Abra) sorgenfreii Anderson 1964

Abra (? Abra) lehmanni Anderson 1964
Azorinus (Azorinus) chamasolen miocaenicus (Cossmann & Peyrot 1909)
Arctica islandica (Linné 1767)
Lutetia (Spaniodontella) nitida (Reuss 1867)
Glossus (Glossus) lunulatus (Nyst 1835) (note 8)
Venus (Ventricoloidea) multilamella (Lamarck 1818)
Gouldia (Gouldia) minima (Montagu 1803)
Pitar (Pitar) rudis rudis (Poli 1795)
Pelecyora (Cordiopsis) polytropa nysti (Orbigny 1852)
Clausinella scalaris (Bronn 1831)
Timoclea (Timoclea) ovata (Pennant 1777)
Veneridae sp.
Corbula (Varicorbula) gibba (Olivi 1792)
Hiatella (Hiatella) arctica (Linné 1767)
Saxicavella pusilla Sorgenfrei 1958
Panopea (Panopea meynardi Deshayes 1828
Teredinidae and/or Xylophagainae sp.
Cochlodesma (Bontaea) aff. praetenue (Pulteney 1799)
Thracia (Thracia) ventricosa Philippi 1844
Poromya (Poromya) neaeroides Seguenza 1876
Haliris (Haliris) sp.
Cuspidaria (Cuspidaria) sp. (note 9)
Cardiomya (Cardiomya) costellata (Deshayes 1832)
Bivalvia sp. indet.

Scaphopoda

Dentalium (Dentalium) mutabile Doderlein 1856
Dentalium (Antalis) dumasi Cossmann & Peyrot 1919
Dentalium (s.lat.) sp. (note 10)
Cadulus (Gadila) gadus (Montagu 1803)

Gastropoda

? Scurria compressiuscula (Karsten 1849) (note 11)
Solariella (Solariella) formosa Janssen 1967
Solariella (Solariella) sp.
Calliostoma (Ampullotrochus) sp. (note 12)
Circulus praecedens praecedens (Koenen 1882)
Circulus hennei Glibert 1952
Putilla (? Ovirissoa) gottscheana westfalica Janssen 1967
Alvania (Alvania) holsatica Anderson 1960
Alvania (Alvinia) pseudopartschi Anderson 1960
Teinostoma (Solariorbis) hosiusi Janssen 1967
Tornus (s.lat.) trigonostoma (Basterot 1825)
Architectonica (Pseudotorinia) berthae (Boettger 1915)
Architectonica (s.lat.) sp.
Haustator (Haustator) eryna (Orbigny 1852)
Archimediella (Torculoidella) subangulata (Brocchi 1814)
Bittium (Bittium) spina (Hoernes 1855)
Bittium (Bittium) tenuispina Sorgenfrei 1958
Triphora (Triphora) fritschi (Koenen 1882)
Cerithiella genei (Bellardi & Michelotti 1840)
Cerithiopsis (Cerithiopsis) sp.
Amaea (Acrilla) amoena subreticulata (Orbigny 1852)
Acirsa (Hemiacirsa) lanceolata (Brocchi 1814)

Opalia (Pliciscala) pertusa (Nyst 1871)
Opalia (Nodiscala) sp. ? n.
Opalia (Nodiscala) pontileviensis (Boury 1903)
Turriscala (s.lat.) straeleni (Glibert 1952)
Cirsotrema (Discoscala) scaberrimum (Michelotti 1847)
Epitonium (Cinctoscala) linoe (Anderson 1964)
Epitonium (Spiniscala) frondiculum (Wood 1848)
Epitonium (Spiniscala) weyersi (Nyst 1871)
Epitoniidae sp.
Strombiformis (Strombiformis) glaber (Costa 1778) s.lat.
Melanella (Polygyreulima) glabella (Wood 1848)
Melanella (Balcis) alba (Costa 1778)
Niso (Niso) terebellum acarinatoconicum Sacco 1892
Aporrhais (Aporrhais) alata (Eichwald 1830)
Calyptraea (Calyptraea) chinensis (Linné 1758)
Xenophora deshayesi (Michelotti 1847)
Naticidae sp. (note 13)
Phalium (Semicassis) bicoronatum bicoronatum (Beyrich 1854)
Eudolium dingdense Anderson 1964
Charonia (Sassia) tarbelliana (Grateloup 1833)
Ficus conditus (Brongniart 1823)
Murex (Haustellum) inornatus Beyrich 1854
Typhis (Typhis) pungens (Solander 1766)
Lyrotyphis (Eotyphis) sejunctus priscus (Rutot 1876)
Hadriania coelata (Grateloup 1840)
Tritonalia (? Ceratostoma) sp. n.
Mitrella (Macrurella) nassoides (Grateloup 1827)
Anachis (Costoanachis) corrugata (Brocchi 1814)
Anachis (Costoanachis) pulchella (Dujardin 1837)
Scalaspira (Scalaspira) festiva (Beyrich 1856)
Phos (Phos) decussatus (Koenen 1872)
Amyclina badensis (Hoernes 1852)
Amyclina facki (Koenen 1872)
Hinia (s.lat.) schroederi (Kautsky 1925)
Hinia (s.lat.) bocholtensis (Beyrich 1854)
Hinia (s.lat.) turbinella (Brocchi 1814)
Hinia (s.lat.) cimbrica (Ravn 1907)
Hinia (s.lat.) holsatica (Beyrich 1854)
Hinia (s.lat.) tenuistriata (Beyrich 1854)
Hinia (s.lat.) c.f. serraticosta (Bronn 1831)
Nassariidae sp.
Vexillum (s.lat.) sp.
Latirus (Pseudolatirus) rothi (Beyrich 1856)
Streptochetus (Streptochetus) sexcostatus (Beyrich 1856)
? Streptochetus (subg. n.) contiguus (Beyrich 1856) (note 14)
Ancilla (Baryspira) obsoleta (Brocchi 1814)
Cancellaria (Merica) sp. n.
Trigonostoma (Trigonostoma) spinifera (Grateloup1832) subsp. n.
Trigonostoma (Trigonostoma) aperta (Beyrich 1856)
Narona (Sveltia) varicosa (Brocchi 1814)
Babylonella fusiformis (Cantraine 1835)
Cancellariidae sp.
Gemmula (Gemmula) stoffelsi (Nyst 1843)
Gemmula (Gemmula) boreoturricula (Kautsky 1925)
Gemmula (Gemmula) denticula borealis (Glibert 1954)

Gemmula (Gemmula) zimmermanni (Philippi 1846)
Turris (Fusiturris) aquensis (Grateloup 1832)
Turris (Fusiturris) duchasteli flexiplicata (Kautsky 1925)
Epalxis (Bathytoma) cataphracta (Brocchi 1814) s. lat.
Turricula (Turricula) steinvorthi (Koenen 1872)
Genota (Genota) ramosa (Basterot 1825)
Clavus (Cymatosyrinx) selenkae (Koenen 1872)
Crassispira (Crassispira) borealis (Kautsky 1925)
Brachytoma obtusangula (Brocchi 1814)
Brachytoma pannoides (Koenen 1872)
? Brachytoma hispidula (Bellardi 1848) sensu Anderson 1964
? Microdrillia grippi Anderson 1964
Asthenotoma festiva (Hoernes 1854)
Boereodrillia hosiusi (Koenen 1872)
Borsonia uniplicata Koenen 1872
Aphanitoma debilis (Beyrich 1856)
Haedropleura maitreja (Koenen 1872)
? Bela tenella (Mayer 1858)
? Bela calais (Kautsky 1925) sensu Anderson 1964
Mangeliidae sp.
Pleurotomoides borealis (Kautsky 1925)
Pleurotomoides luisae (Koenen 1872)
Pleurotomoides campanulata Sorgenfrei 1958
Raphitoma (Philbertia) scabra (Philippi 1856) sensu Sorgenfrei 1958
Metuonella grippi (Kautsky 1925)
Teretia anceps (Eichwald 1830)
Turridae sp.
Conus (Conolithus) antediluvianus Bruguière 1792 s.lat. (note 15)
Strioterebrum hoernesi (Beyrich 1854)
Chrysallida (Pyrgulina) pygmaea (Grateloup 1838) s. lat.
Chrysallida (s.lat.) sp.
Phasianema (? Phasianema) sp. n.
Menestho (Menestho) nordmanni (Sorgenfrei 1958)
Odostomia (s.lat.) sp.
Syrnola (Syrnola) hoernesi (Koenen 1882) (note 16)
Eulimella aff. acicula (Philippi 1836)
Turbonilla (s.lat.) sp. (note 17)
Pyramidella (Pyramidella) plicosa (Bronn 1830)
Pyramidella (Pyramidella) sp.
Actaeonidae sp.
Crenilabium terebelloides (Philippi 1843)
Ringicula (Rin giculina) buccinea (Brocchi 1814) s.lat.
? Actaeocina bellardii (Koenen 1882)
Cylichna (Cylichna) aff. cylindracea (Pennant 1777) (note 18)
Roxania (Roxania) utriculus (Brocchi 1814)
Roxania (subg. n.) paucistriata (Ravn 1907)
Scaphander (Scaphander) grateloupi (Michelotti 1847)
Retusa (Cylichnina) elongata (Eichwald 1830) s.lat.
Rhizorus acuminatus (Bruguière 1792)
Vaginella depressa Daudin 1900
Gastropoda sp. indet.

Notes

1. The material of this species known from the Miocene of the North Sea basin diverges from that of the Neogene of Italy by the radial sculpture being more robust. The difference is so considerable that the two forms surely must be regarded as subspecific different, probably even must be kept as two different species.

2. Including Axinulus sp.

3. "Montacuta" coarctata auct. differs distincly of the types of as well Montacuta as Tellimya. It is probable that a new genus has to be made for this species. Moreover it is not yet sure that the miocene species fit in the species described from the Pliocene, the specimens of the latter showing in general a stronger curving of the lower margin.

4. Including Astarte (Astarte) goldfussi Hinsch. Both forms cannot be distinguished on specific level as there are many intermediates; therefor it is proposed here to regard these forms as Astarte (Astarte) gracilis gracilis (Münster 1835) and Astarte (Astarte) gracilis goldfussi Hinsch 1952.

5. Juvenile, strongly damaged or corroded specimens of Nemocardium (Nemocardium) cyprium are hard to distinguish from those of Laevicardium (? Laevicardium) dingdense, so when counting the samples they were put together. They are cited as Nemocardium cyprium in the text, because this species is the more abundant.

6. The Spisula from the miocene deposits was usually regarded to belong to Spisula subtruncata triangula (Brocchi 1814), but the pos ession of a not-grooved lunula and area and a differently bent mantle-impression indicates it to belong to another species. Only after examination of the type-material can be decided if the name triangula can be used.

7. This species was determined Angulus donacina (Linné 1767) by Anderson 1964, but this is not correct. If the material is conspecific with the species of Wood (as suggested in a recent paper by Glibert & Van de Poel) can only be decided by comparing it with the type-material.

8. The material of Glossus is usually so fragmentary that not can be decided if we are dealing with G. humanus or with G. lunulatus, but since G. lunulatus is the only species known from the middle-miocene deposits from our area the fragments are regarded to belong to this species. Revision of the nomenclature of Glossus from the Neogene of the North Sea basin is needed.

9. This species is usually regarded to belong to Cuspidaria cuspidata (Olivi 1792), but when comparing it with recent material it appears to be considerable different.

10. All smooth species of Dentalium, belonging to the subgenera Laevidentalium and Fustiaria are taken here together.

11. According to A. Warén (in litt.) "Scurria" compressiuscula belongs to a genus in the Cocculinacea.

12. The material belongs to two species, that are kept together here because of the usually juvenile and fragmentary material.

13. The species of the genera Natica and Polinices were kept together under the name Naticidae, because of the usually badly preserved or juvenile material.

14. "Streptochetus" contiguus surely does not belong to one of the existing subgenera in this genus, and probably it does not even belong in this genus.

15. Including C. dujardini (Deshayes 1845), which is no more as a subspecies.

16. Including Syrnola (Syrnola) neumayri (Koenen 1882). These two forms are not separable because of the many intermediates.

17. All species of this genus are kept together here, as for several reasons it was impossible to keep the many species separate.

18. Cylichna "cylindracea" from the Miocene of the North Sea basin is different from the recent specimens of this species. New investigations are required.

EXAMPLE OF A COUNTING-LIST AS OBTAINED FROM ONE SAMPLE

Column one to five indicate the percentages of the species out of 100 specimens, column six the total numbers of the species found in these 500 specimens, column seven indicates the percentages.

Winterswijk - Miste, sample 3.75 - 4.00 m below surface.

	1	2	3	4	5	6	7
Nucula sp.	-	-	1	-	-	1,0	0,2
Nuculana westendorpi	0,5	1	0,5	0,5	1	3,5	0,7
Portlandia pygmaea pygmaea	3,5	2	4	2	4,5	16,0	3,2
Yoldia glaberrima	2	1	-	0,5	1,5	5,0	1,0
Anadara diluvii	1	1,5	1	-	-	3,5	0,7
Limopsis aurita	0,5	-	0,5	0,5	1	2,5	0,5
Limopsis retifera	-	-	-	1,5	-	1,5	0,3
Limopsis lamellata	-	-	0,5	-	-	0,5	0,1
Glycymeris lunulata baldii	0,5	-	0,5	-	-	1,0	0,2
Pseudamussium lilli	0,5	0,5	0,5	1	0,5	3,0	0,6
Pododesmus squamula	-	-	1	-	-	1,0	0,2
Limea aff. strigillata	-	-	-	0,5	-	0,5	0,1
Cavilucina droueti	1,5	2	1,5	1,5	1,5	8,0	1,6
Lucinoma borealis	-	1,5	-	0,5	0,5	2,5	0,5
Diplodonta rotundata	-	0,5	0,5	0,5	-	1,5	0,3
Cyclocardia chamaeformis	0,5	-	1,5	1	0,5	3,5	0,7
Erycinella chavani	1,5	-	1,5	-	2	5,0	1,0
Astarte gracilis	2	3	1,5	1,5	2	10,0	2,0
Astarte radiata	0,5	2	1,5	1	1	6,0	1,2
Astarte waeli	1,5	0,5	0,5	-	1,0	3,5	0,7
Goodallia angulata	-	-	1	-	1,5	2,5	0,5
Goodallia laevigata	0,5	0,5	-	-	-	1,0	0,2
Nemocardium cyprium	2	1	3	1	1	8,0	1,6
Spisula sp.	1	2,5	2	1	1,5	8,0	1,6
Phaxas pellucidus	-	-	-	-	0,5	0,5	0,1
Angulus aff. donacilla	-	-	1	0,5	1	2,5	0,5
Macoma elliptica	-	-	0,5	0,5	1,5	2,5	0,5
Abra sorgenfreii	1,5	2	-	2	2,5	8,0	1,6
Lutetia nitida	-	-	-	1	-	1,0	0,2
Venus multilamella	1	0,5	0,5	1,5	1	4,5	0,9
Gouldia minima	2	1	1	1	3,5	8,5	1,7
Corbula gibba	2,5	1	1,5	2,5	1,5	9,0	1,8
Hiatella arctica	10,5	9,5	21	17,5	12,5	71,0	14,2
Saxicavella pusilla	-	-	0,5	-	-	0,5	0,1
Thracia ventricosa	0,5	0,5	-	-	-	1,0	0,2
Cardiomya costellata	-	-	-	0,5	-	0,5	0,1
Bivalvia sp. indet.	0,5	-	1	0,5	-	2,0	0,4

Dentalium mutabile	2	1	-	-	2	5,0	1,0
Dentalium dumasi	1	-	-	-	-	1,0	0,2
Cadulus gadus	2	4	4	3	4	17,0	3,4
Dentalium sp.	6	2	3	1	-	12,0	2,4
Scurria compressiuscula	-	1	1	1	1	4,0	0,8
Haustator eryna	-	3	3	1	1	8,0	1,6
Archimediella subangulata	3	1	-	1	1	6,0	1,2
Bittium spina	-	-	2	3	1	6,0	1,2
Acirsa lanceolata	-	-	-	1	-	1,0	0,2
Strombiformis glaber	-	-	1	1	-	2,0	0,4
Melanella alba	-	-	1	-	-	1,0	0,2
Niso terebellum acarinatoconica	-	-	1	-	-	1,0	0,2
Aporrhais alata	4	6	4	5	8	27,0	5,4
Xenophora deshayesi	-	-	-	1	-	1,0	0,2
Naticidae sp.	6	4	3	4	6	23,0	4,6
Phalium bicoronatum bicoronatum	1	1	1	-	-	3,0	0,6
Ficus conditus	-	1	1	1	-	3,0	0,6
Murex inornatus	-	-	-	1	-	1,0	0,2
Mitrella nassoides	-	-	-	-	2	2,0	0,4
Anachis corrugata	-	-	-	-	2	2,0	0,4
Anachis pulchella	-	1	-	1	1	3,0	0,6
Amyclina facki	8	11	6	4	5	34,0	6,8
Hinia schroederi	-	1	1	-	-	2,0	0,4
Hinia turbinella	2	3	1	-	1	7,0	1,4
Nassariidae sp.	-	-	-	-	1	1,0	0,2
Latirus rothi	1	-	-	2	-	3,0	0,6
Streptochetus sexcostatus	-	1	-	-	-	1,0	0,2
Ancilla obsoleta	-	-	-	-	1	1,0	0,2
Narona varicosa	1	-	-	-	-	1,0	0,2
Babylonella fusiformis	-	-	-	1	-	1,0	0,2
Cancellariidae sp.	-	1	-	-	-	1,0	0,2
Gemmula stoffelsi	-	-	-	-	1	1,0	0,2
Gemmula denticula borealis	-	1	-	-	1	2,0	0,4
Clavus selenkae	-	-	1	-	-	1,0	0,2
Crassispira borealis	1	-	1	-	-	2,0	0,4
Brachytoma obtusangula	-	1	-	-	-	1,0	0,2
Asthenotoma festiva	-	3	4	1	1	9,0	1,8
Boreodrillia hosiusi	1	-	1	-	-	2,0	0,4
Bela tenella	1	1	1	-	-	3,0	0,6
Pleurotomoides campanulata	-	1	-	-	-	1,0	0,2
Teretia anceps	-	-	-	-	1	1,0	0,2
Turridae sp.	-	-	-	1	3	4,0	0,8
Strioterebrum hoernesi	-	-	-	1	-	1,0	0,2
Actaeonidae sp.	-	-	-	1	1	2,0	0,4
Ringicula buccinea	12	13	4	11	8	48,0	9,6
Cylichna aff. cylindracea	2	-	1	2	-	5,0	1,0
Roxania utriculus	-	-	-	1	-	1,0	0,2
Roxania paucistriata	-	-	-	1	-	1,0	0,2
Retusa elongata	3	1	1	3	1	9,0	1,8
Rhizorus acuminatus	-	2	-	-	-	2,0	0,4
Vaginella depressa	3	-	-	1	-	4,0	0,8
Gastropoda sp. indet.	2	-	2	3	1	8,0	1,6
sum total	100	100	100	100	100	500,0	100 %

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