

NEW OTOLITHS FROM THE SYLTIAN (LATE MIOCENE) OF THE MORSUM CLIFF,
ISLAND OF SYLT (FEDERAL REPUBLIC OF GERMANY),
AND THE PALAEOGEOGRAPHY OF THE NORTH SEA BASIN
DURING AND AFTER THE SYLTIAN

by

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Additional otoliths enlarge the knowledge of the Siltian fauna. Two new genera, viz. *Doyenneichthys* and *Conferencea*, and two new species, viz. *Pseudocolliolus curvidorsalis* and *Melanogrammus morsumensis*, are described. Other species new for the Siltian are *Clupeidarum* sp., *Trisopterus capelanus*, *T. incognitus* and ?*Berycidarum* sp., increasing the total number of species to 46.

The Siltian corresponds to the *Doyenneichthys siltensis* Range Zone (otolith zone 16, Gaemers, in press). The evolution of the *Doyenneichthys* lineage demonstrates the presence of a large hiatus between the Siltian and the Kattendijkian. This hiatus can be explained by the reported world-wide regression during the Messinian, which probably caused the emergence of a large part of the North Sea shelf above sea-level.

Otoliths found in the Venlo Graben show that the Delden Member represents the Siltian in the Netherlands. Fully marine Siltian deposits were recognized at 20 localities in NW-Germany, Denmark and The Netherlands, demonstrating a much more extensive transgression during the Siltian than previously thought.

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SAMENVATTING

Aanvullend otolietenmateriaal van het Morsum-Klif op het eiland Sylt, de type-lokaliteit van het Syltien, wordt in deze publikatie beschreven. Er zijn twee nieuwe soorten, namelijk *Pseudocolliolus curvidorsalis* en *Melanogrammus morsumensis*. Andere soorten die nieuw zijn voor het Syltien van Sylt zijn *Clupeidarum* sp., *Trisopterus capelanus*, *T. incognitus* en ?*Berycidarum* sp., waardoor het totaal aantal soorten beenvissen waarvan de otolieten bekend zijn op 46 is gebracht. Ook worden er twee nieuwe genera beschreven, namelijk *Doyenneichthys* en *Conferencea*, en worden enkele soorten gerediveerd.

Een zorgvuldig verzameld en uitgepikt monster van het Niveau met *Aporrhais* toont aan, dat otolieten in deze laag aanzienlijk sterker geconcentreerd zijn dan in de lagen die er onmiddellijk onder en boven liggen. Het aantal otolieten per kg droog sediment bedraagt meer dan 100.

Het Syltien correspondeert met de *Doyenneichthys syltensis* Range Zone (otolietenzone 16; Gaemers, in press). Er moet een groot hiaat aanwezig zijn tussen het Syltien en het Kattendijkien op grond van "missing links" in de *Doyenneichthys*-evolutielijn. De aanwezigheid van dit hiaat kan verklaard worden door de wereldwijde regressie tijdens het Messinien (Vail et al., 1977) waardoor waarschijnlijk een groot deel van het continentaal plat van de Noordzee droogviel.

In de Venlo Slenk zijn otolieten van *Doyenneichthys syltensis* gevonden in de Delden Member. Deze otolieten tonen aan, dat de Delden Member het Syltien vertegenwoordigt in Nederland. Volmariene afzettingen uit het Syltien zijn herkend op 20 vindplaatsen in Noordwest-Duitsland, Denemarken en Nederland. Hieruit blijkt, dat de transgressie tijdens het Syltien veel uitgebreider was dan men tot nu toe had aangenomen (zie fig. 1).

INTRODUCTION

Additional material of the type locality of the Syltian became available and is described in this paper. Furthermore it was necessary to revise some taxa. The re-examination of the material of some species caused some changes in the total number of specimens per stratum. Therefore a new distribution table of the species is given (tab. 1).

Mr U. von Hacht (Hamburg, Federal Republic of Germany) placed a fine otolith collection at my disposal from the *Aporrhais* bed (see Bosseau & Klockenhoff, 1977). These otoliths were sorted out from a sediment sample of about 10 kg (wet weight) collected by him in October 1978. The residue yielded 930 recognizable otoliths, but the real number of otoliths certainly was higher because of a considerable number of fragments which could not be identified at species level. Probably the sample contained over a thousand otoliths. It can be concluded that the number of otoliths per kg sediment (dry weight) was well over 100. This number is much higher than the figure obtained for the samples collected by Mr A. W. Janssen (Rijksmuseum van Geologie en Mineralogie, RGM, in Leiden) (Gaemers & Schwarzhans, 1982, p. 119). The big difference in number of otoliths per weight unit of sediment can be explained as follows. The *Aporrhais* bed is a very thin horizon (about 4 cm thick) which is very rich in fossils, also in otoliths, whereas the beds immediately below and above it are poor in fossils. It is difficult to collect large samples from this thin bed which have not been mixed with sediment from the surrounding horizons. Mr Von Hacht apparently succeeded in collecting a very pure sample from the *Aporrhais* bed; earlier samples of this horizon

| Species | Horizon with <i>Ditrupe</i> bed (RGM) | Percentages of most common species | Horizon wit <i>Aporrhais</i> bed (RGM) | Percentages of most common species | Horizon with <i>Aporrhais</i> bed other collections | <i>Aporrhais</i> bed (coll. U. von Hacht) | Percentages of most common species | Horizon unknown (coll. F. Weinbrecht) |
|--|---------------------------------------|------------------------------------|--|------------------------------------|---|---|------------------------------------|---------------------------------------|
| 1. <i>Congridarum acutirostris</i> Gaemers & Schwarzahans, 1982 | - | | 1 | | - | 1 | | - |
| 2. <i>Clupeidarum opisthonomus</i> Gaemers & Schwarzahans, 1982 | 1 | | 8 | | 1 | 2 | | - |
| 3. <i>Clupeidarum</i> sp. | 1 | | - | | - | - | | - |
| 4. <i>Osmerus jansseni</i> Gaemers & Schwarzahans, 1982 | - | | 1 | | - | - | | - |
| 5. <i>Argentina</i> sp. | 2 | | 1 | | 1 | - | | - |
| 6. <i>Maurolicus spinus</i> (Heinrich, 1969) | 2 | | 2 | | - | - | | - |
| 7. ? <i>Synodidarum xenosus</i> Gaemers & Schwarzahans, 1982 | 5 | | 2 | | 1 | 2 | | - |
| 8. <i>Notolepis inconspicua</i> Gaemers & Schwarzahans, 1982 | - | | 1 | | - | - | | - |
| 9. <i>Diaphus debilis</i> (Koken, 1891) | - | | 5 | | 2 | 2 | | - |
| 10. <i>Myctophidarum biexcisus</i> Gaemers & Schwarzahans, 1982 | - | | - | | - | - | | - |
| 11. <i>Raniceps</i> sp. | - | | - | | - | - | | - |
| 12. <i>Colliolus friedbergi</i> (Chaine & Duvergier, 1928) | 91 | 11.5 | 311 | 9.2 | 578 | 188 | 20.2 | 19 |
| 13. <i>Pseudocolliolus curvidorsalis</i> n. sp. | - | | - | | - | - | | 5 |
| 14. <i>Doyenneichthys syltensis</i> (Gaemers & Schwarzahans, 1982) | 516 | 65.4 | 2092 | 61.9 | 2217 | 569 | 61.2 | 36 |
| 15. <i>Gadichthys venustus</i> (Koken, 1891) | - | | 1 | | - | 1 | | - |
| 16. <i>Conferencea irregularis</i> (Gaemers, 1973) | 129 | 16.3 | 621 | 18.4 | 195 | 58 | 6.2 | 28 |
| 17. <i>Trisopterus angustus</i> Gaemers & Schwarzahans, 1982 | 1 | 0.1 | 83 | 2.5 | 51 | 29 | 3.1 | - |
| 18. <i>Trisopterus capelanus</i> (Lacepède, 1800) | 1 | | 1 | | - | - | | - |
| 19. <i>Trisopterus incognitus</i> Gaemers, 1976 | - | | - | | 1 | 1 | | - |
| 20. <i>Melanogrammus morsumensis</i> n. sp. | - | | 1 | | - | 1 | | - |
| 21. <i>Phycis tenuis</i> (Koken, 1891) | 7 | 0.9 | 88 | 2.6 | 57 | 39 | 4.2 | 2 |
| 22. <i>Ciliata simplicissima</i> (Schubert, 1906) | - | | 7 | | 2 | - | | - |
| 23. <i>Enchelyopus</i> sp. | - | | 1 | | - | - | | - |
| 24. <i>Gaidropsarinarum</i> sp. | - | | 1 | | - | - | | - |
| 25. <i>Merluccius albidus</i> (Mitchill, 1818) | 10 | 1.3 | 52 | 1.5 | 24 | 16 | 1.7 | 1 |
| 26. <i>Neobythitinarum</i> sp. | - | | 1 | | - | - | | - |
| 27. <i>Morone rectidorsalis</i> Gaemers & Schwarzahans, 1982 | 1 | | 4 | | 3 | 3 | | - |
| 28. <i>Argyrosomus holisaticus</i> (Koken, 1891) | - | | 2 | | 1 | - | | - |
| 29. <i>Sciaenidarum staringi</i> Posthumus, 1923 | - | | 1 | | 2 | 3 | | - |
| 30. <i>Sciaenidarum beseli</i> Gaemers & Schwarzahans, 1982 | - | | 6 | | 3 | - | | - |
| 31. <i>Percoideorum fitchi</i> (Gaemers & Schwarzahans, 1982) | 8 | 1.0 | 31 | 0.9 | 2 | 4 | | 1 |
| 32. <i>Hyperoplus</i> sp. | - | | 1 | | 1 | 1 | | - |
| 33. <i>Gobius pretiosus</i> Procházka, 1893 | - | | 14 | | 5 | 2 | | - |
| 34. <i>Pomatoschistus</i> sp. | 5 | | 5 | | - | - | | - |
| 35. <i>Lycodes lobatus</i> Gaemers & Schwarzahans, 1982 | - | | - | | - | - | | - |
| 36. <i>Perciformorum</i> sp. | - | | - | | 1 | - | | - |
| 37. <i>Scorpaenidarum</i> sp. | - | | 4 | | - | - | | - |
| 38. <i>Trigloporus boschi</i> Gaemers & Schwarzahans, 1982 | - | | 6 | | - | - | | - |
| 39. ? <i>Berycidarum</i> sp. | 1 | | - | | - | - | | - |
| 40. <i>Arnoglossus</i> aff. <i>miocenicus</i> Weiler, 1942 | 4 | | 13 | | - | 4 | | - |
| 41. <i>Lepidorhombus klokenhoffi</i> Gaemers & Schwarzahans, 1982 | 2 | | 5 | | 5 | 1 | | - |
| 42. <i>Lepidorhombus</i> sp. | - | | - | | - | - | | - |
| 43. <i>Phrynorhombus medius</i> Weiler, 1958 | - | | 1 | | - | - | | - |
| 44. <i>Buglossidium</i> aff. <i>approximatum</i> (Koken, 1891) | 3 | | 7 | | 2 | 2 | | 1 |
| 45. <i>Soleidarum</i> sp. 1 | - | | 1 | | 1 | - | | - |
| 46. <i>Soleidarum</i> sp. 2 | - | | - | | - | - | | - |
| Total numbers | 789 | 96.5 | 3382 | 97.0 | 3156 | 929 | 96.6 | 93 |

Table 1. Distribution of otoliths in the Syltian of the Morsum Cliff (see also Table 1 in Gaemers & Schwarzahans, 1982, p. 153).

must have been mixed with a large amount of surrounding sediment. We were already aware of this kind of contamination and for that reason it was mentioned that the otoliths came from an horizon including the *Aporrhais* bed (horizon with *Aporrhais* bed = Niveau mit *Aporrhais*-Bank, Gaemers & Schwarzhans, 1982). The otolith collection of Mr Von Hacht proves that the *Aporrhais* bed contains at least over 10 times more otoliths per kg of dry sediment than the surrounding sediments, probably even several tens of times more otoliths.

A small but also valuable collection was sent to me by Mr F. Weinbrecht (Glücksburg, Federal Republic of Germany). Although the precise horizon of this sample within the Syltian Morsum Cliff section is unknown, it is still of stratigraphical importance owing to the presence of the new species *Pseudocolliolus curvidorsalis*. Finally a few otoliths collected by Mr A. W. Janssen are described which were neglected in the preceding publication.

A part of the new material is stored in the collections of the Rijksmuseum van Geologie en Mineralogie, Leiden, The Netherlands (RGM numbers) and the Senckenberg Natur-Museum, Frankfurt am Main, Federal Republic of Germany (SMF numbers).

The occurrence of the key species of the Syltian, *Doyenneichthys syltensis*, in several new localities made it possible to increase the knowledge about the Syltian transgression in the North Sea Basin. Dr W. Hinsch (Geologisches Landesamt Schleswig-Holstein, Kiel, FRG), Mr A. W. Janssen (RGM, Leiden, The Netherlands) and Mr B. C. Sliggers (Rijks Geologische Dienst, Haarlem, The Netherlands) kindly provided me with otoliths from NW-Germany, Denmark and The Netherlands, respectively. It is the intention to publish this material elsewhere.

The drawings were made by Mr B. F. M. Collet and Mr G. Velthorst (both RGM, Leiden). The photographs were made by Mr W. A. M. Devilé (RGM) and Mr J. Verhoeven (Geologisch Instituut, Leiden) with the exception of the SEM photographs (pl. 2, fig. 7a-b) which were prepared by Mr E. de Stoppelaar (Geologisch Instituut, Leiden). Mr M. C. Cadée critically read the non-systematical part of the manuscript.

By mistake the registration numbers RGM 176500-176682 were used twice. The numbers used in Gaemers & Schwarzhans (1982) are changed here into registration numbers RGM 176300-176482.

BIOSTRATIGRAPHY

The Syltian deposits at the Morsum Cliff belong to the *Doyenneichthys syltensis* Range Zone (otolith zone 16; Gaemers, in press). In a previous paper this zone was called *Trisopterus angustus-Pseudocolliolus syltensis* Concurrent Range Zone (Gaemers, 1978). It is the youngest zone known in the Late Miocene of NW-Europe.

Otolith zone 16 is preceded by the *Pseudocolliolus cuykensis* Lineage Zone which corresponds to the Gramian. *P. cuykensis* Gaemers, 1978, the key species of the Gramian, is the immediate precursor of *P. curvidorsalis* n. sp. occurring in the Syltian at Sylt. From an evolutionary point of view, but also from the lithological succession in NW-Germany, there is no reason to believe that a hiatus exists between the known deposits of the Gramian and the Syltian, or at least no hiatus of real importance.

The zone succeeding otolith zone 16 in the North Sea Basin is the *Gadichthys benedeni* Lineage Zone. The entire Kattendijk Sands in the Antwerp region (Belgium) belong to this zone, therefore otolith zone 16 coincides completely with the Kattendijkian. *Doyenneichthys verticalis* (Gaemers

& Schwarzhans, 1973) occurs in all Pliocene deposits of Antwerp, including the Kattendijkian. This species is considered to be a member of the same lineage to which *D. syltensis* belongs. It can however not be its immediate successor on account of too big differences in shape, ontogeny and size between the two species. One or more unknown transitional forms must have existed, but nowhere in NW-Europe deposits with such forms have been found. From this it can be concluded that an important hiatus exists in NW-Europe between the Syltian and the Kattendijkian. This hiatus is supposed to cover a large period of time, judging from the big differences between *D. syltensis* and *D. verticalis*, and the rates of evolution of these species.

PALAEOGEOGRAPHY

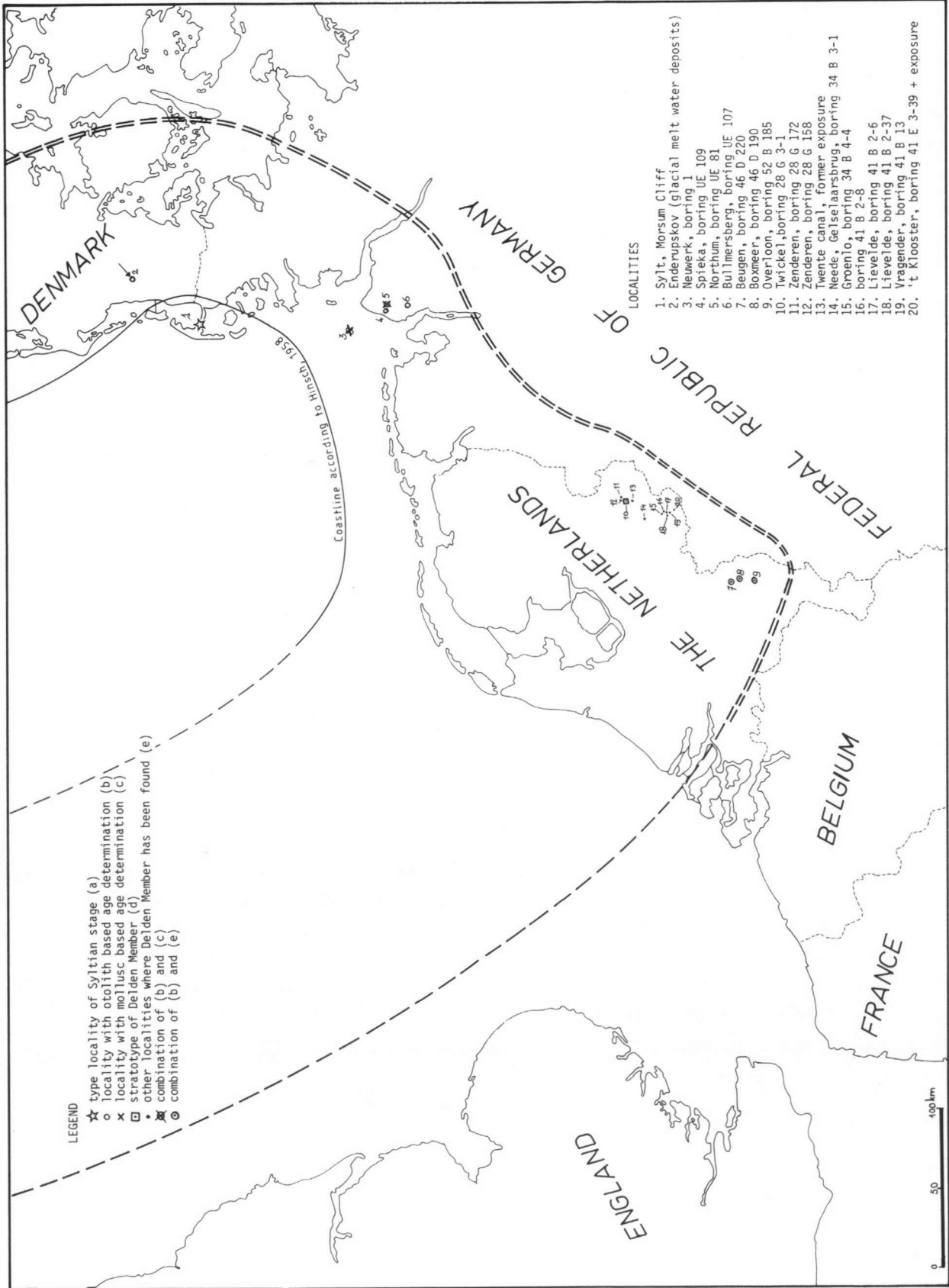
An explanation for the big hiatus between the Syltian and the Kattendijkian can be found when the global cycles of relative change of sea-level during the Tertiary are taken into account (Vail et al., 1977; Vail & Hardenbol, 1979). A large world-wide Messinian regression was recognized, caused by an estimated fall of the sea-level of about 100 metres compared to present day sea-level (Vail & Hardenbol, 1979). With such a low sea-level the largest part of the North Sea shelf would emerge and become dry land. Simultaneously the erosion base would also be lowered as much as the sea-level and a part of the formerly deposited marine sediments would be removed by erosion. Local and regional tectonics are of course also important factors influencing the actual extension of the sea.

According to Vail et al. (1977) the sea-level during the Messinian was much lower than during any other part of the Late Miocene or the Pliocene. Although it is not yet possible to correlate Late Miocene and Pliocene sediments of the Mediterranean accurately by means of fossils with deposits in NW-Europe, the reconstructed hiatus between Syltian and Kattendijkian must approximately be of the same age as the Messinian. Here I posit the thesis that the hiatus and the Messinian regression were caused by the same event, viz. the global lowering of the sea-level. Any other postulate assuming diachronous happenings is much more complicated and has to find another explanation for the hiatus between otolith zones 16 and 17.

During the Messinian regression Syltian deposits (and also older deposits) must have been eroded partly or completely in large areas. This hampers a good reconstruction of the extension of the sea during this stage. One would not expect to find Syltian coast lines preserved at many places. The best places to look for such coast lines are areas where subsidence was strongest during Late Miocene times: the Central Graben and the Venlo Graben in the southeastern part of the Netherlands and the Lower Rhine Embayment in West-Germany.

For a long time the Morsum Cliff at the island of Sylt was the only place from which Syltian deposits were known. Hinsch (1958) made a map with the supposed extension of the Syltian North Sea, having no other localities at his disposal (continuous line on fig. 1). The lack of knowledge of Syltian deposits elsewhere gave the impression that the Syltian in NW-Europe was a regressive period.

With molluscs Hinsch (1977) succeeded in finding two new localities with Syltian deposits, viz. borings at Neuwerk and Northum, both in the northwestern part of Lower Saxony (fig. 1). With otoliths I could recognize Syltian deposits in three borings in the same area: Bullmersberg, Northum and Spieka (Gaemers, in press; see also fig. 1).



A large number of otoliths was found by Mr A. W. Janssen in glacial melt water deposits (Pleistocene) at Enderupskov near Gram in Denmark. Most of the otoliths could be attributed to the Arnun Formation (Early Hemmoorian = Behrendorfian), but one otolith clearly was a specimen of *Doyenneichthys syltensis* (Gaemers & Schwarzahans, 1982), the key species of the Syltian. The distance across which this otolith was transported is unknown, but it can only come from an easterly direction, probably from the northeast, the main direction from which the glaciers came (see arrow near location 2, fig. 1).

In three borings in the southeastern part of the Netherlands Syltian otoliths were found in sediments belonging to the Delden Member (van den Bosch, pers. comm.; Gaemers, in press; fig. 1). These borings, viz. Beugen, Boxmeer and Overloon, situated in the Venlo Graben, were made for the glauconite project of Dr W. H. Zagwijn (Rijks Geologische Dienst, Haarlem). The presence of otoliths of *D. syltensis* demonstrates that the Delden Member in these borings belongs to the Syltian.

The Delden Member was described by van den Bosch et al. (1975) from many places (mainly borings) in the eastern part of the Netherlands (fig. 1). In this area the Delden Member mostly was decalcified and otoliths have not yet been found here. The large number of valves of the inarticulate brachiopod *Lingula* sp. is striking, and this species is also common in the Venlo Graben borings. The presence of a good number of species of sharks and rays, marine mammals, several marine pelecypods, and the worm *Ditrupa* indicates that the Delden Member in the eastern part of the Netherlands was formed under fully marine conditions (van den Bosch et al., 1975). The lithological and palaeontological resemblances with the Delden Member in the Venlo Graben (still to be published) are so close that it can be concluded that the facies is the same in both areas. There is no palaeontological or other evidence for the assumption that the Delden Member in the eastern part of the Netherlands should be of another age than that in the Venlo Graben.

All data taken together twenty localities in the North Sea Basin give evidence of the presence of marine Syltian deposits. The situation of the localities shows that the Syltian North Sea was much larger than formerly thought (fig. 1). The deposits of the Syltian of the Morsum Cliff probably were formed in deeper water than the Delden Member in the Netherlands judging from fauna and lithology. In the reconstruction of the maximum extension of the sea the coast line therefore is drawn farther away from Sylt than from the Dutch localities. The Morsum Cliff section as well as several Delden Member sections show a clear regressive tendency towards the top, indicating a shrinking North Sea during the Syltian. But even the minimum extension of the Syltian North Sea must have been considerably larger than suggested in earlier reconstructions.

Fig. 1. Tentative reconstruction of the maximum extension of the Syltian North Sea (double and single heavy dashed line) based on the occurrence of otoliths of *Doyenneichthys syltensis* (Gaemers & Schwarzahans, 1982) and the distribution of the Delden Member, compared with an earlier reconstruction by Hinsch (1958) (lighter continuous and dashed line).

Fig. 1. Voorlopige reconstructie van de maximale uitbreiding van de Noordzee ten tijde van het Syltien (dubbele en enkele zware streeplijn) gebaseerd op het voorkomen van otolieten van *Doyenneichthys syltensis* (Gaemers & Schwarzahans, 1982) en het verspreidingsgebied van de Delden Member, vergeleken met een eerdere reconstructie van Hinsch (1958) (dunnere ononderbroken lijn en streeplijn).

SYSTEMATIC PART

Phylum PISCES
Classis ACTINOPTERYGII
Subclassis TELEOSTEI
Ordo ANGUILLIFORMES
Familia CONGRIDAE

Congridarum acutirostris Gaemers & Schwarzhans, 1982
Plate 2, fig. 8a-b

Material - *Aporrhais* bed: 1 well-preserved sagitta, coll. RGM 176483, leg. U. von Hacht.
L: 1.55 mm H: 0.98 mm T: 0.40 mm L/H: 1.58 L/T: 3.87.

Discussion - This sagitta is the second find of an otolith of this species. Its features are not yet well-developed because it is a small juvenile specimen. Especially the rostrum differs strongly from that of the holotype: it is very short and blunt, and by that inconspicuous. Therefore the species name does not refer properly to this juvenile specimen. The sulcus is short. The cauda is more distinct than the ostium, but the ostium opens clearly at the rostral rim. The ostium of the holotype is less pronounced and the opening at the rim is hardly visible. The juvenile specimen is clearly shorter than the holotype. The nearly central knob on the outer surface is obvious, but is probably characteristic for this juvenile specimen only.

Ordo CLUPEIFORMES
Familia CLUPEIDAE

Clupeidarum opisthonomus Gaemers & Schwarzhans, 1982

Material - *Aporrhais* bed: 2 sagittas (1 broken), coll. P. A. M. Gaemers, leg. U. von Hacht.

Clupeidarum sp.
Plate 2, fig. 10a-b

Material - Horizon with *Ditrupa* bed: 1 sagitta (rostral part missing, otherwise well-preserved), coll. RGM 176484, leg. A. W. Janssen, 1975.
(L: 0.93 mm) H: 0.71 mm T: 0.23 mm.

Discussion - It is impossible that this sagitta belongs to the same species as *C. opisthonomus*. Although the caudal rim of the latter species is rather variable, it is always rounded. The small otolith pictured here has a pointed caudal end and also a distinct postdorsal angle. Furthermore the cauda is less wide than in the other species. The antirostrum is still present and shows that the sagitta must have been rather short for a clupeid.

Ordo MYCTOPHIFORMES
 Familia MYCTOPHIDAE
 Genus *Diaphus* Eigenmann, 1891

Diaphus debilis (Koken, 1891)

Material - *Aporrhais* bed: 1 sagitta, coll. SMF P. 6563, leg. U. von Hacht; 1 sagitta, coll. P. A. M. Gaemers, leg. U. von Hacht.

Familia ?SYNODIDAE

?*Synodidarum xenosus* Gaemers & Schwarzhans, 1982

Material - *Aporrhais* bed: 2 sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Ordo GADIFORMES
 Familia GADIDAE
 Subfamilia GADINAE
 Genus *Colliolus* Gaemers & Schwarzhans, 1973

Colliolus friedbergi (Chaine & Duvergier, 1928)

Material - *Aporrhais* bed: 175 sagittas (mostly broken specimens and fragments), coll. SMF P. 6564, leg. U. von Hacht; 13 sagittas (mostly broken), coll. P. A. M. Gaemers, leg. U. von Hacht.
 Horizon unknown: 13 sagittas, coll. F. Weinbrecht; 6 sagittas, coll. P. A. M. Gaemers, leg. F. Weinbrecht.

Genus *Gadichthys* Gaemers & Schwarzhans, 1973

Gadichthys venustus (Koken, 1891)
 Plate 1, fig. 3a-d; Plate 2, fig. 5a-d

1976b ?*Gadichthys venustus* (Koken, 1891) - Gaemers, p. 513, pl. 5, fig. 7a-b.

Material - *Aporrhais* bed: 1 eroded sagitta, coll. RGM 176 485, leg. U. von Hacht.
 (L: 8.95 mm) (H: 5.00 mm) (T: 1.62 mm)

Discussion - This large, adult specimen leaves no doubt about the occurrence of the species in the Syltian of the Morsum Cliff. Only one juvenile specimen was known before, resembling adult otoliths of *Doyenneichthys syltensis*. It was not pictured in Gaemers & Schwarzhans (1982) although it is a complete, well-preserved specimen. Therefore a picture is given now (Plate 2, fig. 5a-d). It may look on the photograph as if the dorsal part of the inner surface is damaged, but the light parts are covered with a thin crust of an unknown substance which could not be removed. The characteristics of the sulcus in the adult specimen are so remarkably similar with other *Gadichthys* species (especially those belonging to the *G. spatulatus* lineage), that there is no reason anymore to doubt about the generic position of this species.

Genus *Doyenneichthys* n. gen.

Type species - *Gadichthys benedeni verticalis* Gaemers & Schwarzahans, 1973.

Diagnosis - A genus of the subfamily Gadinae with small otoliths which are not or only slightly bent lengthwise. Outline short pear-shaped with a rounded rostral end and a pointed or truncated caudal end. Predorsal angle is most pronounced angle. Postdorsal angle more weakly developed or absent. Sulcus acusticus rather deep and wide. Colliculi short and round to oval; caudal colliculum not much longer than ostial colliculum. Pseudocolliculum and collum long to very long with a sharp and clear furrow along its ventral side. Knobs along rims and on outer surface not very pronounced; they are mostly low. Ventral and dorsal rims about equally thick. Dorsal rim equally sharp or a little sharper than ventral rim. Thickest part of otoliths is situated medially.

Derivatio nominis - *Doyenne* comes from the pear variety "Doyenne de Comice". The solid of revolution of the outline of otoliths belonging to this genus closely resembles the thickest shape of these pears. *Ichthus* (Greek) = fish.

Distribution - Late Miocene-Late Pliocene.

Doyenneichthys syltensis (Gaemers & Schwarzahans, 1982): Syltian.

Doyenneichthys verticalis (Gaemers & Schwarzahans, 1973): Kattendijkian-Merksemian.

A still undescribed forerunner of *D. syltensis* occurs in the Late Miocene of Maryland (U.S.A.) and will be published in a paper by Gaemers & Fitch.

Discussion - Gaemers (1978) described the new genus *Pseudocolliolus* with *P. cuykensis* as type species. *Doyenneichthys syltensis* was placed in the same genus and was considered to be the forerunner of *P. cuykensis* in the same lineage. Consequently the *P. cuykensis* Range Zone was placed as a younger zone above the *Trisopterus angustus-Pseudocolliolus syltensis* Concurrent Range Zone.

The discovery of *P. cuykensis* in the type locality of the Gramian at Gram in Denmark made it clear that the stratigraphic reconstruction was wrong, for the Gramian is older than the Syltian. From this it could be concluded that the evolutionary reconstruction was also wrong. The two species could only belong to two different lineages. The subsequent finds of other *Pseudocolliolus* and *Doyenneichthys* species in NW Europe and the Atlantic coast of the U.S.A., which for the greater part will be described in future papers, confirmed this new concept.

There are two reasons for the separation of the new genus *Doyenneichthys* from *Pseudocolliolus*. (1) At least two important characters, viz. the shape and size of the colliculi, and the ornamentation, are different between the two lineages, but are highly constant within each lineage. (2) The two lineages did not originate at the same time and probably did not arise from the same ancestral lineage. *Pseudocolliolus* has more affinities with *Colliolus* whereas *Doyenneichthys* resembles *Gadichthys* much more.

Doyenneichthys and *Pseudocolliolus* belong to a group of extinct genera of small cods which have a lot of characteristics in common. Extant genera of small cods have otoliths which differ much more from each other. This makes identification of the fossil species and genera more difficult than that of the living ones.

Doyenneichthys syltensis (Gaemers & Schwarzhans, 1982)

Plate 2, fig. 3a-b

1982 *Pseudocolliolus syltensis* Gaemers & Schwarzhans, p. 130, pl. 1, fig. 10a, b - 12a, b; pl. 6, fig. 1a, b - 5a, b.

Material - *Aporrhais* bed: 514 sagittas (many broken specimens and fragments), coll. SMF P. 6565, 6566, leg. U. von Hacht; 55 sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Horizon unknown: 21 sagittas, coll. F. Weinbrecht; 16 sagittas, coll. P. A. M. Gaemers, leg. F. Weinbrecht.

Discussion - A broken otolith with a rather elongate shape is pictured on plate 2. In first instance this specimen was supposed to be a juvenile of *P. curvidorsalis*, but the width of the sulcus and the poor ornamentation disproved this idea.

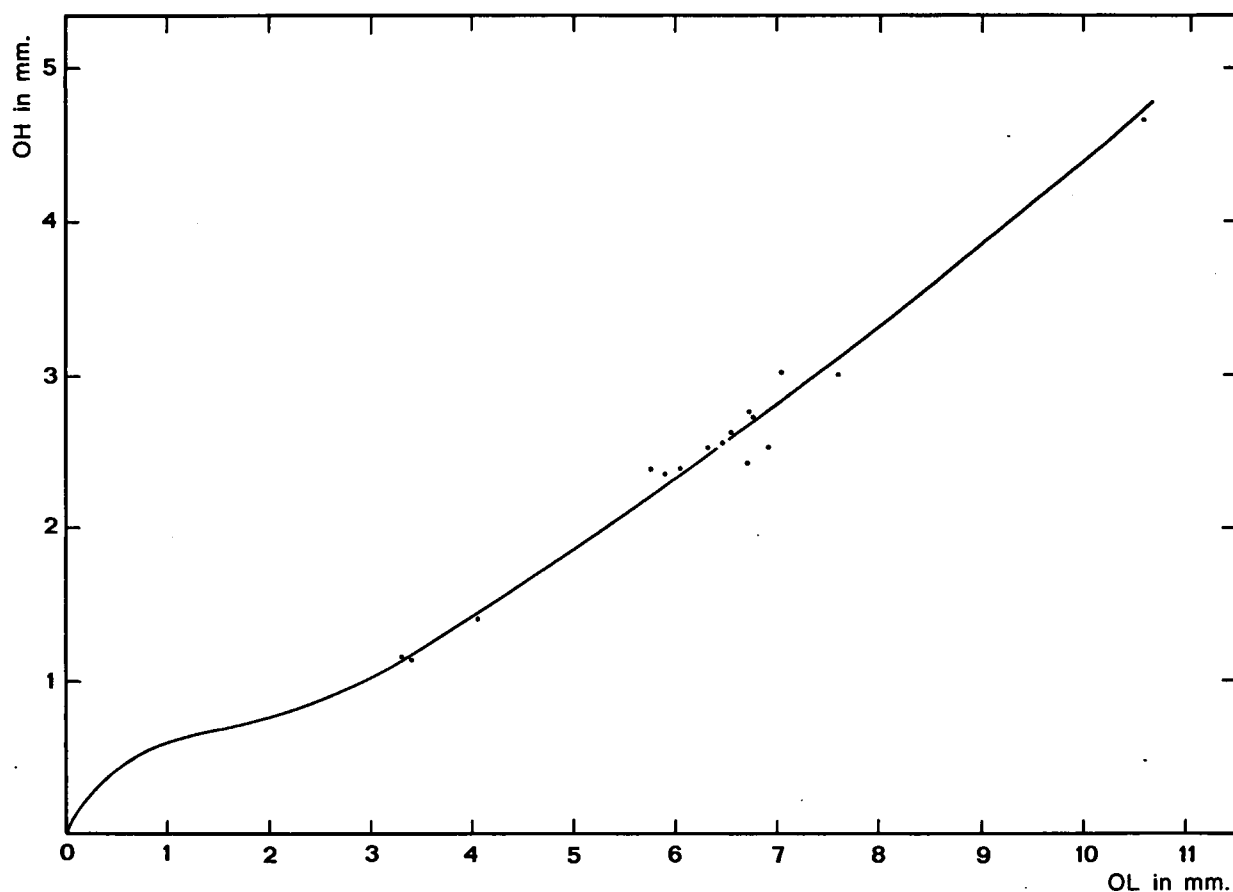


Fig. 2a. Relation between otolith length (OL) and otolith height (OH) of *Trisopterus angustus* Gaemers & Schwarzhans, 1982.

Fig. 2a. Relatie tussen de lengte (OL) en hoogte (OH) van de otolieten van *Trisopterus angustus* Gaemers & Schwarzhans, 1982.

Genus *Pseudocolliolus* Gaemers, 1978

Amended diagnosis - A genus of the subfamily Gadinae with rather small otoliths which are slightly bent lengthwise or flat. Outline pear-shaped with a rounded rostral end and a pointed to sharply

pointed caudal end. Predorsal angle rounded (or even absent) to pronounced, postdorsal angle not or only weakly developed. Sulcus acusticus rather deep to deep and moderately wide. Ostial colliculum oval to elliptical, caudal colliculum oblong filling nearly the whole cauda. Pseudocolliculum and collum long to very long with a sharp and clear furrow along their ventral side. Knobs along rims and on outer surface pronounced and rather high. Ventral and dorsal rims about equally thick. Rims can be blunt (in earlier stages of evolution) to sharp (in later stages of evolution). Ventral rim a little sharper than dorsal rim or equally sharp. Thickest part of otoliths is situated medially.

Distribution – Late Miocene-Pliocene.

Pseudocolliolus cuykensis Gaemers, 1978: Gramian.

Pseudocolliolus curvidorsalis n. sp.: Syltian.

A still undescribed forerunner of *P. cuykensis* occurs in the Miocene of Maryland (U.S.A.) and will be published in a paper by Gaemers & Fitch. A descendant occurs in the Redonian of Brittany (France) and will be described by Gaemers.

***Pseudocolliolus curvidorsalis* n. sp.**

Plate 2, fig. 1a-d, 4a-b

Holotype – Plate 2, fig. 1a-d, coll. RGM 176 487, leg. F. Weinbrecht.

Paratypes – 3 specimens, coll. RGM 176 488, 176 489, leg. F. Weinbrecht.

Locus typicus – Sylt East, Morsum Cliff, Federal Republic of Germany.

Stratum typicum – Late Miocene, Syltian, precise horizon unknown.

Derivatio nominis – *curvus* (Latin) = bent, curved; *dorsalis* (Latin) = dorsal. Named after the (rather) rounded dorsal rim which has only weakly developed angles.

Diagnosis – A *Pseudocolliolus* species with thin otoliths having sharp rims. Dorsal rim rounded or rim rounded or rather rounded with weakly developed or no angles.

Description – Otoliths thin or rather thin. Outline pear-shaped. Entire outline clearly knobbed. Highest part of the otolith shifted rather far to the front. Dorsal rim rounded or rather rounded with rounded predorsal and postdorsal angles. Dorsal angles may even be absent. Rims are sharp or rather sharp. Ventral rim a little sharper than dorsal rim.

Inner surface slightly convex. Sulcus acusticus medial or slightly supramedial and nearly straight, formed as in the genus *Colliolus*: rather narrow and deep, especially the ostium is deep. Crista superior well-developed above ostium, collum and anterior part of cauda. Crista inferior rounded and less pronounced but present along entire sulcus. Large area completely intersected by long sharp furrows. Ventral furrow rather distinct. Small, sharp furrows from ventral rim often traverse ventral furrow.

Outer surface flat, slightly concave or slightly convex lengthwise, slightly convex heightwise. A low medial ridge forms the thickest part of the otoliths. Entire outer surface strongly sculptured, the medial ridge can be somewhat less sculptured. The furrows and knobs outside the ridge are oriented mainly perpendicular to the rims.

Material – Horizon unknown: 4 sagittas, partly broken and/or eroded, coll. RGM 176 487 – 176 489, leg. F. Weinbrecht.

L: 4.76 mm H: 2.32 mm T: 0.80 mm L/H: 2.05 L/T: 5.95 (holotype).

Discussion - The number of specimens available is still small and therefore not much can be said about variability and ontogenetic changes. Length/height and length/thickness ratios are not very different from those of *P. cuykensis*. The otoliths of *P. curvidorsalis* nevertheless have a more thickset shape by their rounded dorsal rim.

To be quite on the safe side I checked all otoliths formerly published as *Doyenneichthys syltensis*, because *P. curvidorsalis* resembles this species more than any other Syltian species. Among the many thousands of specimens I could however find not any *Pseudocolliolus* otolith (see also discussion of *D. syltensis*). On the other hand one can not say that *P. curvidorsalis* is a rare species in the small sample of Mr Weinbrecht. In my opinion this can only lead to the conclusion that his sample comes from an horizon from which no other otoliths were collected yet. The surprising find of *P. curvidorsalis* otoliths thus demonstrates clearly that it is necessary to study more horizons of the Morsum Cliff in detail than has been done up to now in order to get a more complete picture of the Syltian deposits.

Genus *Conferencea* n. gen.

Type species - *Macruridarum irregularis* Gaemers, 1973.

Diagnosis - A genus of the subfamily Gadinae with small, thin otoliths which are not or only very slightly bent lengthwise. Outline oblongly pear-shaped with a rather pointed to pointed rostral end and a pointed or sometimes truncated caudal end. Predorsal angle usually absent or weakly developed. Predorsal angle always more pronounced than postdorsal angle. Inner surface flat heightwise. Sulcus acusticus wide and rather deep, with distinct cristae. Colliculi equally short and round to slightly oval. Pseudocolliculum long to very long with a sharp and clear furrow along its ventral side. Many small knobs along rims, especially with adult specimens. Knobs not very pronounced to rather pronounced; they are usually somewhat better developed along ventral rim. Rims sharp in adult otoliths, with ventral rim sharper than dorsal rim. Thickest part of otoliths is situated medially.

Derivatio nominis - named after the pear variety "Conference". The solid of revolution of the outline of otoliths belonging to this genus often closely resembles the oblong shape of these pears.

Distribution - Late Miocene.

Conferencea irregularis (Gaemers, 1973): Gramian-Syltian.

Discussion - The only known species of the new genus shows most affinities with the extant genus *Boreogadus*. The general outline of the otoliths of both genera agrees in most characteristics. Therefore *C. irregularis* was considered to belong to *Boreogadus* for some time. There are however several important differences that justify the separation of *Conferencea* from *Boreogadus*. The latter genus has otoliths with a different sulcus: there is no pseudocolliculum, the colliculi are closer together, and the crista superior is absent. Also the ventral part of the inner surface is much thicker than the dorsal part. Finally the otoliths as a whole are thicker.

The species *Boreogadus similis* Gaemers & Schwarzahns, 1982, from the Early Pliocene Kattendijk Sands shows much more resemblance with the living *Boreogadus* species. The only clear difference is the presence of a pseudocolliculum in the Pliocene species. This is, however, such an important characteristic that even the Pliocene *B. similis* may belong to another genus which is perhaps intermediate between *Conferencea* and the Recent *Boreogadus*.

Conferencea irregularis (Gaemers, 1973)

- 1942 *Macruridarum minusculus* (Schubert) - Weiler, p. 91, pl. 5, fig. 29, 40.
1973 *Macruridarum irregularis* Gaemers, p. 69, pl. 2, fig. 8a, b.
1977 *Gadiculus deurnensis* Nolf, p. 23, pl. 4, fig. 13, 14.
1982 *Boreogadus irregularis* (Gaemers) - Gaemers & Schwarzahns, p. 132, pl. 6, fig. 6a, b - 11; pl. 7, fig. 1, 2a, b, 5a, b.

Material - *Aporrhais* bed: 50 sagittas, coll. SMF P. 6567, leg. U von Hacht; 8 sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Horizon unknown: 18 sagittas, coll. F. Weinbrecht; 10 sagittas, coll. P. A. M. Gaemers, leg. F. Weinbrecht.

Genus *Trisopterus* Rafinesque, 1814

***Trisopterus angustus* Gaemers & Schwarzahns, 1982**

Plate 1, fig. 2a-d

Material - *Aporrhais* bed: 1 large adult sagitta, coll. RGM 176 490, leg. U von Hacht; 25 sagittas (many fragments), coll. SMF P. 6568, leg. U. von Hacht; 3 sagittas, coll. P. A. M. Gaemers, leg. U von Hacht.

L: 10.58 mm H: 4.66 mm T: 3.41 mm L/H: 2.27 L/T: 3.10.

Discussion - The largest specimen found has been peeled of a little at some places but is otherwise well-preserved. This specimen gives more evidence of the extraordinary allometric growth of the otoliths of this species, especially in the length-thickness ratio. Length-height and length-thickness diagrams are given in fig. 2a and 2b (for the construction of such diagrams see Gaemers, 1976a). Although the species is common in the Syltian of the Morsum Cliff, only a few specimens have been preserved well enough for reliable measurements. Small and medium-sized specimens easily can be distinguished from the forerunner of this species, *T. spectabilis* (Koken, 1891). Unfortunately this is very difficult, if not impossible, for the very large otoliths of both species.

Otoliths larger than 5.5 - 6.0 mm in length mostly have their thickest part somewhat behind the middle. This is very characteristic for this species and its forerunner. Otoliths smaller than 5.5 - 6.0 mm in length have their thickest part at the usual place for Gadinae, viz. before the middle.

***Trisopterus capelanus* (Lacepède, 1800)**

Plate 2, fig. 2a-d

1982 *Trisopterus* sp. Gaemers & Schwarzahns, p. 135, pl. 1, fig. 18a, b, *non* coll. RGM 176 382.

Material - Horizon with *Aporrhais* bed: 1 well-preserved juvenile sagitta, coll. RGM 176 381.

Horizon with *Ditrupa* bed: 1 juvenile sagitta, coll. RGM 176 496, leg. A.W. Janssen, 1975.

Horizon unknown: 1 slightly eroded juvenile sagitta, coll. RGM 176 383, leg. R. Klockenhoff.

L: 3.44 mm H: 1.45 mm T: 0.75 mm L/H: 2.37 L/T: 4.59.

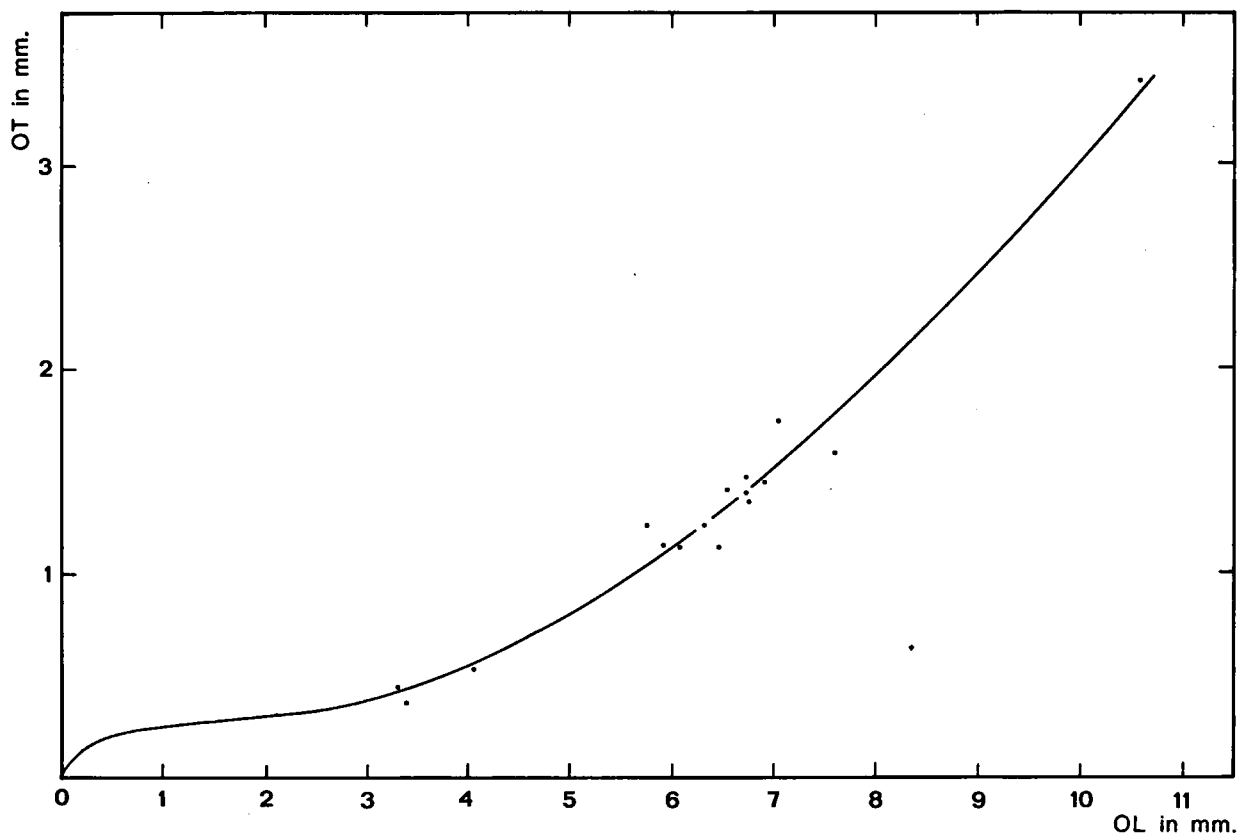


Fig. 2b. Relation between otolith length (OL) and otolith thickness (OT) of *Trisopterus angustus* Gaemers & Schwarzahns, 1982.

The curves represent the estimated average ratios of OL-OH and OL-OT during growth.

Fig. 2b. Relatie tussen de lengte (OL) en dikte (OT) van de otolieten van *Trisopterus angustus* Gaemers & Schwarzahns, 1982.

De krommen zijn een schatting van de gemiddelde verhoudingen van OL-OH en OL-OT tijdens de groei.

Discussion - Careful comparison of the largest and best preserved juvenile specimen (pl. 2, fig. 2a-d) with juvenile otoliths of *T. luscus* and *T. minutus* clearly showed that the fossil otoliths could not belong to these species, for the fossil specimens are too slender. Juvenile otoliths of the common Syltian species *T. angustus* on the other hand are still thinner and more elongate than these *Trisopterus* specimens. Only one other species of the genus known from NW Europe remains, namely *T. capelanus*. Although I do not yet possess Recent juvenile otoliths of this species, all characteristics of the larger fossil juvenile specimen agree well with those of Recent adult ones: a slender outline, a normal thickness, a normal sulcus acusticus, and the absence of a postdorsal angle.

Remark - The classification of the fragments numbered RGM 176 382 as *Trisopterus* sp. by Gaemers & Schwarzahns (1982) is attributable to a mistake. The two fragments probably are from one otolith but the most conclusive middle part is missing which could show the separation or the fusion of the colliculi. However the knob pattern and the convexity of the outer surface make it clear that the fragments belong to the genus *Phycis*.

Trisopterus incognitus Gaemers, 1976

Plate 1, fig. 4a-d

Material – *Aporrhais* bed: 1 somewhat eroded adult sagitta, coll. RGM 176 491, leg. U von Hacht.
Horizon with *Aporrhais* bed: 1 well-preserved juvenile sagitta, coll. P. A. M. Gaemers, leg. M.C. Cadée.
(L: 6,35 mm) (H: 2.85 mm) (T: 1.61 mm) L/H: ca. 2.2 L/T: ca. 3.95.
L: 4.77 mm H: 2.02 mm T: 1.00 mm L/H: 2.36 L/T: 4.77.

Discussion – The first impression was that the largest specimen belonged to *T. luscus* (Linné, 1758). There are however several characteristics which point to *T. incognitus*: (1) the postdorsal angle which is well-developed for a *Trisopterus* otolith, (2) the ornamentation on the outer surface consisting of relatively few large and high knobs, (3) the weak lengthwise bending of the otolith. The postdorsal angle is missing or weakly developed in *T. luscus*; furthermore otoliths of this species with the same size as the fossil specimen are always distinctly finer knobbed.

A juvenile specimen placed in the species *T. angustus* by Gaemers & Schwarzhans (1982) turned out to be considerably different from equally large otoliths of that species. The well-developed postdorsal angle and the weak lengthwise bending leave no doubt to its place in *T. incognitus*. The mistake of Gaemers & Schwarzhans is explicable because of the fact that they did not recognize the real juveniles of *T. angustus* (which are unusually thin) as such in the first version of their manuscript, but interpreted by them as juveniles of *Micromesistius*.

The length-height ratios of both fossil specimens fit *T. incognitus* better than the extant *T. minutus*, which is the descendant of the former species.

This is the second find of *T. incognitus* which was first described from the Langenfeldian of Hohen Woos in the German Democratic Republic (Gaemers, 1976; Heinrich, 1969). With this the stratigraphic range is extended to the whole marine Late Miocene of NW Europe (Langenfeldian-Sylvian).

Remark – The size of the largest otolith matches a total length of the fish of about 12 cm.

Genus *Melanogrammus* Gill, 1863

Melanogrammus morsumensis n. sp.

Plate 1, fig. 1a-d

1982 *Melanogrammus* sp. Gaemers & Schwarzhans, p. 136, pl. 1, fig. 20a-c, 21a-c.

Holotype – Plate 1, fig. 1a-d, coll. RGM 176 492, leg. U. von Hacht.

Paratypes – 5 specimens.

Locus typicus – Sylt East, Morsum Cliff, Federal Republic of Germany.

Stratum typicum – Late Miocene, Sylvian, *Aporrhais* bed.

Derivatio nominis – named after the Morsum Cliff.

Diagnosis – A *Melanogrammus* species with comparatively small otoliths which are relatively short and high. Rostral end rounded or with a short, inconspicuous straight part. Juvenile otoliths slightly bent lengthwise, adult otoliths nearly or completely flat lengthwise.

Description - Juvenile otoliths relatively thin, adult ones fairly thick. Outline elongated and pear-shaped but shorter than other known *Melanogrammus* species. Ventral rim set with relatively strong knobs; regularly bent, most strongly bent toward anterior side. Rostral end rounded or with a short, inconspicuous straight part. Dorsal rim rather smooth with weakly developed predorsal angle and a usually somewhat stronger developed postdorsal angle. Caudal end clearly pointed.

Inner surface slightly to clearly convex lengthwise and about flat across. Sulcus acusticus median or somewhat suprmedian, especially the ostial part. Collum narrow and oblique, with a clear indentation at the ventral side and a weak one at the dorsal side. Ostial colliculum oval in shape, not completely filling the ostium. Caudal colliculum very long and slightly bent to straight. Well-developed crista superior along entire sulcus. Crista inferior indistinct and interrupted. Ventral furrow distinct and long, intersected by small furrows between knobs. Area long, wide and clear; it is traversed by small furrows across its whole width.

Outer surface somewhat concave to slightly convex lengthwise, slightly convex across. Adult specimen clearly convex across in the ventral part, slightly concave across in the dorsal part. Distinct to strong knobs separated by deep and sharp furrows which run about perpendicular to the outline.

Material - *Aporrhais* bed: 1 sagitta, coll. RGM 176 492, leg. U. von Hacht (holotype).

Horizon with *Aporrhais* bed: 1 sagitta, coll. RGM 176 386, leg. A. W. Janssen.

Horizon with *Ditrupa* bed (bed with crab claws): 1 sagitta, coll. R. Klockenhoff.

Horizon unknown: 2 sagittas, coll. RGM 176 384, 176 385, leg. R. Klockenhoff; 1 sagitta, coll. P. Besel.

(L: 6.61 mm) H: 3.09 mm T: 1.49 mm L/H: ca. 2.30 L/T: ca. 4.75 (holotype).

L: 3.67 mm H: 1.69 mm T: 0.75 mm L/H: 2.17 L/T: 4.92.

Variability - The dorsal rim and the rostral end are the most variable parts of the otoliths. The postdorsal angle can vary from pronounced to nearly missing.

Discussion - The holotype is the largest specimen of this Syltian haddock. All other specimens must have belonged to juvenile fishes. Comparison of the holotype with the juvenile otoliths shows important ontogenetic changes from which it can be concluded that the holotype belonged to an adult fish. The strongly developed knobs on the outer surface and along the rims make it clear that it was a still rather young adult fish. Therefore the size of full-grown otoliths of this new species was certainly larger than the holotype. On the other hand, the increase in thickness during growth indicates that this fossil haddock could not have reached the size of the Pliocene, Pleistocene and Recent haddocks.

Subfamilia PHYCINAE

Genus *Phycis* Röse, 1793

Phycis tenuis (Koken, 1891)

Plate 2, fig. 6a-d

1982 *Trisopterus* sp. Gaemers & Schwarzhans, p. 135, coll. RGM 176 382, *non* coll. RGM 176 381, 176 383.

Material - *Aporrhais* bed: 32 sagittas, coll. SMF P. 6569, leg. U. von Hacht; 7 sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Horizon unknown: 1 sagitta, coll. F. Weinbrecht; 1 sagitta, coll. P. A. M. Gaemers, leg. F. Weinbrecht.
L: 4.75 mm H: 1.79 mm T: 1.24 mm L/H: 2.65 L/T: 3.83 (pl. 2, fig. 6a-d).
L: 2.52 mm H: 0.95 mm T: 0.67 mm L/H: 2.65 L/T: 3.76.
L: 2.76 mm H: 1.06 mm T: 0.73 mm L/H: 2.60 L/T: 3.78.
L: 1.52 mm H: 0.59 mm T: 0.36 mm L/H: 2.58 L/T: 4.22.

Discussion - The holotype of *P. tenuis* from the southwestern part of France seems to be trackless. It is therefore difficult to interpret this species. The Syltian specimens are provisionally placed within this species.

The Phycinae are a difficult group concerning their otoliths. In spite of that, the Miocene material of NW Europe of this subfamily available to me at the moment clearly shows that more species existed than *P. tenuis* alone.

Subfamily MERLUCCIINAE
Genus *Merluccius* Rafinesque, 1810

Merluccius albidus (Mitchell, 1818)

1982 *Merluccius miocenicus* Koken, 1891 - Gaemers & Schwarzahns, p. 139, pl. 8, fig. 1a, b - 4a, b; p. 150, pl. 1, fig. 22a-c.

Material - *Aporrhais* bed: 14 sagittas (broken specimens), coll. SMF P. 6570, leg. U. von Hacht; 2 sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Horizon unknown: 1 juvenile sagitta, coll. F. Weinbrecht.

Discussion - Medium-sized and large otoliths of the extant species *M. albidus* which I have at my disposal do not differ essentially from the Late Miocene specimens of Sylt. Therefore there is no good reason anymore to place them in a fossil species. Mitchell originally classified the living species in a new genus. This probably was correct. Although the external characteristics of fishes belonging to this subfamily are very similar, and the general opinion among biologists nowadays is to group all species together in the genus *Merluccius*, there are probably several different genera. The outlines of the otoliths of the living *Merluccius* species are namely considerably different in a lot of species. A revision of recent and fossil species of cod fishes including some merlucciinids is in preparation. For further synonymy see Gaemers & Schwarzahns, 1982.

Ordo PERCIFORMES
Subordo PERCOIDEI
Familia MORONIDAE
Genus *Morone* Mitchill, 1814

Morone rectidorsalis Gaemers & Schwarzahns, 1982

Material - *Aporrhais* bed: 3 posterior fragments of sagittas, coll. RGM 176 493, leg. U von Hacht.

Familia SCIAENIDAE

Sciaenidarum staringi Posthumus, 1923

Material - *Aporrhais* bed: 3 juvenile sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Familia unknown

Percoideorum fitchi (Gaemers & Schwarzahns, 1982)

1982 ?*Sebastes fitchi* Gaemers & Schwarzahns, p. 144, pl. 2, fig. 16a, b - 23a, b.

Material - *Aporrhais* bed: 4 sagittas, coll. SMF P. 6571, leg. U von Hacht.

Horizon unknown: 1 sagitta, coll. F. Weinbrecht.

Discussion - Dr V. W. M. van Hinsbergh drew my attention to the resemblance of these otoliths with *Leiognathidarum nolfi* which he described in 1980. The resemblance indeed is striking, but I doubt if his species and *Percoideorum fitchi* belong to the *Leiognathidae* family. Both species possess a clear middorsal angle and a rather short to short cauda. This is not the case in the otoliths of recent representatives of the *Leiognathidae* (see Nolf, 1977, pl. 14; Nolf & Lapierre, 1979, pl. 3).

The small size of the otoliths of *P. fitchi* on the other hand makes it unlikely that it belongs to *Sebastes*. Therefore the real systematic position of this species still remains obscure.

Subordo AMMODYTOIDEI
Familia AMMODYTIDAE
Genus *Hyperoplus* Günther, 1862

Hyperoplus sp.
Plate 2, fig. 7a-b

1982 *Hyperoplus lanceolatus sculptus* Gaemers & Schwarzahns, 1973 - Gaemers & Schwarzahns, p. 142, pl. 10, fig. 3a, b.

Material - *Aporrhais* bed: 1 sagitta, coll. RGM 176 494, leg. U. von Hacht.

L: 3.65 mm H: 1.64 mm T: 0.59 mm L/H: 2.23 L/T: 6.19.

Discussion - A third specimen, larger and more slender than the first ones, has been found. It is somewhat eroded, but it still shows some indistinct knobs on the outer surface along the rims. The few otoliths available actually are so poor that a good comparison with the Pliocene *H. lanceolatus sculptus* is still difficult. Therefore classification in open nomenclature is preferable.

Subordo GOBIOIDEI
Familia GOBIIDAE
Genus *Gobius* Linné, 1758

Gobius pretiosus Procházka, 1893

Material - *Aporrhais* bed: 2 sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.

Ordo BERYCIFORMES
Familia ?BERYCIDAE

?*Berycidarum* sp.
Plate 2, fig. 9a-b

Material – Horizon with *Ditrupa* bed: 1 juvenile sagitta, coll. RGM 176 495, leg. A. W. Janssen 1975.
(L: 1.00 mm) (H: 0.80 mm) T: 0.31 mm.

Description – A small, compact and thick otolith with a nearly round outline. Dorsal rim and rostrum broken. Rostrum and antirostrum large and protruding. Excisura deep and sharp. Sulcus clearly suprmedian with a short and deep ostium, and a somewhat longer, much shallower cauda filled with a thick colliculum. Posterior part of cauda directed dorsally.

Outer surface has one large knob above the centre. A clear, but somewhat irregular furrow runs more or less lengthwise underneath the rostrum.

Discussion – The general outline of the otolith agrees with that of otoliths belonging to the Berycidae family. Several characteristics of the sulcus are also in accordance with this family. However, the ostium is less wide and deeper than usual; it is not known to me whether these are only juvenile characteristics or that the otolith belongs to a related family.

Ordo PLEURONECTIFORMES
Familia BOTHIDAE
Genus *Arnoglossus* Bleeker, 1862

Arnoglossus aff. *miocenicus* Weiler, 1962

Material – *Aporrhais* bed: 4 sagittas, coll. SMF P. 6572, leg. U. von Hacht.

Genus *Lepidorhombus* Günther, 1862

Lepidorhombus kloekenhoffi Gaemers & Schwarzahns, 1982

Material – *Aporrhais* bed: 1 broken juvenile sagitta, coll. P. A. M. Gaemers, leg. U. von Hacht.

Familia SOLEIDEI
Genus *Buglossidium* Chabanaud, 1930

Buglossidium aff. *approximatum* (Koken, 1891)

Material – *Aporrhais* bed: 2 juvenile sagittas, coll. P. A. M. Gaemers, leg. U. von Hacht.
Horizon unknown: 1 juvenile sagitta, coll. P. A. M. Gaemers, leg. F. Weinbrecht.

*Lapilli***Lapillus inc. sedis sp. 2 Gaemers & Schwarzhans, 1982**

Material – *Aporrhais* bed: 1 eroded lapillus, coll. P. A. M. Gaemers, leg. U. von Hacht.

Horizon unknown: 1 eroded lapillus, coll. P. A. M. Gaemers, leg. F. Weinbrecht.

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PLATE 1

All specimens figured are from the Syltian (Late Miocene) deposits of the Morsum Cliff, island of Sylt, the type locality of the Syltian.

- Fig. 1a-d *Melanogrammus morsumensis* n. sp. Holotype.
Aporrhais bed, coll. RGM 176 492, leg. U. von Hacht. 10 x.
- Fig. 2a-d *Trisopterus angustus* Gaemers & Schwarzhans, 1982. Topotype.
Aporrhais bed, coll. RGM 176 490, leg. U. von Hacht. 7.5 x.
- Fig. 3a-d *Gadichthys venustus* (Koken, 1891).
Aporrhais bed, coll. RGM 176 485, leg. U. von Hacht. 7.5 x.
- Fig. 4a-d *Trisopterus incognitus* Gaemers, 1976.
Aporrhais bed, coll. RGM 176 491, leg. U. von Hacht. 10 x.

All photographs were made with ordinary light.

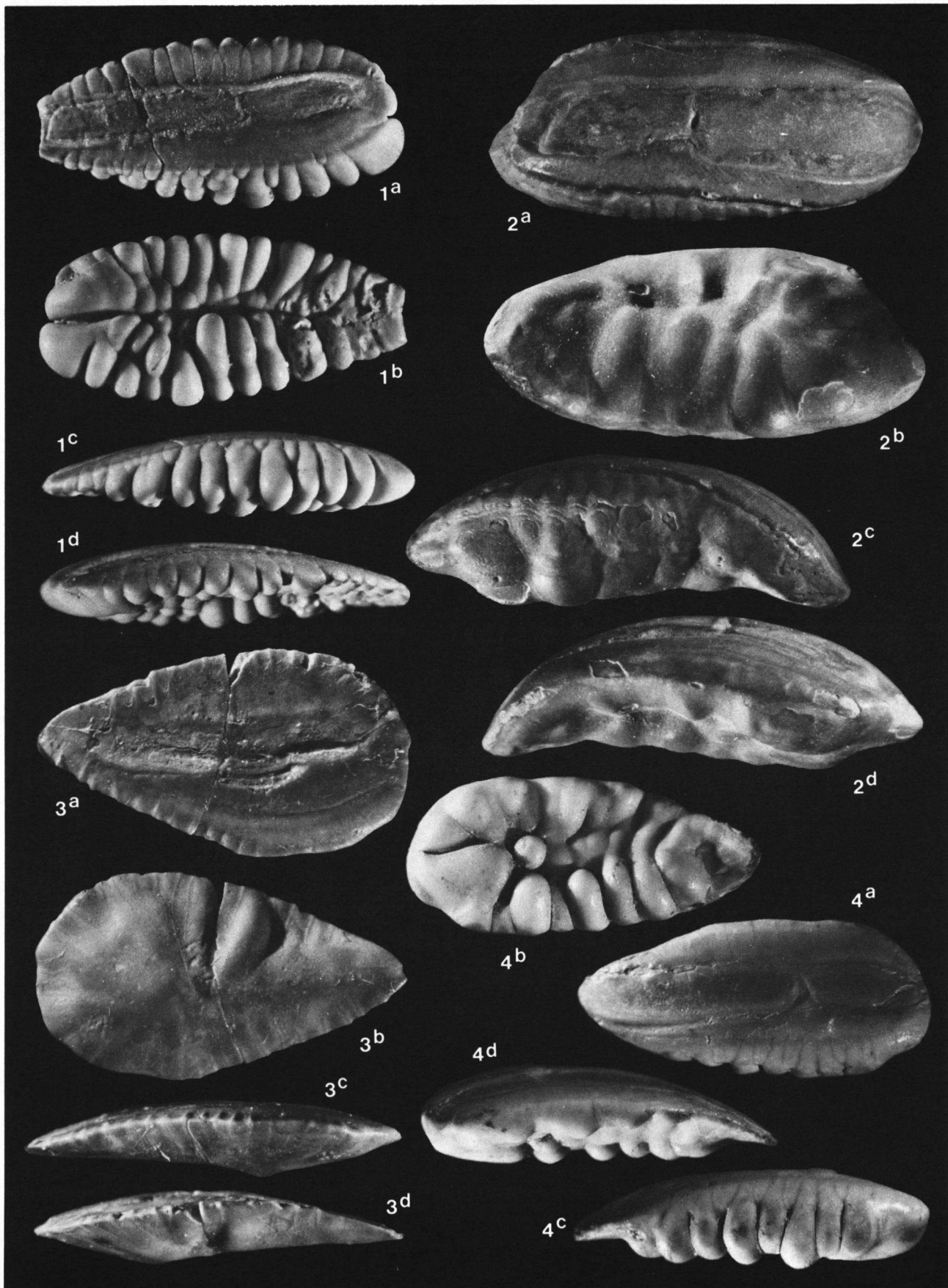


PLATE 2

All specimens figured are from the Syltian (Late Miocene) deposits of the Morsum Cliff, island of Sylt, the type locality of the Syltian.

- Fig. 1a-d *Pseudocolliolus curvidorsalis* n. sp. Holotype.
Horizon unknown, coll. RGM 176 487, leg. F. Weinbrecht. 15 x.
- Fig. 2a-d *Trisopterus capelanus* (Lacepède, 1800).
Horizon with *Aporrhais* bed, coll. RGM 176 381, leg. A. W. Janssen. 15 x.
- Fig. 3a-b *Doyenneichthys syltensis* (Gaemers & Schwarzhans, 1892). Paratype.
Horizon with *Ditrupa* bed, coll. RGM 176 486, leg. A. W. Janssen. 15 x.
- Fig. 4a-b *Pseudocolliolus curvidorsalis* n. sp. Paratype.
Horizon unknown, coll. RGM 176 488, leg. F. Weinbrecht. 15 x.
- Fig. 5a-d *Gadichthys venustus* (Koken, 1891).
Horizon with *Aporrhais* bed, coll. RGM 176 354, leg. A. W. Janssen. 10 x.
- Fig. 6a-d *Phycis tenuis* (Koken, 1891).
Aporrhais bed, coll. P. A. M. Gaemers, leg. U. von Hacht. 15 x.
- Fig. 7a-b *Hyperoplus* sp.
Aporrhais bed, coll. RGM 176 494, leg. U. von Hacht. 15 x.
- Fig. 8a-b *Congridarum acutirostris* Gaemers & Schwarzhans, 1982. Topotype.
Aporrhais bed, coll. RGM 176 483, leg. U. von Hacht. 15 x.
- Fig. 9a-b ?*Berycidarum* sp.
Horizon with *Ditrupa* bed, coll. RGM 176 495, leg. A. W. Janssen. ca. 28 x.
- Fig. 10a-b *Clupeidarum* sp.
Horizon with *Ditrupa* bed, coll. RGM 176 484, leg. A. W. Janssen. ca. 26 x.

Fig. 7a-b are Scanning Electron Microscope photographs.
All other figures were made with ordinary light.

