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LATE QUATERNARY AND RECENT OTOLITHS FROM THE SEAS AROUND SOUTHERN NORWAY

by

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Many bottom samples from the sea around Norway from depths varying between 77 and 407 m yielded fish otoliths. The state of preservation of the fossil otoliths is indicative of carbonate dissolution in the entire area studied. This area is the western and northern continuation of a large area of dissolution described by Alexandersson (1978). Two assemblages, determined by depth, can be recognized. The critical boundary seems to be the 290 m depth line. The shallower assemblage is strongly dominated by Gadidae, and *Neocolliolus esmarki* is the most common species in it. Gadidae and Myctophidae are about equally important in the deeper assemblage; *Micromesistius poutassou* is the most common species in it. It can be concluded that the largest numbers of otoliths are furnished by fish species which are small, occur in large numbers and possess a relatively small total length compared with the size of the otoliths.

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Contents:

SAMENVATTING

Bodemmonsters, genomen met de Van Veen happer tijdens twee vaartochten van het schip Aurelia (NIOZ, Texel), bleken geregeld otolieten te bevatten. De stations waarvan deze otolieten afkomstig zijn, variëren in zeediepte van 77 tot 407 m, en liggen in een gebied dat zich uitstrekt van 63° N en 1°40' E tot 57°10' N en 8°50' E. Ook worden een aantal otolieten uit de Stjörnfjord beschreven, die wat noordelijker ligt.

Naar gelang de conservatietoestand kunnen fossiele, 'subfossiele' en recente otolieten onderscheiden worden. De fossiele otolieten zijn flink uitgeloogd. Het onderzochte gebied is de westelijke en noordelijke voortzetting van een groot gebied van waar oplossing van kalk reeds bekend was (het oostelijke deel van het Skagerrak, het Kattegat en de Oostzee; Alexandersson, 1978).

Er kunnen twee otolietengezelschappen onderscheiden worden, die ieder hun eigen dieptebereik hebben. Het ene gezelschap komt voor boven de 290 m diepte en wordt zeer sterk gedomineerd door de kabeljauwachtigen (Gadidae). *Neocolliolus esmarki*, de noorse kabeljauw, is hierin de meest algemene soort. Het andere gezelschap komt voor beneden de 290 m diepte. Hierin zijn de kabeljauwachtigen en de lantaarnvissen (Myctophidae) ongeveer even sterk vertegenwoordigd en is *Micromesistius poutassou*, de blauwe wijting, de meest algemene soort.

Bijna alle otolieten zijn afkomstig van vissen met een totale lengte van 20 cm of minder. Dit komt goed overeen met de otolieten van het Long Forties gebied. De conclusie die werd getrokken uit laatstgenoemde fauna (Gamers, 1977), namelijk dat de grootste aantallen otolieten aan het sediment worden geleverd door die vissoorten die klein zijn, in grote aantallen voorkomen en een relatief kleine totale lengte hebben ten opzichte van hun otolieten, wordt bevestigd door de hier beschreven otolietenfauna.

INTRODUCTION

During two voyages of the vessel Aurelia of the Netherlands Institute for Sea Research (NIOZ, Texel), made in June and September 1976 for the geological investigation of the subsurface of the Norwegian Trough, quite a number of Van Veen grab samples were taken from the sea bottom in this area. Mr. G. C. A. Duineveld who was one of the students assisting Mr. Tj. van Weering during these voyages, has picked out the samples and placed the otoliths from these samples at my disposal. The stations sampled at these voyages have been plotted on a map (fig. 1). A distinction has been made between the stations where otoliths actually were found and those where they were absent in the samples. Only the code numbers of the stations which furnished otoliths are given on the map. In order to keep the map surveyable only the serial numbers of these stations have been given. The otoliths of the NIOZ samples are kept in the collections of the Rijksmuseum van Geologie en Mineralogie, Leiden (RGM registration numbers).

Furthermore some otoliths are described which were collected by Mr. M. C. Cadée. They originate from a drag sample taken in the Stjörnfjord (westernmost part of the Trondheimsfjord; 63°43' N and 9°52' E) at a depth varying between 50 and 100 m. This sample was collected on 25 August 1965.

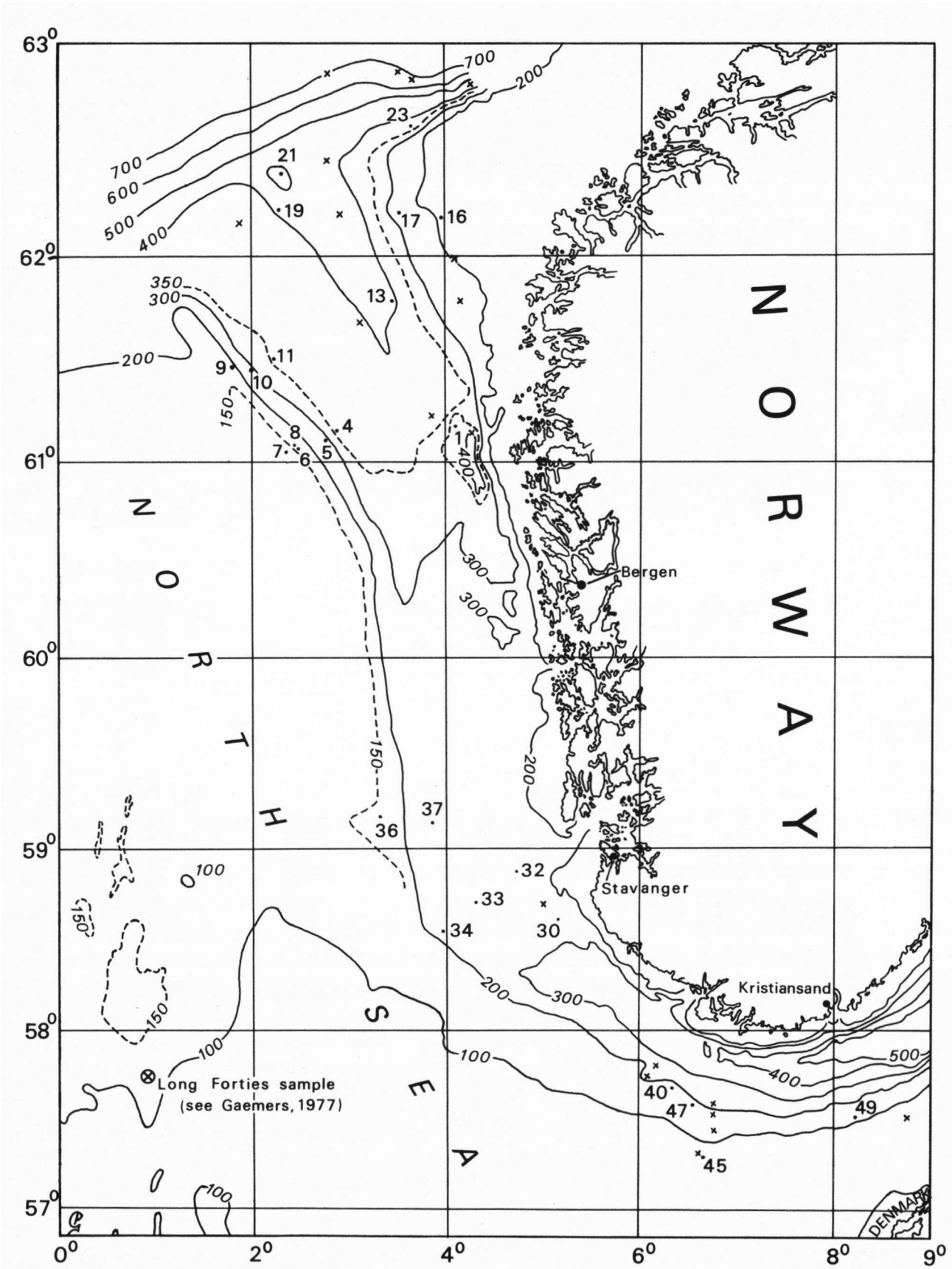

Fig. 1. Map indicating the stations of the NIOZ voyages of June and September 1976. Stations at which otoliths were found are marked with a dot plus the serial number of the station. Stations at which no otoliths were found are indicated with a cross.

STATE OF PRESERVATION OF THE OTOLITHS

Only a minority of the otoliths can be considered to be recent or 'subfossil'. The recent otoliths have a fresh appearance: they are gleaming white, at least for a part of their surface; moreover they are strong, which testifies to the fact that no dissolution has taken place. The 'subfossil' otoliths are dull white and already somewhat lixiviated by dissolution.

Most specimens have a fossil appearance. They are more or less coloured, most frequently in light hues: light yellow, cream-coloured or light brown. Sometimes they are rather dark brown or bluish. The otoliths from the Stjörnfjord all have a medium brown colour. These different colours indicate that the otoliths are not equally old. How old they are exactly is difficult to tell, but they are presumably of a Holocene and/or Late Pleistocene age. These otoliths are always more or less brittle; this fragility has been caused by dissolution, which has often proceeded further than that of many Tertiary otoliths. This process of dissolution seems to happen rather rapidly, for it is highly unlikely that the soft sediments which form the present sea bottom are really old, geologically speaking.

It is not immediately obvious how this process takes place. Normal sea water has a pH slightly over 7. Otoliths consist for the greater part of calcium carbonate, and one would expect that they only can be dissolved in an acid environment. Probably the carbonate dissolution can be explained by a lack of calcium and carbonate ions in the sea water, so that the chemical equilibrium between the solid calcium carbonate and the calcium and carbonate in solution shifts to the latter side.

Recently Alexandersson (1978) has discovered a large area in this neighbourhood where dissolution takes place: *'Dissolution of carbonate constituents seems to be an ordinary ingredient in the normal, healthy marine environment in the eastern Skagerrak. Spotchecks indicate the presence of dissolution also in the Kattegat and the brackish Baltic Sea - in total, an area of 450.000 km^2. This is supposed to be the largest occurrence of carbonate dissolution so far reported from shallow waters'.*

From the fragile fossil otoliths in the bottom samples described in this paper it can be concluded that the area of dissolution stretches much farther away to the West (at least to 1°40' E) and to the North (at least to 63° N).

It can easily be observed that the fossil otoliths are more frequently rounded by erosion than the subfossil or recent specimens. This can be explained by the fact that the fossil otoliths are much more fragile than the other ones.

SIZE OF THE SAMPLES

The Van Veen grab apparatus takes bottom samples of 0.1 m^2. The depth below sea bottom reached by this apparatus is, however, variable, depending largely on the resistance of the sediment. Thus the volumes of the various samples are not equal, so that the numbers of otoliths per sample are not completely comparable mutually. Moreover, the number of otoliths per kg of sediment usually is small in the area, so that many Van Veen grab samples from each station would be necessary in order to get a thorough knowledge of the distribution of the otoliths of all species which deliver ear stones to the sediment. The best proof of the statistically unreliable quantities of otoliths per grab sample is given by the four examples that are available of two grab samples per station (see table 1, stations at depths of 107, 199, 285 and 405 m). Species that are present in one sample of a

station are often absent in the parallel sample. The absence of otoliths at a station of which only one grab sample is available therefore does not mean that we can be certain that otoliths are absolutely absent at that station.

SURVEY OF THE FAUNA

It can easily be read from table 1 that there are two assemblages of otoliths in the area which are determined by depth: the first assemblage is characterized by a strong dominance of the otoliths of the Gadidae, the second by a more or less equivalent distribution of the Gadidae and the Myctophidae (lantern fishes). *Neocolliolus esmarki* is the most frequently occurring codfish in the first assemblage, whereas *Micromesistius poutassou* gradually takes over this position towards the second assemblage. All stations at a depth of 285 m or less belong to the first assemblage and all stations at a depth of 298 m or more belong to the second one. The 290 m depth line thus seems to be the critical boundary between both assemblages.

All species of which otoliths have been found are common or even abundant in the area studied. The depths at which the otoliths occur are usually in accordance with what is known about the depth distribution of the living fishes (Svetovidov, 1962; Muus, 1966; Hureau & Monod, 1973). *N. esmarki* seems to have a somewhat larger depth distribution than recorded in the literature. According to Svetovidov (in Hureau & Monod, 1973) this species generally lives at depths of 100 - 250 m. Muus (1966) gives a depth interval of 80 - 300 m. In the Norwegian Trough the otoliths of this species frequently occur up to a depth of 387 m.

The depth distribution for *Gadichthys thori* is given as 200 - 1000 m by Svetovidov (in Hureau & Monod) and as 60 - 1000 m by Muus, who mentions that the species prefers muddy bottoms at depth of 100 - 300 m. The data from the sea around Norway added to the otolith fauna of the Long Forties (Gaemers, 1977) suggest that the critical upper boundary of the distribution of *G. thori* lies between 124 m (= the depth of the Long Forties sample) and 150 m (the shallowest occurrence of the species in the area studied.

At first glance the depth data of the otoliths of *Merlangius merlangus* do not seem to fit with the known depth distribution of the living fishes of this species, for one otolith has been found at a depth of 249 m. According to Svetovidov and Muus the whiting, *M. merlangus*, lives at the bottom at depths of 30 - 100 m and is rare below 200 m. The otolith involved, however, comes from a small fish of ca. 6.5 cm. Whitings of this size live pelagically and consequently they may have been living above shallow as well as deep sea bottoms.

It is striking that nearly all otoliths come from fishes with a total length of 20 cm or less. This agrees very well with the lengths of the fishes which furnished otoliths to the Long Forties fauna. Another similarity between both faunas is the strong dominance of the codfish family. Other families which include species with relatively small otoliths are not or hardly represented in both faunas. The conclusion, drawn in my paper of 1977, that the largest numbers of otoliths are furnished by those fish species which are small, which occur in large numbers and which must possess a relatively small total length with respect to the size of the otoliths, thus is confirmed by the otolith fauna from the sea around Norway.

An important difference between the Long Forties fauna and the Norwegian fauna is that the recent otoliths form a minority in the Norwegian area, whereas these otoliths form a distinct majority in the Long Forties area. This gives us another indication that the extremely rich otolith fauna

of the Long Forties can indeed have been a resting place of predators, as Cadée (1977) suggests. If this was indeed the case fossilisation of otoliths must be a rapid process.

There are 5 species which occur both in the Norwegian fauna and in that of the Long Forties. These are *Neocolliolus esmarki* (the most abundant species in both areas), *Melanogrammus aeglefinus, Merlangius merlangus, Echiodon drummondi* and *Glyptocephalus cynoglossus*. A little more than 50% of the faunas consists of species which were found in only one of the areas. Certainly this is partly due to the fact that not yet enough otoliths are available of these areas, but for an important part the discrepancy is caused by differences in sea depth. Also the proportions in which most species are to one another, change with depth.

It seems that at least 4 otolith assemblages occur in the North Sea which are indicative of a special depth interval. In order of succession from shallow to deeper marine these assemblages are:
1. an assemblage in which Gadidae and Pleuronectiformes are about equally important (see Gaemers, in prep.),
2. a Gadidae dominated assemblage, with *N. esmarki* as the most abundant species, but (almost) without *M.poutassou* and *G. thori*,
3. a Gadidae dominated assemblage, with *N. esmarki* as the most abundant species, and with considerable numbers of *M.poutassou* and *G. thori*,
4. an assemblage in which Gadidae and Myctophidae are about equally important.

The boundary between assemblages 1 and 2 presumably will lie around a depth of 80 m. The boundary between assemblages 2 and 3 perhaps can be situated between 135 and 150 m. Finally the boundary between assemblages 3 and 4 occurs at a depth of 290 m. More data are necessary for a better delimitation of the first two boundaries.

SYSTEMATICAL PART

Phylum PISCES
Superclassis TELEOSTOMI (OSTEICHTHYES)
Classis ACTINOPTERYGII
Subclassis TELEOSTEI
Ordo SCOPELIFORMES
Familia MYCTOPHIDAE Gill, 1892
Genus *Benthosema* Goode & Bean, 1895

Benthosema glaciale (Reinhardt, 1837)
Plate 1, fig. 1a - b

Material - 1 well-preserved fossil sagitta, sta. V76-10, depth 298 m, Coll. RGM 176 118.
L: 1.44 mm H: 1.81 mm

Discussion - The otoliths of this species can not be confused with those of *Benthosema suborbitale*: the length of the latter species is greater than the height (see also Kotthaus, 1972a, b), whereas in *B. glaciale* just the opposite is the case. Furthermore *B. glaciale* is the only species of this genus living in the area studied; *B. suborbitale* has a tropical and subtropical distribution (Hureau & Monod, 1973).

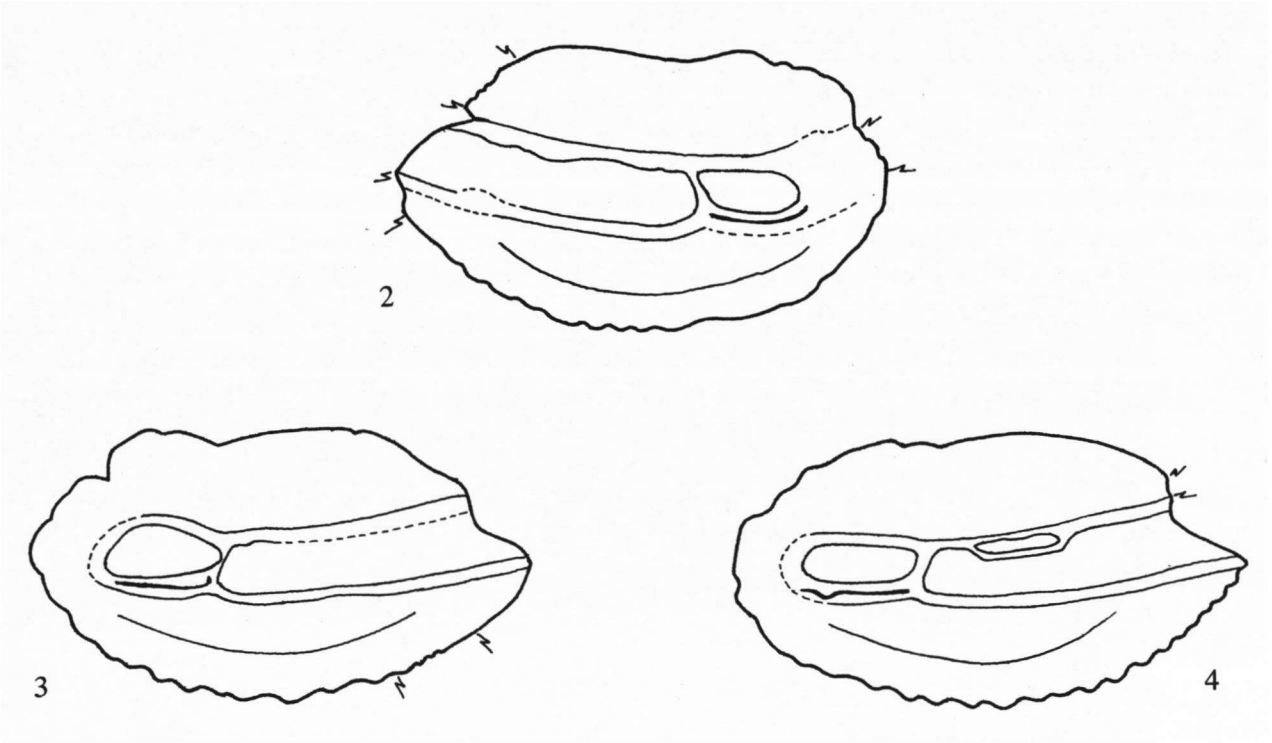

Fig. 2. Inner surface of right sagitta of *Notoscopelus kroeyeri* (Malm, 1861). Off SW Ireland, Coll. D. Nolf, 12 x.
Fig. 3, 4. Inner surface of left sagittas of *Notoscopelus elongatus* (Costa, 1844). Off Sardinia, Coll. D. Nolf, 12 x.

Genus *Notoscopelus* Günther, 1864

Notoscopelus kroeyeri (Malm, 1861)
Plate 1, fig. 3 - 6, text fig. 2

Description - Thin, medium-sized sagittas. Outline elongated and oval. Thin, sharp ventral rim regularly bent and lobated. Most important lobes along anterior part of this rim; lobes sometimes developed as spines. Fragile rostrum clearly pointed. Antirostrum rounded or pointed. Excisura ostii sharply and rather deeply incised. Thin and sharp dorsal rim irregularly and weakly undulated; deepest part slightly behind the middle. Predorsal and postdorsal angles weakly developed. Caudal rim rounded with mostly one distinct indentation situated more towards dorsal rim.

Inner surface nearly flat. Sulcus acusticus long, shallow, nearly straight and medially situated. Ostium 3 times the length of cauda. Ostium widens somewhat towards rostrum. Colliculi well-developed. Ostial colliculum more distinct than caudal colliculum. Cristae along cauda weak or nearly absent. Cristae along ostium better visible, especially the crista superior along anterior part of ostium. Area large, elongated and shallow; widest part of it just above the collum and below the deepest part of the dorsal rim. Ventral furrow distinct and regularly bent; it sometimes cuts through the ventral part of the ostium. Ventral furrow and dorsal boundary of area form a nearly complete ellipse. Short and shallow small furrows reach all rims, but occur especially along ventral rim.

Outer surface only slightly convex. Radial ribs along all rims, most densely spaced along ventral rim. A low, but nevertheless clear elevation behind the middle. This elevation has a round shape and

narrows to a less distinct medial ridge which runs up to the rostrum. Elevation and ridge are smooth.

Material - All otoliths with a subfossil to fossil appearance. They are somewhat rounded by erosion or hardly eroded. Totally 12 sagittas.

3 sagittas, sta. V76-10, depth 298 m, Coll. RGM 176 119, 176 120; 3 sagittas, sta. V76-4, depth 358 m, Coll. RGM 176 121, 176 122; 1 sagitta, sta. V76-21, depth 388 m, Coll RGM 176 123; 5 sagittas, sta. V76-19, depth 405 m, Coll. RGM 176 124, 176 125.

L: 4.49 mm H: 2.63 mm T: 0.64 mm (Plate 1, fig. 5)
L: 4.29 mm H: 2.50 mm T: 0.54 mm (Plate 1, fig. 4)
L: 4.18 mm H: 2.37 mm T: 0.55 mm (Plate 1, fig. 3)
(L: 4.06 mm) H: 2.35 mm T: 0.55 mm (Plate 1, fig. 6)

Discussion - *Notoscopelus kroeyeri* is the only species of the genus which is known to live in the area. All other Atlantic species occur at clearly lower latitudes (Hureau & Monod, 1973). To be sure about the identification of the *Notoscopelus* otoliths found, it is necessary to compare them with the other species of this genus in the North Atlantic. Photographs of the otoliths of *N. caudispinosus* (Johnson, 1863) and *N. resplendens* (Richardson, 1845) can be found in Kotthaus (1972a). Their outlines are clearly different from our otoliths: they are for instance more compact than our specimens. The otoliths of *N. elongatus* (Costa, 1844) on the other hand are somewhat more elongated (text figs. 3 and 4); moreover their rims are more strongly sculptured.

It is the first time that otoliths of this species are described and pictures are given.

Ordo GADIFORMES
Familia GADIDAE Rafinesque, 1810
Subfamilia MERLUCCIINAE
Genus *Merluccius* Rafinesque, 1810

Merluccius merluccius (Linnaeus, 1758)
Plate 1, fig. 7a - b

Material - 1 broken fossil sagitta, sta. V76-6, depth 150 m, Coll. RGM 176 126; 1 eroded subfossil sagitta, sta V76-8, depth 155 m, Coll. RGM 176 127.

Remarks - The otoliths belonged to juvenile fishes with total lengths of ca. 12.5 and 17.5 cm.

Subfamilia GADINAE
Genus *Gadichthys* Gaemers & Schwarzhans, 1973

Gadichthys thori (J. Schmidt, 1914)
Plate 2, fig. 3a - d, 4a - b, 7

Material - 23 sagittas, the state of preservation of which suggests that 16 specimens are fossil, 5 subfossil and 2 recent. The fossil specimens are mostly rounded by erosion. Only few otoliths are reasonably to well preserved.

3 sagittas (ca. adult), sta. V76-6, Coll. RGM 176 128, 176 129; 2 ca. adult sagittas and 2 very young sagittas, sta. V76-8, Coll. RGM 176 130, 176 131; 1 juvenile sagitta, sta. V76-16, Coll. RGM 176 132; 3 very young sagittas, sta.

V76-9, Coll. RGM 176 133, 176 134, 176 135; 1 juvenile and 2 adult sagittas, sta. V76-5, Coll. RGM 176 136, 176 137; 1 juvenile sagitta, sta. V76-10, Coll. RGM 176 138; 1 juvenile and 2 adult sagittas, sta. V76-11, Coll. RGM 176 139; 1 juvenile sagitta, sta. V76-4, Coll. RGM 176 140; 1 ca. adult sagitta, sta. V76-1, Coll. RGM 176 141; 1 very young sagitta, sta. V76-21, Coll. RGM 176 142; 1 juvenile and 1 adult sagitta, Stjörnfjord, Coll. Gaemers.

L: 4.55 mm H: 3.05 mm T: 0.87 mm
L: 4.35 mm H: 2.80 mm T: 0.79 mm (Plate 2, fig. 3)
L: 2.22 mm H: 1.35 mm T: 0.40 mm
L: 1.54 mm H: (Plate 2, fig. 4)
L: 1.21 mm H: 0.75 mm (Plate 2, fig. 7)

Discussion - Adult otoliths of *Gadichtys thori* and *Gadiculus argenteus* in most cases can be distinguished from one another. Juvenile specimens of these species resemble each other closely. As only *G. thori* is living in the area, all otoliths (also the juvenile ones) are supposed to belong to this species.

Remarks - The otoliths belonged to fishes with a total length of ca. 2 to 11 cm. Depth interval of the otoliths of this species in the area studied: 150 (50) - 388 m.

Genus *Neocolliolus* Gaemers, 1976

Neocolliolus esmarki (Nilsson, 1855)
Plate 1, fig. 8a - d, Plate 2, fig. 5a - d

Material - 82 sagittas, of which, according to the state of preservation, 74 specimens are fossil, 5 subfossil and 3 recent. Many fossil specimens are rounded by erosion.

1 sagitta, sta. V76-45, Coll. RGM 176 143; 6 sagittas, sta. V76-49, Coll. RGM 176 144; 6 sagittas, sta. V76-7, Coll. RGM 176 145; 32 sagittas, sta. V76-6, Coll. RGM 176 146, 176 147, 176 148; 8 sagittas, sta. V76-8, Coll. RGM 176 149; 4 sagittas, sta. V76-36, Coll. RGM 176 150; 4 sagittas, sta. V76-9, Coll. RGM 176 151; 2 sagittas, sta. V76-30, Coll. RGM 176 152; 4 sagittas, sta. V76-34, Coll. RGM 176 153; 1 sagitta, sta. V76-37, Coll. RGM 176 154; 2 sagittas, sta. V76-5, Coll. RGM 176 155; 1 sagitta, sta. V76-10, Coll. RGM 176 156; 2 sagittas, sta. V76-11, Coll. RGM 176 157; 4 sagittas, sta. V76-4, Coll. RGM 176 158; 1 sagitta, sta. V76-23, Coll. RGM 176 159; 1 sagitta, sta. V76-1, Coll. RGM 176 160; 2 sagittas, sta. V76-29, Coll. RGM 176 161; 1 sagitta, Stjörnfjord, Coll. Gaemers.

L: 7.76 mm H: 3.37 mm T: 1.77 mm (Plate 2, fig. 5)
L: 7.17 mm H: 2.85 mm T: 1.58 mm
L: 6.83 mm H: 2.76 mm T: 1.49 mm (Plate 1, fig. 8)

Remarks - *N. esmarki* is the most commonly occurring species in the bottom samples of the area studied. The otoliths belonged to fishes with a total length of ca. 6.5 to 18.5 cm. Depth interval of the otoliths of this species in the area studied: 77 (50) - 387 m.

Genus *Micromesistius* Gill, 1864

Micromesistius poutassou (Risso, 1826)
Plate 2, fig. 1a - d, 2a - d

Material - 49 sagittas, of which, judging from the state of preservation, 42 specimens are fossil and 7 subfossil. Their condition varies from strongly rounded to completely unaffected by erosion.

1 sagitta, sta. V76-45, Coll. RGM 176 162; 1 sagitta, sta. V76-49, Coll. RGM 176 163; 11 sagittas, sta. V76-6, Coll. RGM 176 164, 176 165; 1 sagitta, sta. V76-40, Coll. RGM 176 166; 2 sagittas, sta. V76-47, Coll. RGM 176 167; 3 sagittas, sta. V76-8, Coll. RGM 176 168; 1 sagitta, sta. V76-36, Coll. RGM 176 169; 1 sagitta, sta. V76-9, Coll. RGM 176 170; 1 sagitta, sta. V76-17, Coll. RGM 176 171; 3 sagittas, sta. V76-34, Coll. RGM 176 172; 2 sagittas, sta. V76-37, Coll. RGM 176 173; 1 sagitta, sta. V76-33, Coll. RGM 176 174; 4 sagittas, sta. V76-5, Coll. RGM 176 175, 176 176; 5 sagittas, sta. V76-10, Coll. RGM 176 177; 4 sagittas, sta. V76-11, Coll. RGM 176 178; 3 sagittas, sta. V76-4, Coll. RGM 176 179; 1 sagitta, sta. V76-21, Coll. RGM 176 180; 1 sagitta, sta. V76-19, Coll. RGM 176 181; 1 sagitta, sta. V76-13, Coll. RGM 176 182; 2 sagittas, Stjörnfjord, Coll. Gaemers.
L: 9.71 mm H: 3.35 mm T: 1.43 mm (Plate 2, fig. 1)
L: 8.75 mm H: 2.72 mm T: 1.05 mm
L: 5.71 mm H: 1.93 mm T: 0.67 mm (Plate 2, fig. 2)

Remarks - With respect to the number of specimens *M. poutassou* is the second common species in the area, although no other species has been found at so many stations. The otoliths belonged to fishes with a total length of ca. 7 to 29 cm. The species occurs in the entire depth interval of the stations which contain otoliths: 77 (50) - 407 m.

Genus *Merlangius* E. L. Geoffroy, 1767

Merlangius merlangus (Linnaeus, 1758)
Plate 1, fig. 9a - d, Plate 2, fig. 6a - b

Material - 3 sagittas in total.

1 subfossil juvenile sagitta, sta. V76-40, depth 154 m, Coll. RGM 176 183; 1 recent juvenile sagitta, sta. V76-32, depth 249 m, Coll. RGM 176 184; 1 fossil juvenile sagitta, Stjörnfjord, Coll. Gaemers.
L: 3.42 mm H: 1.26 mm T: 0.50 mm (smallest specimen, Plate 2, fig. 6)

Remarks - The otoliths belonged to fishes with a total length of ca. 6.5 to 10 cm. Depth interval of the otoliths of this species in the area studied: 154 (50) - 249 m.

Genus *Melanogrammus* Gill, 1863

Melanogrammus aeglefinus (Linnaeus, 1758)

Material - 3 sagittas in total.

1 fossil, rather eroded juvenile sagitta, sta. V76-6, depth 150 m, Coll. RGM 176 185; 1 well-preserved subfossil sagitta, sta. V76-9, depth 199 m, Coll. RGM 176 186; 1 fossil, well-preserved juvenile sagitta, sta. V76-1, depth 387 m, Coll. RGM 176 187.

Remarks - The otoliths belonged to juvenile fishes with a total length of ca. 9 to 14.5 cm. Depth interval of the otoliths of this species in the area studied: 150 - 387 m.

Genus *Pollachius* Nilsson, 1832

Pollachius sp.

Material - 1 fossil, somewhat eroded juvenile sagitta, Stjörnfjord, Coll. Gaemers.

Remarks - The specimen found is a very juvenile otolith. For want of comparison material of recent otoliths of such a small size an identification of the species is not yet possible.

GADINAE sp. indet.

Material - 2 badly preserved sagittas, Stjörnfjord, Coll. Gaemers.

Ordo OPHIDIIFORMES
Familia CARAPIDAE
Genus *Echiodon* Thompson, 1837

Echiodon drummondi Thompson, 1837
Plate 1, fig. 2a - d

Material - 1 fossil, little eroded sagitta, sta. V76-6, depth 150 m, Coll. RGM 176 188.
L: 5.66 mm H: 2.75 mm T: 1.52 mm

Remarks - It is the second time that this species has been found in bottom samples of the North Sea (see Gaemers, 1977, where a description of the otoliths is given). Thus *E. drummondi* does not seem to be a rare species, although it is not known to occur in large numbers at one place. The depth distribution of the living population of this species is not yet well-known.

Ordo PLEURONECTIFORMES
Familia PLEURONECTIDAE
Genus *Glyptocephalus* Gottsche, 1835

Glyptocephalus cynoglossus (Linnaeus, 1758)

Material - 1 badly preserved fossil sagitta, sta. V76-5, depth 285 m, Coll. RGM 176 189.

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Reliable identifications are impossible without recent otolith material for comparison. Therefore I wish to thank Dr. D. Nolf (Gent, Belgium) for giving me the opportunity to study recent

otoliths of *Notoscopelus kroeyeri* and *N. elongatus*, and Dr. J. E. Fitch (Long Beach, California, U.S.A.) for sending me recent otoliths of *Benthosema glaciale* and *B. suborbitale*. Thanks are also due to Dr. T. Bakke (Institutt for Marinbiologi, Blomsterdalen, Norway) who has sent me a large number of specimens of *Gadichthys thori*.

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Tabel 1. Otolith distribution in the seas around southern Norway (see fig. 1 for location of stations)

Station	Co-ordinates		Depth	*B. glaciale*	*N. kroeyeri*	*M. merluccius*	*G. thori*	*N. esmarki*	*M. poutassou*	*M. merlangus*	*M. aeglefinus*	*Pollachius* sp.	Gadinae indet.	*E. drummondi*	*G. cynoglossus*
V76-45	57°18'30" N	6°39' E	77 m					1	1						
V76-49 no.1	57°32' N	8°15' E	107 m						1						
V76-49 no. 2	57°32' N	8°15' E	107 m					6							
V76-7	61°03' N	2°21' E	150 m					6							
V76-6	61°04'30" N	2°28' E	150 m			1	3	32	11		1			1	
V76-40	57°41'20" N	6°20'30" E	154 m						1	1					
V76-47	57°36' N	6°33' E	155 m						2						
V76-8	61°05' N	2°26' E	155 m			1	4	8	3						
V76-36	59°09'40" N	3°19' E	159 m					4	1						
V76-16 no. 2	62°11' N	3°58' E	172 m				1								
V76-9 no. 1	61°28' N	1°48' E	199 m				2								
V76-9 no. 2	61°28' N	1°48' E	199 m				1	4	1		1				
V76-17 no. 2	62°12'30" N	3°31' E	240 m						1						
V76-32	58°52'30" N	4°43' E	249 m							1					
V76-30	58°36'30" N	5°09' E	250 m					2							
V76-34	58°33' N	3°57'10" E	262 m					4	3						
V76-37	59°08' N	3°51' E	269 m					1	2						
V76-33	58°42'40" N	4°17'30" E	271 m						1						
V76-5 no. 2	61°07' N	2°45' E	285 m				2	2	3						1
V76-5 no. 2'	61°07' N	2°45' E	285 m				1		1						
V76-10	61°27' N	2°00' E	298 m	1	3		1	1	5						
V76-11	61°30' N	2°14' E	352 m				3	2	4						
V76-4	61°09' N	2°52' E	358 m		3		1	4	3						
V76-23 no. 3	62°37' N	3°40' E	380 m					1							
V76-1	61°10'30" N	4°06' E	387 m				1	1			1				
V76-21	62°23'30" N	2°19' E	388 m		1		1		1						
V76-19 no. 1	62°12'30" N	2°18'30" E	405 m						1						
V76-19 no. 2	62°12'30" N	2°18'30" E	405 m		5										
V76-13	61°47' N	3°28' E	407 m						1						
V76-29	position and depth unknown							2							
Stjörnfjord	63°43' N	9°52' E	50-100m				2	1	2	1		1	2		
			Total	1	12	2	23	82	49	3	3	1	2	1	1

Plate 1

Fig. 1a -b *Benthosema glaciale* (Reinhardt, 1837).
Late Quaternary, sta. V76-10, depth 298 m. Coll. RGM 176 118.
15 x

Fig. 2a - d *Echiodon drummondi* Thompson, 1837.
Late Quaternary, sta. V76-6, depth 150 m. Coll. RGM 176 188.
10 x

Fig. 3a - c *Notoscopelus kroeyeri* (Malm, 1861).
Late Quaternary, sta. V76-21, depth 388 m. Coll. RGM 176 123.
10 x

Fig. 4a - d *Notoscopelus kroeyeri* (Malm, 1861).
Late Quaternary, sta. V76-19, depth 405 m. Coll. RGM 176 124.
10 x

Fig. 5a - b *Notoscopelus kroeyeri* (Malm, 1861).
Late Quaternary, sta. V76-10, depth 298 m. Coll. RGM 176 119.
10 x

Fig. 6a - b *Notoscopelus kroeyeri* (Malm, 1861).
Late Quaternary, sta. V76-4, depth 358 m. Coll. RGM 176 121.
10 x

Fig. 7a - b *Merluccius merluccius* (Linnaeus, 1758).
Late Quaternary, sta. V76-6, depth 150 m. Coll. RGM 176 126.
10 x

Fig. 8a - d *Neocolliolus esmarki* (Nilsson, 1855).
Late Quaternary, sta. V76-6, depth 150 m. Coll. RGM 176 146.
10 x

Fig. 9a - d *Merlangius merlangus* (Linnaeus, 1758).
Late Quaternary, sta. V76-40, depth 154 m. Coll. RGM 176 183.
10 x

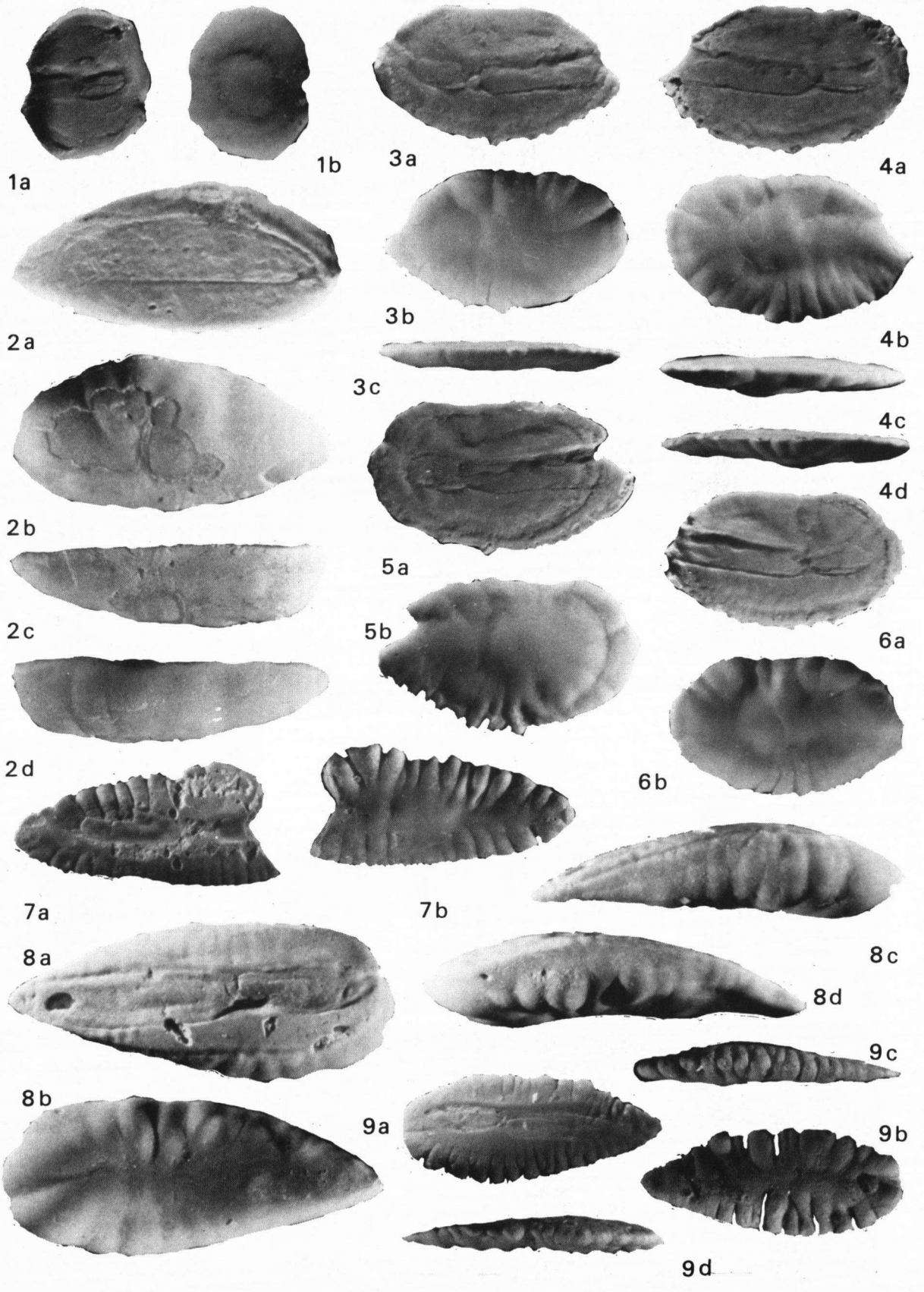
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Plate 2

Fig. 1a - d *Micromesistius poutassou* (Risso, 1826).
Late Quaternary, sta. V76-45, depth 77 m. Coll. RGM 176 162.
7.5 x

Fig. 2a - d *Micromesistius poutassou* (Risso, 1826).
Late Quaternary, sta. V76-6, depth 150 m. Coll. RGM 176 164.
10 x

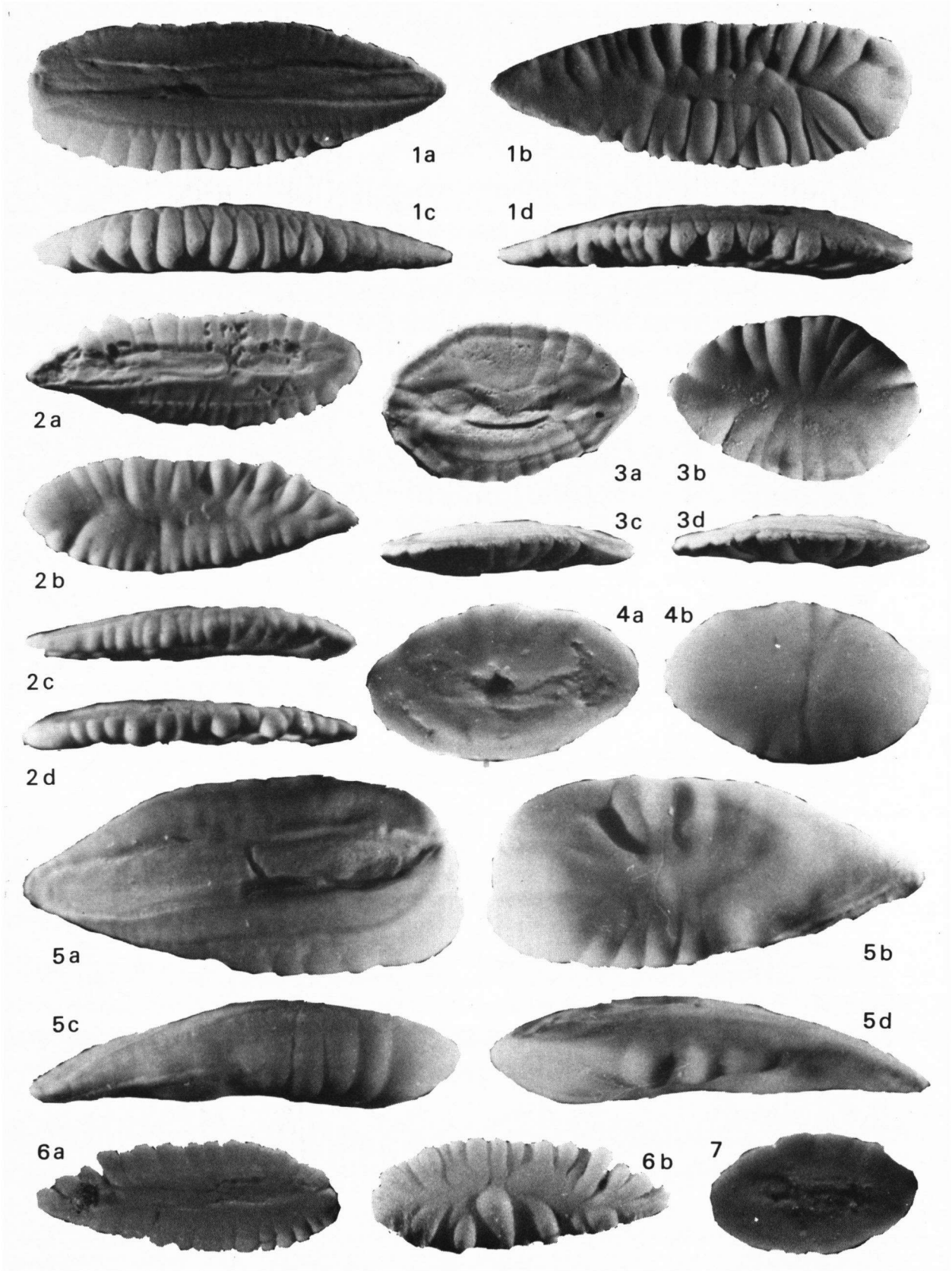
Fig. 3a - d *Gadichthys thori* (J. Schmidt, 1914).
Late Quaternary, sta. V76-6, depth 150 m. Coll. RGM 176 128.
10 x

Fig. 4a - b *Gadichthys thori* (J. Schmidt, 1914).
Recent, sta. V76-8, depth 155 m. Coll. RGM 176 130.
30 x

Fig. 5a - d *Neocolliolus esmarki* (Nilsson, 1855).
Late Quaternary, sta. V76-6, depth 150 m. Coll. RGM 176 147.
10 x

Fig. 6a - b *Merlangius merlangus* (Linnaeus, 1758).
Recent, sta. V76-32, depth 249 m. Coll. RGM 176 184.
15 x

Fig. 7 *Gadichthys thori* (J. Schmidt, 1914).
Recent, sta. V76-9, depth 199 m. Coll. RGM 176 133.
30 x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