Otolith stratigraphy of Late Weichselian and Holocene sediments of Malangsdjupet, off northern Norway

PIETER A. M. GAEMERS & TORE O. VORREN

Otoliths of eleven fish species have been identified in cores recovered from the trough Malangsdjupet (close to 70°N) on the Norwegian continental shelf. The codfish family (Gadidae) dominates with eight species. Three acme-zones belonging to the Merlangius merlangus Lineage-Zone are established: the Boreogadus sp. Acme-Zone (about 15,000 or 14,000 to 10,000 years B. P.), the Neocolliolus esmarki Acme-Zone (10,000 to 7,800 years B. P.) and the Micromesistius poutassou Acme-Zone (7,800 B. P. to present). The Boreogadus sp. Acme-Zone reflects an arctic environment while the two others reflect boreal conditions. The M. poutassou Acme-Zone represents a more oceanic environment than the early Holocene N. esmarki Acme-Zone.

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Studies of otoliths from the present sea floor and the youngest Quaternary sediments are few in number. Jensen (1905) described otoliths from an area between Jan Mayen, Iceland and the Faroes, and many years later Wigley & Stinton (1973) described otoliths from grab samples off Massachusetts. More recently Gaemers (1977, 1978a, 1979a and 1979b) has described recent and Late Quaternary otoliths from the North Sea Basin.

We report here results from a shelf area off northern Norway (Fig. 1A) which has a well-dated Late Quaternary stratigraphy (Vorren et al. 1983, 1984, Hald & Vorren 1984, Thomsen & Vorren, in prep.). We conclude that otoliths are a useful stratigraphic tool and that they give additional information about the paleo-environment.

The cores investigated were recovered from a trough, Malangsdjupet, crossing the shelf (Fig. 1B). The trough is 451 deep in the inner reaches, whilst the threshold at the shelf break is about 260 m deep. The watermasses in this area are dominated by Atlantic water in the Norwegian Current (salinity about 35 % or more) and the less saline overlying, seaward thinning wedge of water in the Norwegian Coastal Current. Temperatures fluctuate between 4 and 12°C throughout the year.

Material and methods

Twenty-seven gravity cores (diameter 100 mm) from ten stations (Fig. 1B) were investigated for otoliths. After splitting the cores vertically in two halves, they were investigated for various geotechnical and geological properties (Vorren et al. 1978, 1983, 1984). One-half of the core was divided into 10 cm long units and sieved. The > 1 mm grade was searched for otoliths and other fish remains. Altogether, 239 otoliths and two fish teeth were found. Identifications were made by comparing them with the senior author's recent otolith collection, and with fossil otoliths in the collection of the Rijksmuseum van Geologie en Mineralogie, Leiden, the Netherlands, where the present material has been deposited (RGM registration numbers 176.716–176.863).

Stratigraphy

The stratigraphy of the cores from Malangsdjupet and adjacent shelf areas (Fig. 2) has been described by Vorren et al. (1983, 1984). Details of the Holocene stratigraphy based on foraminifera and macrofossils are given in Hald & Vorren (1984) and Thomsen & Vorren (in prep.) respectively. Otoliths were found in units tD, tC, tB, tA and the Fugløybanken Sand comprising the dA, dB and sA units on Fig. 2.
Units tD and tC are very dark grey glaciomarine pebbly and sandy pelites, deposited in an iceberg environment. A recent dating from the lower part of unit tD gave $13,740 \pm 400$ B. P. (AA-400). Unit tC is shown by several $^{14}$C-datings to comprise the time span 13,000 to 10,000 B. P. The tB unit (= the Børingan Pelite of Hald & Vorren 1984) is an olive grey mud containing between 15 and 35% carbonate. It was deposited 10,000 to 7,800 years ago. During the last 7,800 years unit tA (= Andfjorden Sand) was deposited. This unit is composed of a sandy calcareous (30–50% carbonate) mud having an olive colour. The Fugløybanken Sand (= units dA + dB + sA), mostly occurring in the shallower areas, is a Holocene sandy gravel, produced by winnowing.

The investigated cores show the following stratigraphy (Table 1). Cores from the outer stations (1, 2, 5 and 55) comprise units tI, tF, tE, tD, tC, a hiatus, and on top Fugløybanken Sand. The Pleistocene diamictons in station 1 could not easily be referred to the described stratigraphy; probably they are older Pleistocene sediments. Cores from the stations 56, 57, 58 and 60 comprise units tA, tB and do occasionally penetrate into unit tC (all four cores from station 56, one from 57 and two from 60). At the relatively shallow station 61 (287–257 m) Fugløybanken Sand was overlying older Pleistocene deposits. The one core from station 62 showed a heavily disturbed sequence of tB and tA sediments. The disturbances may possibly be the result of submarine mass movement.
Table 1. Investigated cores; sampling depth, total core length in cm and thickness of the individual lithostratigraphic units in cm. FS = Fugløybanken Sand and P = undifferentiated Pleistocene. Units where otoliths were found are shaded.

Thanatocoenosis versus biocoenosis

Otoliths from eleven fish species were identified, eight of which belong to the codfish family (Tables 2 and 4). For illustrations of most species see Plates 1–3. The most common species is the blue whiting, *Micromesistius poutassou* (50.6%), followed by the Norway pout, *Neocolliolus esmarki* (30.5%), and cod, *Gadus morhua* (5.4%). All species represented still live in the sea surrounding northern Norway or in the immediate neighbourhood. According to Hognestad & Vader (1979), abundant present-day species in the waters off northern Norway are: *Gadus morhua, Melanogrammus aeglefinus, Micromesistius poutassou, Neocolliolus esmarki, Pollachius virens, Sebastes marinus* and *Glyptocephalus cynoglossus*. The following species are fairly common:
Table 2. Total numbers and percentages of the different otoliths found, and their occurrence in the various lithostratigraphic units. Core 62-2 is shown separately as it was impossible to distinguish unit tA and tB in this core.

<table>
<thead>
<tr>
<th>Species</th>
<th>F. Sand</th>
<th>Unit A</th>
<th>Unit B</th>
<th>ST.62-2 (A+B)</th>
<th>Unit C</th>
<th>Unit D Total (and E?)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. %</td>
<td>No. %</td>
<td>No. %</td>
<td>(A+B) %</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M. poutassou</strong></td>
<td>40 54.1</td>
<td>65 66.3</td>
<td>4 20.2</td>
<td>10 24.4</td>
<td>2</td>
<td>121</td>
</tr>
<tr>
<td><strong>N. esmarki</strong></td>
<td>17 23.2</td>
<td>14 14.3</td>
<td>15 75.2</td>
<td>27 65.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G. morhua</strong></td>
<td>5 6.8</td>
<td>6 6.1</td>
<td>1 5.1</td>
<td>1 2.4</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td><strong>M. aeglefinus</strong></td>
<td>3 4.1</td>
<td>2 2.1</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Boreogadus</em> sp.</td>
<td></td>
<td>3</td>
<td></td>
<td>3 (and E?)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>P. virens</strong></td>
<td>2 2.7</td>
<td>1 1.0</td>
<td>1 2.4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G. thori</strong></td>
<td>1 1.3</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M. merlangus</strong></td>
<td>4 5.4</td>
<td>6 6.1</td>
<td>1 2.4</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gadinarum sp. (otoliths)</td>
<td>2</td>
<td>2</td>
<td>1.2</td>
<td>1.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Gadinarum sp. (teeth)</td>
<td>4</td>
<td>4</td>
<td>1.5</td>
<td>1.5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>N. kroeyeri</strong></td>
<td>1 1.3</td>
<td>2 2.1</td>
<td>1 2.4</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G. cynoglossus</strong></td>
<td>1 1.0</td>
<td>1 2.4</td>
<td>1 2.4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL: 74 98 20 41 5 3 241

Table 3. Size, age, and maturity of fish represented by fossil otoliths in Malangsdjupet. Fish lengths for each species calculated from otolith lengths. Ages of fish inferred from lengths, not counted by year rings in the fossil otoliths. Sexual maturity: juv. = juvenile, ad. = adult.

<table>
<thead>
<tr>
<th>Species</th>
<th>fish length in cm</th>
<th>estimated age in years</th>
<th>sexual maturity</th>
<th>family</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Notoscopelus kroeyeri</em>  (Malm, 1861)</td>
<td>ca. 10</td>
<td>1 or 2</td>
<td>juv. Myctophidæ</td>
<td></td>
</tr>
<tr>
<td><em>Gadus morhua</em> Linnaeus, 1758</td>
<td>6.5–11</td>
<td>&lt;1</td>
<td>juv. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Melanogrammus aeglefinus</em> (Linnaeus, 1758)</td>
<td>7–11</td>
<td>&lt;1</td>
<td>juv. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Merlangius merlangus</em> (Linnaeus, 1758)</td>
<td>10</td>
<td>&lt;1</td>
<td>juv. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Pollachius virens</em> (Linnaeus, 1758)</td>
<td>5–21</td>
<td>&lt;1–&lt;2</td>
<td>juv. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Micromesistius poutassou</em> (Risso, 1826)</td>
<td>8–28</td>
<td>&lt;1–&lt;4</td>
<td>juv. + few ad. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Neocolliolus esmarki</em> (Nilsson, 1855)</td>
<td>8–19</td>
<td>&lt;1–3</td>
<td>juv. + few ad. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Gadiculus thori</em> J. Schmidt, 1914</td>
<td>ca. 7</td>
<td>ca. 1</td>
<td>juv. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Boreogadus</em> sp.</td>
<td>10–20</td>
<td>ca. 2–ca. 4</td>
<td>juv. + ad. Gadidæ</td>
<td></td>
</tr>
<tr>
<td><em>Sebastes</em> sp.</td>
<td>6.5–10</td>
<td>1–2 or 3</td>
<td>juv. Scorpaenidæ</td>
<td></td>
</tr>
<tr>
<td><em>Glyptocephalus</em> cynoglossus* (Linnaeus, 1758)</td>
<td>12–25</td>
<td>1–3</td>
<td>juv. Pleuronectidæ</td>
<td></td>
</tr>
</tbody>
</table>

*Notoscopelus kroeyeri*, *Gadiculus thori* and *Merlangius merlangus*. *Boreogadus saida* has only been found occasionally in north Norwegian waters, but it is abundant in the seas north of Russia and other Arctic waters.

Most otoliths are from juvenile fish less than one to two years old, and from specimens smaller than 15 cm. Only a few specimens come from fish larger than 20 cm (a survey is given in Table 3). This can be explained by the high mortality rate for most fish species. Thus the large numbers of small otoliths in the bottom sediments reflect to a high degree the biological situation that young fish outnumber the older. It necessarily follows that most otoliths found in bottom sediments come from fish that were eaten by larger animals.

One would, however, expect that otoliths of the very smallest fishes are most abundant, but this is not the case; fish smaller than 7 cm are nearly completely lacking. This can be explained by more rapid dissolution of smaller otoliths in gastric acid of predators or in sediment pore water – because of a less favourable surface/volume ratio and higher percentages of protein and less aragonite – than in later formed layers of larger and older otoliths (the diminishing percentage of organic material from the centre towards the rim can be observed in Degens et al. (1969, Fig. 3), where the organic material is visible as dark bands).

Due to the high juvenile mortality and the solution problem, small fish species having relatively large otoliths will be better represented in
the fossil assemblage than large species and species with relatively small otoliths (Gaemers 1977, 1978a). Owing to this, the percentages of the different fish species in the fossil record are usually not a reliable reflection of the original percentages of former living faunas. This is also true for the Malangsdjupet otoliths. The cod family, which is most frequent, possesses relatively large otoliths in comparison to many other fish families, thus it may be concluded that several other families were more common in the area during Late Weichselian and Holocene times than can be concluded from the fossil record.

Otolith stratigraphy

A close correlation between the litho- and biostratigraphy has been shown by Vorren et al. (1984), Hald & Vorren (1984) and Thomsen & Vorren (in prep.). When considering the occurrence of the otoliths within the investigated lithostratigraphy, a clear pattern emerges (Table 2).

No otoliths were found in units older than unit tD (or tE). Units tC and tD (or tE) are the only units bearing otoliths of polar cod (Boreogadus sp.). We establish the Boreogadus sp. Acme-Zone, and define it by the dominance of Boreogadus sp. (Hedberg 1976). This acme-zone seems to coincide with the lithostratigraphic units tC and tD (or tE). The term range-zone is avoided here because this zone certainly does not cover the entire stratigraphic range of Boreogadus sp.

Unit tB has a dominance of Neocolliolus esmarki (75 %) and we define the N. esmarki Acme-Zone for strata where this otolith is dominant. The data at hand indicate that this corresponds to the tB-unit.

A third biozone is defined by the dominance of Micromesistius poutassou (mean: 61 %). This M. poutassou Acme-Zone seems to correspond to the Fugløybanken Sand and the unit tA.

It should be pointed out that the frequencies of otoliths are rather low in the Late Weichselian and Early Holocene sediments. A larger data set may show that the acme-zone boundaries deviate somewhat from the lithostratigraphic boundaries. A generalized picture of the relation between litho-, chrono- and otolith-stratigraphy in the deeper part of Malangsdjupet is shown in Fig. 3.

All the fossil zones defined belong to the Merlangius merlangus Lineage-Zone of the Gadidae otolith zonation of Gaemers (1978b).

Paleoenvironmental implications

Boreogadus sp. Acme-Zone

In addition to the four Boreogadus sp. otoliths, two teeth of Gadinarum sp. and two otoliths from M. poutassou occur in this zone. The Boreogadus otoliths may belong to B.saida or B. agilis, probably the latter (see Appendix: Selected Systematics). Boreogadus saida prefers to live under sea ice or at its edge. It is a coastal fish, but it also occurs around icebergs and among floating ice far from land (Jensen 1905, Svetovidov 1962). B. agilis is only known from a small number of specimens west of Greenland (Svetovidov 1962), and lives in the same environment as B. saida. This environmental description fits well with earlier interpretation of the environment during tE to tC-time, i.e., about 15,000 to 10,000 years ago (Vorren et al. 1984). The findings of M. poutassou in unit tD may indicate periods with somewhat warmer water. However, it should be noted that reworked fossils occur...
Table 4. Distribution of otoliths in the cores; numbers of otoliths per sample and per species. Lithostratigraphic units are given before the vertical line of each core; their boundaries are indicated with a dashed line. FS = Fugløybanken Sand and P = undifferentiated Pleistocene.

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Table content is not clearly visible due to the image quality.
boundary between litostratiographic units

sample with otoliths; the numbers before the line are depths in cm below sea-bottom, the numbers behind the bar are the numbers of otoliths in the sample

length of core in cm below sea-bottom when not drawn to scale

length of core drawn to scale

Table 4
relatively frequently in this unit (Thomsen & Vorren, in prep.) as also demonstrated by radiocarbon datings (Vorren et al. 1984). The poor state of preservation of the otoliths of *M. poutassou* (both are worn and broken) in comparison with those of *Boreogadus*, and the difference in colour of the two species, make it much more likely that the *M. poutassou* otoliths have been reworked.

**Neocollilius esmarki Acme-Zone**

Represents the time span 10,000–7,800 YBP. A change to warmer water is indicated by the disappearance of *B. saida* and appearance of *N. esmarki* together with *M. poutassou* and *G. morhua*. *N. esmarki* is an extremely common small gadoid in northern European waters (Wheeler 1978). It lives close to the bottom, prefers a smooth sand-mud substrate and is most common offshore in depths of 80–300 m (Muus 1966, Svetovidov 1973). It spawns in deep water over the edge of the continental shelf (Wheeler 1978). The *N. esmarki* Acme-Zone is found in cores recovered from depths between 448 and 350 m. This is deeper than the maximum abundance of living fish of this species as recorded in the literature (300 m). It is also deeper than the transition off southern Norway together with the dominant *M. poutassou* (Gaemers 1978a). Gjøsaeter (1981) studied the mode of life and ecology of *N. kroeyeri* west of southern Norway, and north and west of Scotland and Ireland. He could find neither specimens with ripening gonads nor young fish or larvae of this species, so he suggested that the observed population was expatriated. Spawning probably takes place farther away above deeper parts of the Atlantic. The more frequent occurrence of otoliths of this lantern fish in sediments off southern Norway suggests that it is more common there than in the north, where it seems to be close to its northern boundary.

**Glyptocephalus cynoglossus** is another representative of deeper water. According to Wheeler (1978), it lives at depths of 300–900 m and more; it appears to be confined to mud and mud-sand bottoms. Wheeler mentions that this species is especially common in the deep fjords of Norway and the Faeroe Islands.

The occurrence of otoliths from *G. morhua*, *M. aeglefinus*, *P. virens*, *G. thori* and *Sebastes* sp. agrees with the horizontal and vertical distribution of the living species. The rarity of otoliths of *G. thori* in samples investigated is striking; its otoliths are common off southern Norway (Gaemers 1978a). The rarity in the Malangsdjupet sediments must reflect a much rarer occurrence of this species off northern Norway. The only rather unexpected element is one juvenile otolith of *M. merlangus* found at a depth of 426 m (station 60). This species is a shallow water fish which is most abundant between 30 and 100 m, and exceptionally goes down to 200 m (Wheeler 1978). The one specimen may be a stray individual – much shallower waters are close to station 60. Moreover, the species does not only live close to the bottom, but also in intermediate and upper water layers (Svetovidov 1962). Another explanation may be that the fish
was eaten in shallower water by a larger fish which excreted the otolith in deeper water.

Looking at the depth distribution of otoliths in the *M. poutassou* Acme-Zone a slight difference can be observed between the shallower and the deeper areas. Fugloybanken Sand, representing stations between 348 m and 257 m, has higher frequencies of *N. esmarki* and less of *M. poutassou* than unit tA representing stations between 448 m and 348 m. This can be explained by the larger numbers of living *N. esmarki* above shallower sea floors. In spite of its mixed stratigraphy, this trend is also seen in core 62–2 from 304 m having an overall higher content of *N. esmarki* (Table 2). The data from the *M. poutassou* Acme-Zone in Malangsdjupet agree with data from the sea off southern Norway, where a dominance shift between *N. esmarki* and *M. poutassou* occurs at about 290 m water depth (Gaemers 1978a).

When explaining the faunal change from the *N. esmarki* to the *M. poutassou* Acme-Zone, it should be noted that this change seems to occur concurrently with a registered change in the benthonic and planktonic foraminifera fauna. The change in the foraminifera fauna was explained by Hald & Vorren (1984) as being caused by the water masses becoming less turbid, warmer, more saline and more nutrient rich.

*M. poutassou* is a more oceanic fish than *N. esmarki*. The faunal change in the Holocene deposits of Malangsdjupet thus indicates that the water masses became more oceanic in the later part of the Holocene.

**Conclusions**

Analysis of fish fossils (otoliths and teeth) in Late Weichselian and Holocene sediments from Malangsdjupet shows that:

- Most otoliths are derived from juvenile specimens,
- Small fishes with relatively large otoliths are best preserved in the fossil record,
- Polar cod (*Boreogadus sp.*) was the dominating species from about 15,000 or 14,000 to 10,000 YBP, indicating an arctic iceberg/sealice environment,
- Norway pout (*Neocolliolus esmarki*) was the dominant species in the Early Holocene, indicating a boreal environment,
- After 7800 YBP blue whiting (*Micromesistius poutassou*) became the dominant species, also indicating a boreal, but more oceanic environment,
- Three acme-zones can be established which probably will be useful for the whole Norwegian continental shelf and some adjoining shelf areas.

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**References**


Biologists often consider G. thori a subspecies of G. argenteus, but adult otoliths of these species have a different shape. Also the larvae of these species have distinctly different pigmentation (Schmidt, 1914) what is considered an important species character by biologists studying young fish. For illustrations of otoliths of G. thori (as well as of Notoscopelus kroeyeri) see Gaemers (1978a).

**Boreogadus sp.**

A comparison could be made with recent otoliths of several individuals of B. saida from the Alaskan part of the Bering Sea, the Atlantic off Newfoundland and from off northern Norway. All these specimens are however clearly more slender in shape than the fossil otoliths. The shapes of the sulcus and the colliculi agree well with the recent B. saida otoliths, ensuring the generic identification. Probably the fossil otoliths belong to the other recent species, B. agilis, which seems to be rare nowadays. The otoliths of this species are still unknown, unfortunately. Photographs of a well-preserved juvenile otolith from the Weichselian of the Island of Arnøy are given on Plate 3, Fig. 2, because the juvenile specimens from the Malangsdjupet are too poorly preserved.

**Sebastes sp.**

Juvenile otoliths from S. marinus and S. mentella appear to be very similar when the illustrations of Kelly & Wolf (1959, Figs. 2 and 4) and Trout (1961, pl. 2) are compared. Unfortunately not the same small sizes of recent Sebastes otoliths are available as comparison for the fossil otoliths. A species identification therefore is difficult at the moment. It is most likely that the fossil otoliths belong to S. marinus because this is by far the most common redfish species in the area.

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**PLATE 1**

All specimens from the Andfjorden Sand (unit tA). Enlargement of all specimens × 10. All a-numbers are medial views, b-numbers lateral views, c-numbers ventral views, and d-numbers dorsal views.

Fig. 1a-d. Neocolliolus esmarki (Nilsson, 1855), station 60-1, 130–140 cm, RGM 176.807. Fig. 2a-d. Neocolliolus esmarki (Nilsson, 1855), station 58-2, 200–210 cm, RGM 176.798. Fig. 3a-d. Neocolliolus esmarki (Nilsson, 1855), station 60-3, 76–87 cm, RGM 176.809. Fig. 4a-d. Gadus morhua Linnaeus, 1758, station 60-4, 60–70 cm, RGM 176.829. Fig. 5a-d. Gadus morhua Linnaeus, 1758, station 60-2, 27–37 cm, RGM 176.827. Fig. 6a-c. Sebastes sp., station 60-4, 89–100 cm, RGM 176.858.
PLATE 2

All specimens from the Andfjorden Sand (unit tA). Enlargement of all specimens (except Fig. 2) \( \times 10 \). All a-numbers are medial views, b-numbers lateral views, c-numbers ventral views, and d-numbers dorsal views.

Fig. 1a-d. *Micromesistius poutassou* (Risso, 1826), station 60-1, 30-40 cm, RGM 176.761. Fig 2a-b. *Micromesistius poutassou* (Risso, 1826), station 60-3, 56-66 cm, RGM 176.770, \( \times 9.3 \). Fig. 3a-b. *Micromesistius poutassou* (Risso, 1826), station 62-2, 55-65 cm, RGM 176.783. Fig. 4a-b. *Melanogrammus aeglefinus* (Linnaeus, 1758), station 58-1, 20-30 cm. RGM 176.833. Fig. 5a-c. *Merlangius merlangus* (Linnaeus, 1758), station 60-4, 112-120 cm, RGM 176.842.
PLATE 3

Enlargement of all specimens (except Fig. 2) × 10. All a-numbers are medial views, b-numbers lateral views, c-numbers ventral views, and d-numbers dorsal views.

Fig. 1 a-d. *Boreogadus* sp., Late Weichselian, unit tC, station 2-9, 80-90 cm. RGM 176.843. Fig. 2a-d. *Boreogadus* sp., Weichselian, fossiliferous till, Leirhda, Island of Arnøy (N of Tromsø), sample no. 10-79/KA, coll. Gaemers, leg. Vorren, × 9.5. Fig. 3a-d. *Pollachius virens* (Linnaeus, 1758), Fugløybanken Sand, station 61-3, 0-10 cm. RGM 176.839. Fig. 4a-d. *Melanogrammus aeglefinus* (Linnaeus, 1758), Andfjorden Sand, station 60-2, 17-27 cm, RGM 176.834.