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The Early Mesolithic fisheries of southern Scandinavia

Harry K. Robson and Kenneth Ritchie

Abstract
Southern Scandinavian Mesolithic research has one of the longest traditions within archaeology, dating back to the 1820s and 1830s. However, a combination of site visibility and an emphasis on the Mesolithic-Neolithic transition has meant that research has primarily been directed towards the Late Mesolithic Ertebølle culture (c. 5400–4000 cal. BC) at the expense of the Early Mesolithic Maglemose culture (c. 9600–6400 cal. BC). Whilst fishing during the Ertebølle culture is well studied (Enghoff 2011; Ritchie 2010), fishing during the Early Mesolithic is rarely discussed in any detail. In this contribution we attempt to rectify this imbalance by collating all readily available data on fish remains and related technologies within the literature. Although our primary focus is the Early Mesolithic Maglemose culture of Southern Scandinavia, an area encompassing Denmark, Scania in Sweden and Schleswig-Holstein in Northern Germany, we draw on contemporaneous sites within the broader region to provide a more nuanced picture of the exploitation of this important resource, fish.

1 Introduction

On June the 8th, 1900, Georg Frederik Ludvig Sarauw was sent by the National Museum to the 'Magle Mose' peat bog in western Zealand, Denmark. Here, excavations were undertaken in an area known as Mullerup where charcoal, faunal remains and worked flints had been unearthed during peat extraction. In 1903, a monograph on the excavations was published, and the term Maglemose was coined (Sarauw 1903). Sarauw argued that the site represented a culture that predated the Late Mesolithic Ertebølle kitchen middens (*køkkenmøddinger*), which had been previously investigated by the First and Second Kitchen Midden Commissions (Madsen et al. 1900; Steenstrup et al. 1851), with an economy that was based on the exploitation of aquatic and terrestrial resources (Sarauw 1903). Owing to additional excavations at other Danish peat bog sites located on Zealand, including Sværdborg I (Friis Johansen et al. 1919), Holmegård I (Broholm 1924), Holmegård IV, V, and VI (Becker 1945), Lundby II (Henriksen et al. 1976; 1980), Ulkestrup I and II (Andersen 1951; Andersen et al. 1982), and the Åmose bog (Mathiassen et al. 1943), as well as lithic typo-chronologies (Becker 1945; 1953; Petersen 1966; 1973), the Maglemose culture as an archaeological construct was born.

Moreover, broadly contemporaneous peat bogs and sites from the Maglemose and similar cultures were examined throughout the wider region. In 1937, Mathiassen published on the site of Klosterlund on Jutland, which at the time yielded the largest Preboreal assemblage from Southern Scandinavia.

Almost simultaneously, Early Mesolithic sites were investigated in Germany, for instance Friesack in Brandenburg (Schneider 1932), and the Duvensee peat bog in Schleswig Holstein (Schwantes et al. 1925; Schwantes 1928). In 1938 and 1939 further sites were investigated, including Pinnberg (Rust 1958), which led to an established chronology before the start of the Second World War. Early Mesolithic research in Northern Germany resumed in 1946 at the Duvensee peat bog (Schwabedissen 1949), whilst several years later Schuldt excavated the Hohen Viecheln site between 1953 and 1955 (Schuldt 1961). Early Mesolithic research has continued intermittently to this day. Additional excavations have since been undertaken at some previously investigated localities, for instance Friesack (Gramsch 1987; 2000), and the Duvensee peat bog (Bokelmann 1971; 2012), and new sites have been found, for example Bedburg-Königshoven in Westphalia (Street 1991), and Rothenklempenow in Mecklenburg-Vorpommern (Schacht 1993; Kaiser 2003).

The Maglemose culture is the earliest Mesolithic culture of Southern Scandinavia. Preceding the Middle Mesolithic Kongemose and Late Mesolithic Ertebølle cultures, it is dated from c. 9600–6400 cal. BC (Petersen 1973; Møller Hansen et al. 2004). Although the majority of the investigated sites on Zealand listed above are dated from the Boreal to Atlantic chronozones, there are some Maglemosian sites that are dated to the Preboreal or Preboreal/Boreal transition, for example Favrbo, Lundby Mose, Prejlerup, and Vig on the island of Zealand (Aaris-Sørensen 1999; Aaris-Sørensen/Petersen 1986a; 1986b; Møller Hansen 2003; Møller Hansen/Buck Pedersen 2006; Møller Hansen et al. 2004; Noe-Nygaard 1973), as well as Skottemarke on the island of Lolland (Møhl 1978; Sørensen 1978).

Despite the substantial number of excavations (see above), fishing during the Early Mesolithic Maglemose is still not fully understood. The oft-discussed imbalance between a predominance of Middle and Late Mesolithic sites in Southern Scandinavia along the coasts with mostly marine fishes (see Enghoff 2011; Ritchie 2010 for comprehensive overviews) and Early Mesolithic sites in inland locations with freshwater fishes is an intriguing situation with possible environmental and cultural explanations.

From an environmental standpoint, isostatic and eustatic changes occurring in response to the melting of the Pleistocene ice sheets have served to veil some sites, and have also dramatically altered the nature of the available waterscapes. The paucity of Early Mesolithic (generally Maglemose) sites along the shores of the North and Baltic Seas is undoubtedly related to flooding of the relevant zones in many areas of interest. To take the most obvious example, Doggerland (the region of the North European plain that once connected the British Isles with continental Europe) is now an underwater landscape where much of the relevant evidence is submerged under many metres of sea. Human occupation of this zone dating back to at least 11,700 BC has been recognised since the 1930s, but only recently has archaeological methodology advanced to the point where some of this evidence can begin to come to light in sufficient quantity and quality that discussions about its significance are possible (Bonsall/Smith 1989; Stewart et al. 2016; van der Plicht et al. 2016). Furthermore, in Denmark, underwater survey and trial excavations have begun to reveal evidence for Early and Middle Mesolithic coastal occupations in areas of the Western Baltic Sea at, for example, Amager on Zealand, and around Århus Bay off the eastern coast of Jutland (e.g. Johansen 2004; Skriver/Borup 2012). Similar new and exciting developments off the southern coast of Sweden at Haväng suggest that our picture of this period is about to undergo a period of rapid paradigm adjustment (Hansson et al. 2016).

In addition to its role in obscuring sites under modern seas, changes in the relationship between land and water in Southern Scandinavia have had major impacts on the environment with which prehistoric peoples interacted. Most notably, perhaps, is the succession of salt- and freshwater seas and lakes that occupied the area today known as the Baltic Sea during the period of the Early Mesolithic. It is not just the gradual variation in salinity regimes and sea levels that must be considered, but also the sudden, dramatic changes such as the proposed catastrophic drainage of the Baltic Ice Lake (Berglund et al. 2005) that would have had major repercussions for groups' relationships to and understanding of the aquatic environment, probably for generations. The high degree of variability affecting the regions comprising the shorelines of the various stages of what is now the Baltic Sea may have been one reason that Early Mesolithic peoples often turned to the resources of the inland waterways, when they exploited aquatic resources at all. However, as noted above, this picture is necessarily incomplete and subject to change from new evidence – and there were at least some groups who relied extensively on the archaic seas for their livelihoods, for example the Komsa/Fosna/Hensbacka cultures that colonised the coasts of Norway and parts of Sweden in the early Holocene (e.g. Bjerck 2009). Despite some sites with fish bone assemblages discussed here, our knowledge of Early Mesolithic fisheries remains rather sparse.

In this contribution we collate the currently available information on fish remains and related technologies from Early Mesolithic sites in Southern Scandinavia and adjoining regions. With the data at hand, some interesting patterns are apparent that point to the importance of aquatic resources, while at the same time noting that they were generally exploited in a more limited fashion than that of the maritime hunter-gatherers of the Middle and Late Mesolithic that followed.

2 Some notes about the data

Several of the entries in Tables 1 and 2 appear more than once, which, for the most part, is due to more than one excavation campaign, for example Hohen Viecheln. In these cases, NISP (Number of Identified Specimens) values deriving from the two investigations are listed separately. In addition, some of the material has been subjected to varying degrees of re-analyses, which has also resulted in it being reported more than once in the literature. In general, the most recent data available were used. Furthermore, some of the assemblages listed are lacking definitive NISP values, whereas for others there is a complete absence of data; thus, sites with an absence of data were omitted from Fig. 1. Since some of the assemblages had disaggregated the fish remains according to certain skeletal elements, for example bones and scales, we decided to combine all NISP values per site. Finally, while acknowledging the importance of excavation methodology (especially sieving) on the results, we use the assemblages as reported without further exploring these limitations.

3 The dataset

As of December 2016, a total of 34 fish faunal assemblages are available (Table 1; Fig. 2). Whilst some sites are listed more than once, for instance Mullerup in Denmark, at least 29 different archaeological sites are represented. Of these, 17 assemblages are affiliated with or have been dated to the Early Mesolithic Maglemose culture of Southern Scandinavia, whilst the remaining have varying lengths of intermittent occupation, for instance Friesack 4, which is represented by at least four primary occupation phases dating to the Mesolithic, from c. 9340–5430 cal. BC (Robson 2016). One Maglemose-Kongemose transitional site, Ringsjöholm in Sweden, and five unaffiliated sites are also present in the dataset. Moreover, we have incorporated three Estonian sites, Lammasmägi, Pulli, and Umbusi, affiliated with the Kunda culture that bears remarkable similarities with the Maglemose culture.

Regarding distribution, the majority of the sites listed in Table 1 and shown in Figs. 1–2 are located in Denmark. Of the 29 archaeological sites, 23 yielded NISP values, and of these, ten are located in present day Denmark. Four sites are situated in Germany and Poland, respectively, whilst three are located in Estonia. Lastly, only two localities in Sweden are represented. Interestingly, of the sites listed not one would have been situated on the coast during occupation.

Table 1. Early Mesolithic archaeological sites with fish remains. Blank space – cultural epoch not provided; n.d. – data not reported.

Number	Site name, country (years, excavator)	Period	Cultural epoch	NISP	Reference
1	Barmosen I, Denmark	Early Mesolithic	Maglemose	<10	Johansson 1990
2	Bedburg-Königshoven, Germany	Early Mesolithic	Maglemose	242	Street 1993
3	Bølling Sø, Denmark	Early Mesolithic	Maglemose	30+	Rosenlund 1976
4	Calbe, Germany	Early Mesolithic		n.d.	Clark 1936
5	Dudka I, Poland	Early Mesolithic-Early Neolithic		1104	Makowiecki 2000
6	Duvensee, Germany	Early Mesolithic	Maglemose	n.d.	Clark 1936
7	Esperöds Mosse, Sweden	Early Mesolithic		n.d.	Clark 1936
8	Friesack 27a, Germany	Early Mesolithic	Maglemose	12	Gross 2014
8	Friesack 4, Germany	Early Mesolithic-Early Neolithic	Maglemose-Funnel Beaker	1733	Robson 2016
9	Hohen Viecheln, Germany (1953–1955)	Early Mesolithic	Maglemose	32	Schuldt 1961
9	Hohen Viecheln, Germany (1995)	Early Mesolithic	Maglemose	14+	Schacht 1996
10	Holmegård, Denmark (1922–1923, H. C. Broholm)	Early Mesolithic	Maglemose	27	Rosenlund 1976
10	Holmegård, Denmark (1944–1950, C. J. Becker)	Early Mesolithic	Maglemose	93+	Rosenlund 1976
11	Krzyż Wielkopolski, Poland	Early Mesolithic		2395	Zabilska-Kunek et al. 2015
12	Lammasmägi, Kunda, Estonia	Early Mesolithic	Kunda	73	Lõugas 1995; Paaver/Lõugas 2003
13	Lundby I, Denmark (1929–1931, T. Thomsen)	Early Mesolithic	Maglemose	82	Rosenlund 1976
13	Lundby II, Denmark (1945, C. J. Becker)	Early Mesolithic	Maglemose	115	Rosenlund 1980
14	Maglemose, Mullerup, Denmark (Neergaard‘s Island)	Early Mesolithic	Maglemose	3	Rosenlund 1976
14	Maglemose, Mullerup, Denmark (Neergaard‘s Island)	Early Mesolithic	Maglemose	6+	Rosenlund 1976
14	Maglemose, Mullerup, Denmark (Sarauw‘s Island)	Early Mesolithic	Maglemose	109	Leduc 2013
14	Maglemose, Mullerup, Denmark (Sarauw‘s Island)	Early Mesolithic	Maglemose	c. 95	Rosenlund 1976
15	Miłuki 4, Poland	Early Mesolithic		16	Makowiecki 2000
16	Mszano 14, Poland	Early Mesolithic-Early Neolithic		74	Makowiecki 2000
17	Præstelyngen B II, Denmark	Early Mesolithic	Maglemose	n.d.	Rosenlund 1976
18	Pulli, Estonia	Early Mesolithic	Kunda	99	Lõugas 1996
19	Ringsjöholm, Sweden	Early Mesolithic-Middle Mesolithic	Maglemose-Kongemose	405	Svensson 2006
19	Rönneholm, Sweden (2008–2009)	Early Mesolithic-Late Mesolithic	Maglemose-Ertebølle	30	Magnell 2010
20	Rothenklempenow, Germany	Early Mesolithic	Maglemose	n.d.	Schacht 1993
21	Sværdborg I, Denmark (1943–1944, C. J. Becker)	Early Mesolithic	Maglemose	1013	Aaris-Sørensen 1976
21	Sværdborg II, Denmark (1946, C. J. Becker/M. Ørsnes)	Early Mesolithic	Maglemose	22	Rosenlund 1976
22	Ulkestrup Lyng Øst, Denmark (1947–1951, K. Andersen)	Early Mesolithic	Maglemose	867	Noe-Nygaard 1995
22	Ulkestrup Lyng Øst, Denmark (1947–1951, K. Andersen)	Early Mesolithic	Maglemose	586	Richter 1982
23	Umbusi, Estonia	Early Mesolithic	Kunda	38	Lõugas 1996
24	Vinde-Helsinge, Denmark	Early Mesolithic	Maglemose	n.d.	Degerbøl 1943

Table 2. Fish identified in the assemblages listed in Table 1. P – presence indicated.

Site name, country	*Esox lucius*	*Coregonus lavaretus*	Cyprinidae	*Carrassius carassius*	*Tinca tinca*	*Scardinius erythrophthalmus*	*Leuciscus idus*	*Leuciscus aspius*	*Abramis brama*	*Blicca bjoerkna*	*Rutilus rutilus*	*Siluris glanis*	Percidae	*Perca fluviatilis*	*Sander lucioperca*	*Anguilla anguilla*	*Gasterosteus aculeatus*	*Lota lota*
Barmosen I, Denmark	P		P															
Bedburg-Königshoven, Germany	108		40		11		1		5	4	1			67		5		
Bølling Sø, Denmark	1	4														11	14	
Dudka I, Poland	353		388		15						14	102	1	231				
Friesack 27a, Germany	10		1											1				
Friesack 4, Germany	703		279					1			2	467	1	226	1	48		5
Hohen Viecheln, Germany (1953–1955)	35								P					>5				
Hohen Viecheln, Germany (1995)	9		4						1									
Holmegård, Denmark (1922–1923, H. C. Broholm)	24											3						
Holmegård, Denmark (1944–1950, C. J. Becker)	87				2							3		1				
Krzyż Wielkopolski, Poland	P		P									P	P			P		
Lammasmägi, Kunda, Estonia	66				1									6				
Lundby I, Denmark (1929–1931, Th. Thomsen)	82																	
Lundby II, Denmark (1945, C. J. Becker)	115																	
Maglemose, Mullerup, Denmark (Neergaard's Island)	3																	
Maglemose, Mullerup, Denmark (Neergaard's Island)	6																	
Maglemose, Mullerup, Denmark (Sarauw's Island)	109																	
Maglemose, Mullerup, Denmark (Sarauw's Island)	95																	
Miłuki 4, Poland	8													8				
Mszano 14, Poland	11		49								4		1	5	4			
Pulli, Estonia									5						94			
Ringsjöholm, Sweden	225		48		67	2					1		58	1		3		
Rönneholm, Sweden (2008–2009)	21		1						1		2			4		1		
Sværdborg I, Denmark (1943–1944, C. J. Becker)	1006				1				1							5		
Sværdborg II, Denmark (1946, C. J. Becker/M. Ørsnes)	22																	
Ulkestrup Lyng Øst, Denmark (1947–1951, K. Andersen)	536		4	4	3	2			2			5		30				
Ulkestrup Lyng Øst, Denmark (1947–1951, K. Andersen)	794		4	6	14	4			3			6		36				
Umbusi, Estonia	31								7									

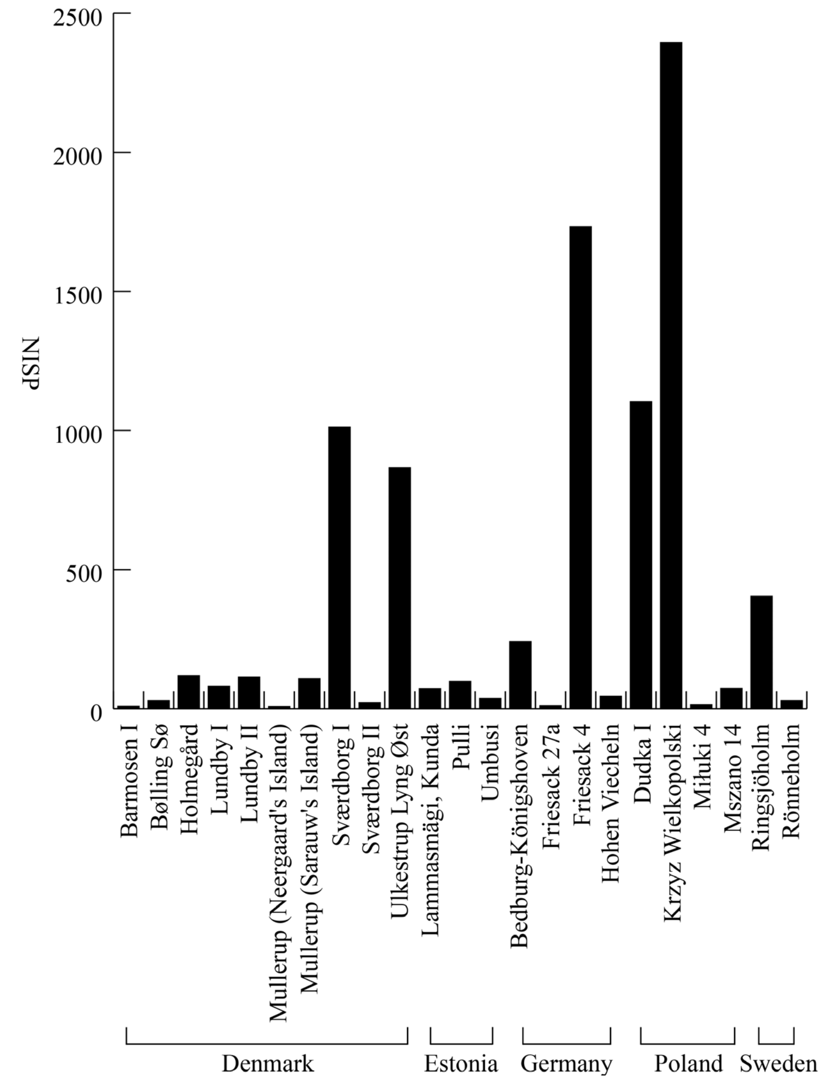

Fig. 1. NISP values for the archaeological sites according to country.

In terms of NISP values, 18 of the assemblages yielded a NISP <100. These assemblages are included with some reservations about whether they present an accurate picture of fish use at a site due to strong taphonomic biases, or because they may represent natural death assemblages (see Noe-Nygaard 1995, 170). Moreover, there are five assemblages present in the dataset that yielded a NISP >100 but less than <500, and two assemblages that yielded a NISP >500 but <1000. Only four assemblages (Dudka I, Friesack 4, Krzyż Wielkopolski, and Sværdborg I) throughout the region yielded a NISP >1000.

4 Fishing technologies

Barbed and bone points (as well as harpoons) are one of the most ubiquitous types of Early Mesolithic artefacts. Routinely recovered from present day peat bogs that were once aquatic landscapes, they provide indirect evidence for fishing during the period. Generally it is assumed that they were hafted onto wooden shafts for spearing or throwing (Robson et al. 2018), alternatively two or more could have been hafted together, as evidenced at the Early Mesolithic site of Star Carr in the United Kingdom (Clark 1954), or complemented with the addition of a central point to form a leister. Barbed and bone points have been recovered from a number of the Early Mesolithic sites listed in Table 1, for example Holmegård, Lundby I and II, Mullerup, Ulkestrup Lyng, Sværdborg I and II and Vinde-Helsinge (in Denmark), Duvensee, Friesack 4, Friesack 27a and Hohen Viecheln (in Northern Germany) (Aaris-Sørensen 1976; Broholm 1924; Clark 1948; Gramsch/Beran 2007/2008; Gross 2017; Jessen et al. 2015; Noe-Nygaard 1995; Robson 2015; Rosenlund 1980; Schuldt 1961). The most evocative description of their use is provided by Indreko (1934, 283; see Clark 1952), noting the presence of two barbed points at the eponymous site of Kunda in Estonia, where they were encountered impaling a northern pike (*Esox lucius* L., 1758), and were recovered from the skull and back of a large individual.

Bows and arrows as well as clubs and spears are other classes of artefacts that may have been used for fishing (Aaris-Sørensen 1976). At least one probable bow made of pine is known from the lakeshore settlement of Friesack 4 in Germany (Gramsch/Kloss 1989, 322). Recovered from a middle Preboreal context, it is currently the oldest known example from Northern Europe (Gramsch pers. comm. 2016). An unknown number of arrows as well as spears have also been recovered from this site (Gramsch/Kloss 1989). Although scarce when compared to evidence from the Kongemose and Ertebølle cultures, other Early Mesolithic examples are known. From the Duvensee peat bog an unknown number of arrow shafts have been documented (Holst 2007; Schwantes et al. 1925), whilst at least five bows were recovered from Holmegård in Denmark that are dated by proxy to the younger Maglemose culture, between c. 8000 and 6500 cal. BC (Becker 1945). A further example was recovered from Ulkestrup Lyng (Andersen et al. 1982).

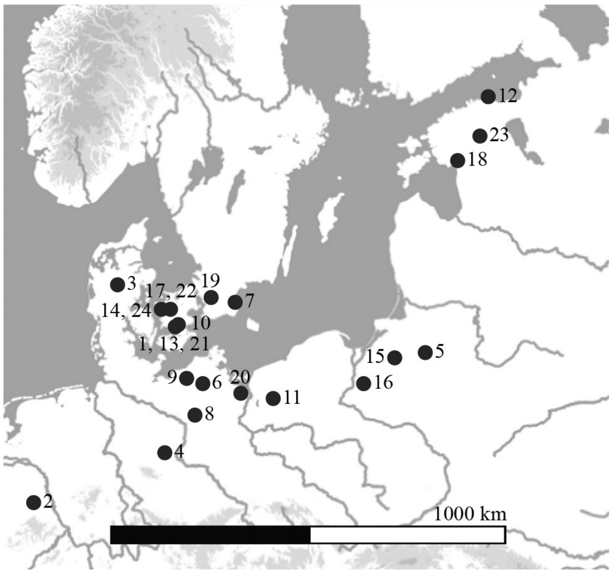

Fig. 2. Distribution of the Early Mesolithic sites listed in Tables 1 and 2.

More evidence of fishing equipment derives from floats made of wood or birch bark rolls. Routinely recovered throughout southern Scandinavia and the wider region, their prevalence indicates an established methodology for fish procurement at the start of the Holocene. Birch bark rolls are known from several Early Mesolithic sites, including Friesack 4 and Mullerup Syd (Gramsch 1992; Gramsch/Kloss 1989; Sarauw 1903) as well as Flixton Island and Star Carr in the UK (Clark 1954; Robson et al. 2018). In addition, at least two examples were recovered from Ulkestrup Lyng, which were radiocarbon (^{14}C-) dated to 8170±120 BP (K-1507; Andersen et al. 1982; Tauber 1971; calibrated to 7514–6815 cal. BC at 95.5 % confidence), i.e. the Maglemose culture. On the other hand, wooden floats including discs with perforations have been recovered at Friesack 4 (Gramsch 1992; Robson 2016), as well as Hohen Viecheln (Schuldt 1961) and Holmegaard IV (Troels-Smith 1960).

Dugout canoes and paddles are additional fishing related implements that would increase the available fishing grounds and resource spectrum. Waterborne navigation during the Middle and Late Mesolithic

Fig. 3. The paddle blade from Ulkestrup Lyng, Denmark (photo H. Robson).

in Northern Europe is well attested (see Klooss 2015), however, by comparison the Early Mesolithic evidence is very scant. Presently, the oldest known boating technology in Northern Europe, a paddle, was recovered from Star Carr (Clark 1954). In addition, at least two examples were recovered from Friesack 4 and have been dated to the Younger Preboreal and Early Boreal, respectively (Gramsch 1987; 1992; Gramsch/Kloss 1989). A further example is known from the Duvensee peat bog (Holst 2007; Hartz/Lübke 1999; 2000; Jenke 2009; 2011; Schwantes et al. 1925). It has recently been AMS dated to 8477±49 BP (KIA-36362; Jenke 2009; calibrated to 7591–7482 cal. BC at 95.5 % confidence) and 8261±38 BP (KIA-36363; Jenke 2009; calibrated to 7458–7173 cal. BC at 95.5% confidence). In addition, a slightly younger example was recovered from the Maglemose site of Holmegård (Broholm 1924), while a further specimen is known from Ulkestrup Lyng (Fig. 3; Andersen et al. 1982).

5 Highlights

While acknowledging the source limitations discussed above and recognising the potential for new research to produce data that will require major shifts in how we view fishing in the earlier parts of the Mesolithic, based on the data at hand some discussion of fishing during the Maglemose and related periods is in order. First, the absolute dominance of pike on Danish Early Mesolithic sites is a striking phenomenon. Taking into account only those sites with more than 50 identified specimens, pike account for c. 93 % or more of the fish in the assemblage at each of these sites. While this predominance in the Maglemose and related cultures is also seen elsewhere to some extent (e.g. Lammasmägi, Estonia), at many other localities such as Ringsjöholm in Sweden and most of the Polish sites they are present in much lower percentages. Before looking for cultural or environmental explanations for this pattern, it must be stressed that many of the Danish sites were excavated before the widespread recognition of the importance of wet sieving to recover smaller artefacts such as the bones of fish from small individuals, whereas the Polish (and some of the other) sites were recently excavated. However, if the variability is not merely taphonomic, it is an intriguing difference that suggests flexibility in how fish resources were exploited across the region, especially as pike are clearly present in the other assemblages, merely in lower proportions.

Although pike are excellent fish for eating, their predominance in most Maglemosian assemblages is somewhat of a surprise, given their relatively solitary nature (Muus/Dahlstrøm 1964). Other fishes, especially diadromous ones such as sea trout (*Salmo trutta* L., 1758), Atlantic salmon (*Salmo salar* L., 1758) and European eel (*Anguilla anguilla* L., 1758) that aggregate in large numbers during their migrations, might appear to be more attractive resources from a human behavioural ecology perspective.

Following the absolute dominance of pike, the taxa most commonly present in the assemblages was Cyprinidae (carp and minnow family), found at c. 71 % of the sites (Table 2). At least eight Cyprinidae species have been identified in the fish faunal assemblages (Table 2): crucian carp (*Carassius carassius* L., 1758), tench (*Tinca tinca* L., 1758), common rudd (*Scardinius erythrophthalmus* L., 1758), asp (*Leuciscus aspius* L., 1758), ide (*Leuciscus idus* L., 1758), common bream (*Abramis brama* L., 1758), white bream (*Blicca bjoerkna* L., 1758), and roach (*Rutilus rutilus* L., 1758). Next in relative frequency was Percidae (perches) at 64 %, represented by the European perch (*Perca fluviatilis* L., 1758), and pike-perch (*Sander lucioperca* L., 1758), followed by wels catfish (*Siluris glanis* L., 1758) at 36 % and European eel at 21 % of the sites.

One further strand of evidence for the direct consumption of aquatic organisms, including fish, derives from stable isotope analysis. In recent years, carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope analysis of human bone collagen has routinely been undertaken in order to reconstruct the long-term consumption practices of past populations. Despite certain limitations, including sample size, the lack of

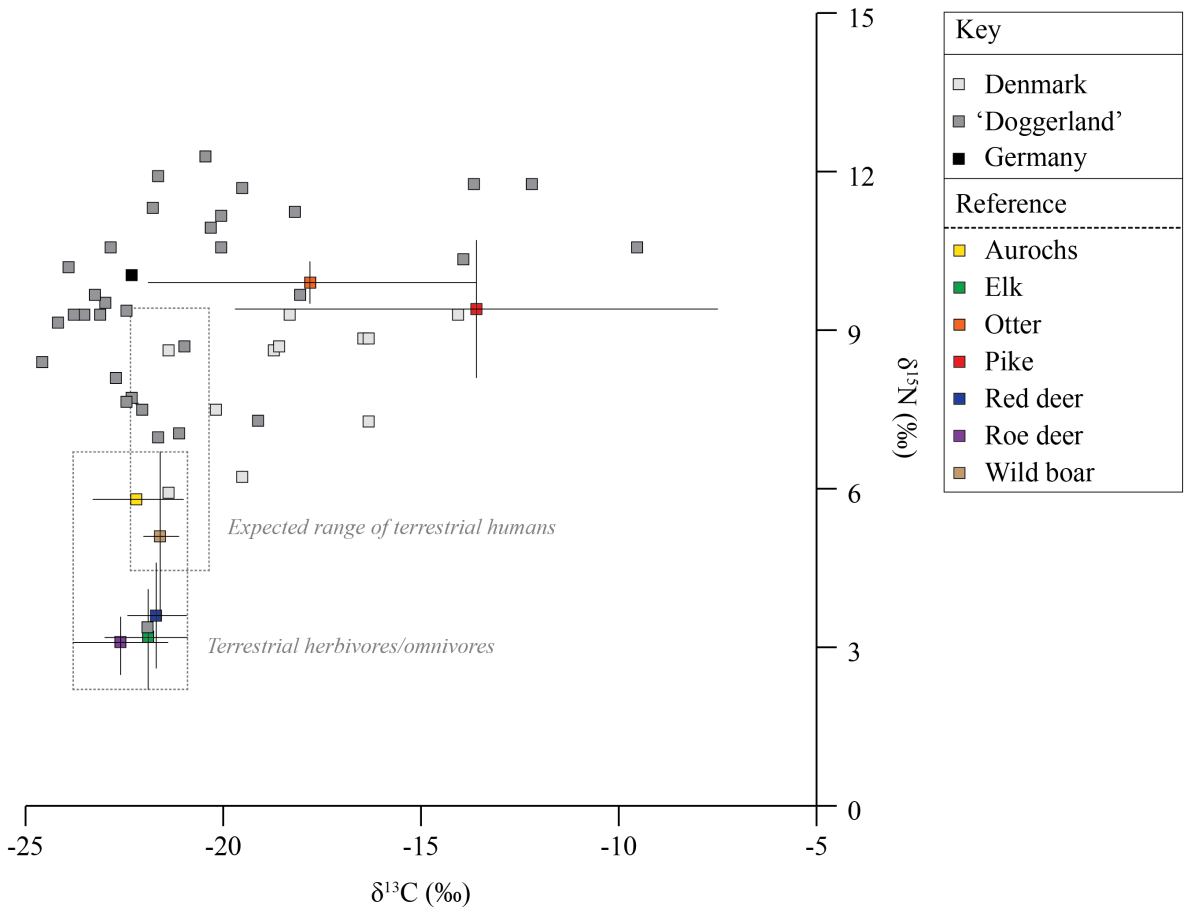

Fig. 4. Carbon and nitrogen stable isotope data obtained from human bone collagen dating to the Early Mesolithic Maglemose culture of Southern Scandinavia and Doggerland (human bone collagen data from Fischer et al. 2007; Terberger et al. 2012; van der Plicht et al. 2016; reference data from Fischer et al. 2007; Noe-Nygaard et al. 2005). Since consumers will typically have $\delta^{13}C$ and $\delta^{15}N$ values that are between +1–2 and +3–5 ‰ higher than those of their prey, respectively, the expected range of a diet derived from terrestrial protein is included.

a comprehensive ecological baseline for the Early Mesolithic, and the nature of the method (i.e. the data obtained reflect the last 10–15 years of diet), it has been usefully applied to assess Early Mesolithic human diet (Fig. 4). In general, $\delta^{13}C$ values primarily differentiate between marine and freshwater/terrestrial environments, whilst $\delta^{15}N$ values are an indication of position in the trophic level (Richards/Hedges 1999; Schulting/Richards 2001). In light of this, the data can broadly distinguish what an individual has consumed due to the trophic level enrichment from prey to consumer. Since it is widely accepted that the marine and freshwater/terrestrial endpoints are -10.1 and -21.7 ‰, respectively (Arneborg et al. 1999; Richards/Hedges 1999), the data plotted in Fig. 4 demonstrate that the majority of the Early Mesolithic inhabitants of Southern Scandinavia (Fischer et al. 2007; Terberger et al. 2012) as well as Doggerland (van der Plicht 2016) consumed freshwater resources, particularly fish.

6 Discussion and conclusions

Based on the evidence presented here (fish remains, fishing technology, stable isotope data), fish were without doubt an important resource for groups in the Early Mesolithic. Until now, the evidence points to a clear focus on freshwater fishes since not one marine species has been identified yet (Tables 1–2).

Some of the species do have limited brackish water tolerance, but only the catadromous European eel unequivocally spend part of their lives in the sea and thus prove exploitation of (semi-)marine resources (although they were in all likelihood taken from freshwater waterbodies). It is noteworthy that the presence of European eel in one assemblage from Bølling Sø demonstrates that this species must have (re-) colonised Northern Europe quite early in the Holocene.

Given that pike are present at nearly every site considered and that they are often the dominant fish in the assemblage (although with reservations due to varying recovery methodology), the question as to 'why' is of some importance for understanding the groups exploiting them. Seasonality and fishing technology provide possible answers. During the spring (March to May), pike move into shallow waters to spawn and are easily taken by spearing. Bone points suitable for this activity are numerous at many Maglemosian sites, whereas fishhooks and evidence for nets or other means of fishing, while known, are not common. For mobile bands of hunter-gatherers, spearing fish with tools that might also be employed for different game at other times was a means to take advantage of plentiful aquatic resources at certain times, especially spring, when other sources of food were scarce – without the large resource investment in the stationary fishing structures that become prevalent later in the Mesolithic (although see Hansson et al. 2016 for early evidence of such structures in Sweden). It might also be the case that fluctuating sea levels repeatedly restructuring inland water systems made it difficult for groups to acquire the knowledge of local conditions necessary to develop fisheries that more fully exploited the whole range of species available.

The other species fished by Early Mesolithic people, especially cyprinids, do demonstrate that the fisheries were more complex than simply spearing pike during the spawn, but overall the picture is of relatively limited exploitation of aquatic resources. Environmental changes, decreased mobility and increasing populations are some of the possible explanations for the greatly increased emphasis on (especially marine) aquatic resources that characterise the subsequent periods of the Mesolithic. Of course, the role of cultural choices in this transformation must also be considered. Above all, in order to understand the lives of the people who inhabited southern Scandinavia and adjacent regions in the early Holocene before the advent of farming, we must remember to occasionally step off the land and into the water.

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