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RESEARCH REPORT

Flexibility and diversity in subsistence during the late Mesolithic: faunal evidence from Asnæs Havnemark

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In 2007, excavations at the late Mesolithic (Ertebølle) coastal site of Asnæs Havnemark recovered a wealth of flint, bone, and ceramic artefacts. A comprehensive analysis of the faunal remains resulted in over 50,000 identified specimens. Roe deer and gadids predominate, but there are a wide variety of other species represented. Stable isotope analyses of dog bones point to the importance of marine resources. Oxygen isotope analyses of otoliths indicate that fishing was conducted in multiple seasons of the year. Comparison with other late Mesolithic sites demonstrates that while generally the same species of animals were exploited everywhere, there are major differences in the relative abundances of species. The broad subsistence base available and flexibility in how it was exploited weaken arguments for a subsistence crisis brought on by environmental stresses as the causal mechanism for the adoption of domesticated plants and animals at the onset of the Neolithic.

Keywords: Ertebølle; Mesolithic; fauna; isotopes; seasonality; coastal settlement; fish; dogs

Archaeological background

The Ertebølle site of Asnæs Havnemark lies on the north coast of the peninsula of Asnæs near the town of Kalundborg in western Zealand, Denmark (Figure 1). The site is designated as Årby SB365 in the Danish national site catalogue. The landscape here is dominated by the end-moraine that is the Asnæs peninsula and the sea that is gradually changing the shape of the peninsula. There are a large number of prehistoric sites on this peninsula, discovered by various amateurs, landowners, and others. There are more than 100 prehistoric barrows from the Bronze and Iron Age along with substantial remains from the Mesolithic and Neolithic. The area is well known as a very good source of raw flint, particularly along the coast.

The deep waters of the fjord and the rich seas of the Great Belt between the Baltic Sea and the Kattegat created a rich environment for Mesolithic fisher-hunter-gatherers. In all probability, large runs of eels, herring, and other species of fish passed along the coast of Asnæs as is known to have been the case in historical times (Drechsel 1890). The sea is also eroding and building along the coast, a process, which has been going on for millennia. The archaeological site of Asnæs Havnemark today is in an active area of beach ridge construction and it is slowly eroding into the sea. The original size of the site is unknown.

The Ertebølle is the last period of the Mesolithic in southern Scandinavia, beginning around 5400 cal BC, and ending with the arrival of the Neolithic shortly after 3950 cal BC. Radiocarbon dates from Asnæs Havnemark document the occupation of the site at the end of the Ertebølle. Nine radiocarbon measurements from the site ranged between 5696 ± 63 and 5172 ± 60 years cal BP (Supplementary Information Appendix I) document the likelihood of at least two episodes of site use (ca. 4500 cal BC and ca. 4100cal BC) and the occupation of this site near or at the time of the transition to agriculture in southern Scandinavia.

The major focus of our project was the cultural layer that was exposed by wave erosion on the north coast of Asnæs, but we also uncovered an *in situ* deeper settlement layer at the same place on top of the moraine surface. The contents of the cultural layer and related deposits are the concern in the following pages. It appears that the original settlement was located directly on the beach ridge and that there may have been several episodes of occupation. The deposits are terrestrial, rather than waterlain, and a portion of the settlement area is intact.

The stratigraphy at the site was largely the result of the formation of two beach ridges at this location. Sediments were generally sandy with varying amounts of gravel and stones associated with the beach ridges. The younger beach ridge had buried the cultural layers that had accumulated on top of the older beach ridge. This beach ridge deposition at this elevation must have taken place during a time of higher sea level, probably

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Figure 1.   The location of Asnæs Havnemark and comparison sites.

during the Littorina transgression at the end of the Atlantic climatic episode. This event fits extremely well with the radiocarbon dates available for the site and also provides important information on potentially significant environmental changes at the end of the Mesolithic period.

Beneath the beach ridges and at some depth there was a base of ground moraine beneath the older beach ridge. The cultural layers that accumulated atop the older beach ridge were divided into three strata, based on colour and content. The bottom of the cultural layer was black with many artefacts. The middle of the cultural layer was brown with shell and artefacts and the upper portion of the cultural layer was black with shell and artefacts. The presence of the shell was responsible for the good preservation of bone at the site. This cultural layer likely accumulated over a substantial period of time, perhaps several hundred years at the end of the Atlantic climatic episode. The cultural layer appears to represent a long-term series of occupations, lying between two episodes of beach ridge formation. Radiocarbon dates from the site suggest an occupation primarily between 4300 and 4000 BC with a few younger and older dates present.

Excavations in 2007 exposed ca. 22 m^2 of this rich cultural layer at the site. Water screening and fine mesh sieving of sediment samples was conducted that provided a glimpse into the contents of the site. Good preservation is one of the hallmarks of the archaeology of this region and the materials recovered at Asnæs Havnemark include lithics, faunal remains, ceramics, and some plant remains in the form of burnt hazelnut

shells. The flint tools consist primarily of projectile points, cores, some distally concave truncated blade knives, a few borers, a very few scrapers, a very few possible burins, and a very few rough core axes. There were large numbers of stylistically homogeneous projectile points, distinctive flake axes, well preserved faunal remains including bone fishhooks and preforms, seal bones, large bird bones, and an extraordinary amount of fish. A quantity of pottery was recovered in the excavations, including both pointed-bottom vessels and oval lamps in different sizes from the late Mesolithic and several examples of Early Neolithic ceramics. The rich occupation layer with its diverse artefact content also included a fragment of a human mandible and several teeth, documenting a substantial residential settlement on the north coast of the Asnæs peninsula.

The studies reported here focus on the faunal remains from the site, which include both terrestrial and marine mammals, birds, as well as fish. These animals were taken for both food and raw materials and provided a rich resource base for the inhabitants of the site. Comparison of Asnæs Havnemark with other Ertebølle sites in the region documents the flexibility and range of these coastal peoples as well as raising doubts about the role of climatic change leading to the introduction of agriculture at the end of the Mesolithic period.

Taphonomy

In considering the bone material it is important first to discuss taphonomic issues relating to the assemblage in acknowledgement of the fact that not all of the bones originally brought to the site in prehistory were later recovered and identified for this project. While it is not possible to determine the precise degree of loss attributable to scavenging, bone degradation, method of excavation, etc., some observations provide insight into the likely representativeness of the data.

The mammal bone material from Asnæs Havnemark shows no signs of cracking or flaking, considered to be hallmarks of weathering due to exposure to the elements, although exfoliation has occurred on the surface of some of the bones and they appear to have lost some weight, i.e., they fall into Behrensmeyer's (1978) Category 0 index of bone weathering. The comparatively light degree of weathering suggests that the bones did not lie exposed on the surface for long after they were deposited. Quantitatively, over 70% of the mammal bones recovered by sieving through 4 mm mesh are between one and three centimetres in maximum length, indicating a high degree of fragmentation (Figure 2, Gron in press).

An estimate of taphonomic loss was only undertaken on the roe deer part of the mammal material as it is the best represented species and the single taxon for which it was possible to estimate the number of fragments resulting from the breakup of complete elements. Following Aaris-Sørensen (1983) and Noe-Nygaard (1977), the total taphonomic loss was estimated to be at a minimum 79%, based on an estimate of 375 fragments of bone per roe deer present at the site. It is acknowledged that the majority of the material of all species that was originally deposited was not recovered, although taphonomic losses of this magnitude are common at other Mesolithic sites (Noe-Nygaard 1977, Aaris-Sørensen 1983).

Fragmentation and preservation were assessed by different methods for the fish assemblage. An approximate assessment of the condition of the fish bones was created by comparing the weight of identified to unidentified bone. The 3113 g of identified specimens compared to just 488 g of unidentified ones (86% to 14% of the total weight) indicates an assemblage that is in good condition.
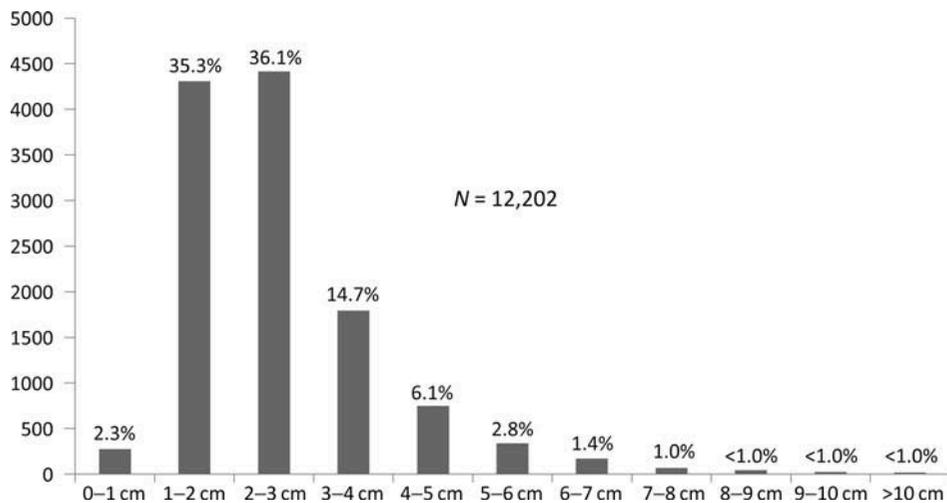

Figure 2.   Degree of fragmentation (modified data from Gron in press).

A second approach to examining differential preservation in the fish assemblage focused on the presence of specific skeletal elements of individual species (see Russ and Jones [2009] for a complete discussion of the method). Vertebrae are present at between 65% and 73% of the values that would be expected, suggesting that not all of the ones that came to the site were preserved or recovered. Other elements are generally present at even lower levels, supporting the conclusion that some fish bones were lost (Supplementary Information Appendix II). Still, these results are generally higher than or equal to the percentages from other Ertebølle sites that have been checked by this method (Ritchie 2010), reinforcing that the taphonomic loss of fish bones at Asnæs Havnemark was relatively low.

Differential recovery of animal remains due to excavation technique is another aspect of taphonomy that can affect the final results. At Asnæs Havnemark wet-screening with 4 mm mesh sieves was undertaken on site, although not all of the excavated matrices were sieved. While this methodology was sufficient to recover enormous quantities of fish remains, smaller fishes are undeniably underrepresented in the assemblage because of the size of the sieves used (see below), although this bias does not seem to be so great as to nullify interpretations based on the data.

These observations indicate that the faunal data recovered at Asnæs Havnemark probably give a good, if not perfect, idea of what animals were exploited by the site inhabitants. The bone material can be used to answer questions about the subsistence economy if care is taken to consider some of the potential biases that may be present due to preservation and recovery issues.

Faunal assemblage

In total, the faunal material from Asnæs Havnemark consists of 50,005 identified bones. Of this, 47,760 (95.5%) are fish (Pisces), 2214 (4.4%) are mammals (Mammalia), 29 (0.1%) are birds (Aves), and 2 are amphibian (Table 1). Gadids dominate the fish bone assemblage (86%), while roe deer account for the vast majority of the mammal remains (67%). Despite the preponderance of these two species, the assemblage presents an impressive variety of other fish (18 families in all), mammals (at least 17 species), and birds (13 species). Overall, all classes of faunal remains from the site show uniformity in their relative abundances across contexts and therefore the assemblage is discussed as a whole (Supplementary Information Appendix III).

Fish

The fish bone assemblage from Asnæs Havnemark is remarkable because of its size – NISP (Number of Identified Specimens) over 47,700 – and diversity (18 different families of fish). Gadids dominate the assemblage with eel following at a distant second and other fishes contributing relatively minor amounts (Table 1; see below for the effect of smaller mesh-size on relative abundances). Freshwater fish are very rare (only eight cyprinid vertebrae), but diadromous fish include eel, shad, and trout/salmon. These results are very much in accordance with the site's location far out on the Asnæs peninsula with no major bodies of freshwater in the vicinity. Preservation of the fish bones was generally good and all of the skeletal elements seemed to have been discarded together (Supplementary Information Appendix IV), though not all elements were recovered and identified in equal proportions.

In order to evaluate the effect of sieve mesh-size on recovery rates of fishbones, 14 samples of mostly 2 litres each (31 litres total) were taken from several of the proveniences and washed through nested geologic screens of 4, 2, and 1 mm sizes (Supplementary Information Appendix V). The 2 mm fraction produced the largest number of identified specimens (1805 or 55% of the total), followed by the 4 mm fraction (1292 or 39%), and the 1 mm fraction (202 or 6%). This shows that a significant portion of the fish remains present in the deposits were probably missed using 4 mm screens during excavation. Considering relative abundances, gadids show a fairly large percentage decline with increasingly finer mesh sizes. Flatfish are little changed, perhaps because they comprise only a small percentage of the assemblage. Eel and other species characterized by smaller bones markedly increase in abundance when smaller mesh-size sieves are used (Supplementary Information Appendix VI). Mammal and bird bones that were recovered during the sieving tests were added to the rest of the materials recovered from these contexts, but the effects of screen mesh-size was not specifically evaluated for these classes of fauna. In general, it can be said that while the use of 4 mm mesh-size sieves affected which types of fish bones were recovered, even with much finer sieves the assemblage would still have been dominated by gadids.

Because of the enormous numbers of fish remains present in the deposits and a desire to sample a sufficient area of the site in the time available, fish bones were only sampled from arbitrarily selected proveniences to expedite processing. The matrices were hand-excavated and wet-screened in the field with 4mm mesh-size sieves. Because of the very large quantity of fish remains found in square 124E 135N, the contents of the screen after washing were emptied onto a white table and sorted. This resulted in exceptionally good recovery of fishbones from this square. All recovered fish material has been analysed.

Before examining the results of the analysis in more detail, it is perhaps helpful to add a few notes on the taxonomy of the fishes. Although some identifications

Table 1. Identified faunal remains.

Family	Species	Common name	NISP	MNI
Gadidae	*Gadus morhua*	Cod	675	
	Melanogrammus aeglefinus	Haddock	4	
	Merlangius merlangus	Whiting	46	
	Pollachius pollachius/virens	Pollock/saithe	9	
	Unspecified gadid	Codfish	38,103/2244*	
Gadidae total			40,347	856
Anguillidae	*Anguilla anguilla*	Eel	3849/598*	52
Pleuronectidae	*Platichthys flesus*	Flounder	(4 dermal denticles)	
	Unspecified pleuronectid	Flatfish	897/59*	
Pleuronectidae total			956	32
Cottidae	*Myoxocephalus scorpius*	Shorthorn sculpin	601/96*	27
Scombridae	*Scomber scombrus*	Atlantic mackerel	444/117*	18
Clupeidae	*Clupea harengus*	Herring	158/106*	5
Triglidae		Gurnard	136/5*	4
Belonidae	*Belone belone*	Garfish	45/–*	1
Squalidae	*Squalus acanthias*	Spurdog	40/1*	5
Trachinidae	*Trachinus draco*	Greater weever	34/9*	1
Zoarcidae	*Zoarces viviparous*	Viviparous Eelpout	18/12*	1
Clupeidae	Alosa sp.	Shad	13/–*	1
Salmonidae	*Salmo* sp.	Trout/salmon	13/2*	1
Cyprinidae		Carp family	8/2*	1
Callionymidae	*Callionymus lyra*	Dragonet	1/–*	1
Scophthalmidae		Flatfish	1/–*	1
Gasterosteidae	*Gasterosteus aculeatus*	3-spined stickleback	–/44*	2
Gobiidae	Gobius sp.	Goby	–/3*	1
Syngnathidae		Pipefish	–/1*	1
Fish total			**47,760**	**1011**
	Capreolus capreolus	Roe deer	1493	19
	Martes martes	Pine marten	65	5
	Sus scrofa	Wild boar	141	4
	Canis familiaris	Domestic dog	119	4
	Erinaceus europaeus	Hedgehog	12	4
	Cervus elaphus	Red deer	122	3
	Vulpes vulpes	Fox	43	2
	Castor fiber	Beaver	21	2
	Sciurus vulgaris	Red squirrel	5	2
	Lutra lutra	Otter	5	2
	Apodemus flavicollis	Yellow-necked Mouse	4	2
	Phocoena phocoena	Harbour porpoise	14	1
	Felis silvestris	Wildcat	2	1
	Clethrionomys glareolus	Bank vole	1	1
	Arvicola terrestris	Water vole	1	1
Phocidae		Seal	166	5

(*continued*)

Table 1. (*Continued*).

Family	Species	Common name	NISP	MNI
Mammal total			**2214**	**61**
	Penguinis impennis	Great auk	3	2
	Cygnus olor	Mute swan	6	1
	Pandion haliaetus	Osprey	4	1
	Hallieetus albicilla	White-tailed Eagle	3	1
	Aquila chrysaetos	Golden eagle	3	1
	Gavia stellata	Red-throated loon	2	1
	Podiceps grisegena	Red-necked Grebe	2	1
	Cygnus cygnus	Whooper swan	1	1
	Larus argentatus	Herring gull	1	1
	Mergus serrator	Red-breasted Merganser	1	1
	Podiceps cristatus	Great crested Grebe	1	1
	Turdus merula	Common Blackbird	1	1
	Turdus philomelos	Song thrush	1	1
Bird total			**29**	**14**
	Bufo bufo	Common toad	2	2
Amphibian total			**2**	**2**
Total fauna			**50,005**	**1088**

Note: * = screen test samples.

are to species level, the predominance of vertebrae (especially from gadids) means that most of the specimens are only identified to the family level. In order to avoid comparisons between different taxonomic levels, fish families are used to report results. Gadidae were represented by *Gadus morhua*, *Melanogrammus aeglefinus*, *Pollachius* sp. (*P. virens* or *P. pollachius*), and *Merlangius merlangus*. *Gadus morhua* (cod) are most common (at 75.1%, with 5.1% *M. merlangus*, 1.0% *Pollachius* sp., 0.4% *M. aeglefinus*, and 18.4% unspecified gadid – based on identifications of 899 otoliths). Flatfish were represented by *Platichthys flesus* (although *Pleuronectes platessa* and *Limanda limanda* may also be present) and *Psetta maxima/Scophthalmus rhombus*. Clupeidae remains consisted of both *Clupea harengus* and 13 vertebrae of *Alosa* sp. (*A. alosa* and *A. fallax* are both possible in Danish waters). The only other Ertebølle sites where shad bones have been recovered are Dragsholm and Henriksholm-Bøgebakken (Ritchie 2010, Enghoff 2011). None of the cyprinid vertebrae could be assigned to species, so it is not possible to say which fish are present from among the several options. Salmonids were also only represented by vertebrae, so it is not possible to state whether these are *Salmo salar* or *Salmo trutta*. Triglids (gurnards) could be either *Eutrigla gurnardus* or *Trigla lucerna*, but only *E. gurnardus* was definitely present. The single specimen that is attributable to

dragonet (family Callionymidae) is of note as this fish has only been identified in one other Ertebølle assemblage (Norsminde, Enghoff 1991). Some fishes that are present in the assemblage (i.e., three-spined stickleback and pipefish) were only recovered because of the use of very fine (1 mm) mesh-size sieving.

Size information

The sizes of individual fish represented in the bone material were estimated based on regression formulas. For cod, measurements of otolith total length (OL) were used to estimate fish total length (TL) based on the formula (Härkönen 1986):

$$TL = -202.13 + 48.37(OL)$$

Summary data is graphically displayed in Figure 3. Estimates range from cod as small as 20 cm (with a weight of ca. 100 g) up to a maximum of 53 cm (weight ca. 1.5 kg), with an average of around 33–34 cm (weight ca. 300 g). Although the distribution is skewed to the right, this is likely the result of recovery issues related to sieve size. It should be noted that some specimens of other elements indicate fish of an even larger size than shown by the otolith estimates. There is little difference between the sizes of the fish in the various levels
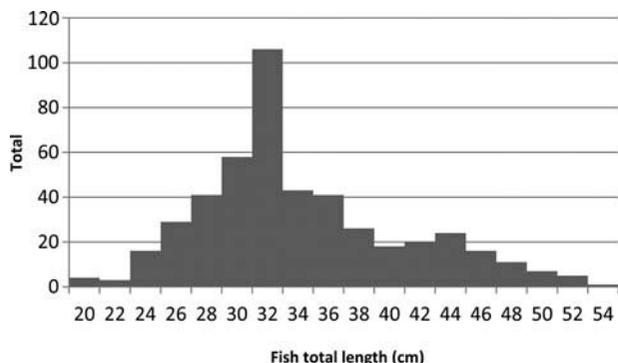
Figure 3. Total lengths of cod for all levels combined based on otolith total length. See Supplementary Information Appendix VII for data on individual levels.

(Supplementary Information Appendix VII), which accords well with the similarity in relative abundances seen earlier.

Eel total lengths (TL) were estimated from the width of the ceratohyal (K) according to the formula (after Enghoff 1987):

$$TL = 345.2232(K)^{0.7460}$$

Estimates of eel sizes ranged from 42 to 86 cm, with an average of approximately 61 cm (Figure 4). Although the shell layer does have slightly smaller eels on average when compared to the other layers (59 *versus* 62 cm), the small sample size for this layer and the similarity between the median lengths suggest that this variation is not meaningful (Supplementary Information Appendix VIII). The fact that most of the eels are greater than 50 cm in length implies that the majority of the catch was female eels (Muus, Dahlstrøm 1967).

Sizes of flatfish in the plaice/flounder/dab group were estimated based on the width (W) of first vertebrae according to the formula (after Enghoff 1991):
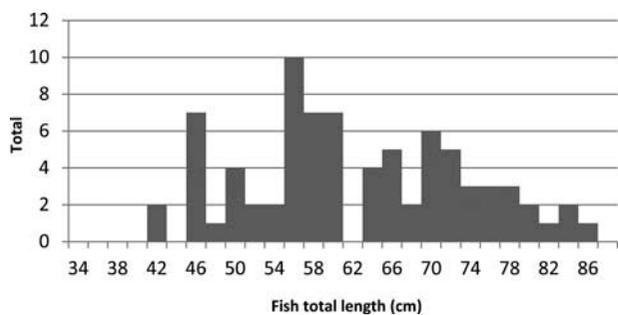

Figure 4. Total lengths of eel for all levels combined. NB. The apparent gap at 62 cm is most likely merely an artefact of rounding. See Supplementary Information Appendix VIII for data on individual levels.
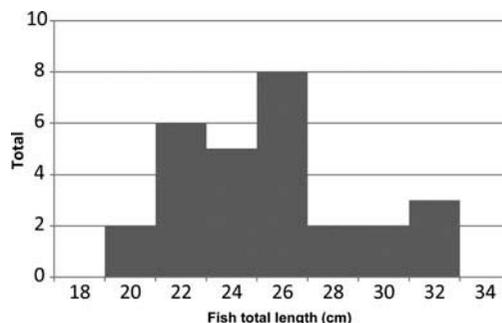

Figure 5. Total lengths of flatfish for all levels combined. See also Supplementary Information Appendix IX.

$$TL = 69.7268(W)^{0.9068}$$

The results shown in Figure 5 indicate that there was not a great deal of variation in the sizes of the flatfish, with an average length of about 25 cm.

The size estimates for the fish are similar to those from other Ertebølle sites in Denmark. Cod usually average around 30–40 cm, slightly larger at Lystrup Enge and Grisby. The largest fish at Asnæs Havnemark estimated from otolith length are not as large as the ones seen at many other sites, but as noted, there are some elements in the assemblage that indicate larger fish were caught. Eels from the site are similar in size to those seen elsewhere, although the absence of any specimens less than 42 cm is notable. The flatfish from Asnæs Havnemark are also similar in size to those found in other Ertebølle assemblages (Enghoff 1994).

The fish bone assemblage is interesting because of the high number of different fishes present, but also because of the clear dominance of gadids. Even when the use of finer mesh sieves increased the recovery of smaller fishes, gadids still comprised over two-thirds of the material. Eel were the second most common fish recovered, and the estimated lengths of the individual fish point to mostly female eels – perhaps caught during their fall migration. The fish bones represent an MNI (Minimum Number of Individuals) of 1011, demonstrating that fish were a significant part of the diet, even if their precise importance is difficult to quantify.

Mammals

The mammal assemblage from Asnæs Havnemark is also diverse, with at least 17 species represented. Highly fragmented assemblages are often difficult to interpret due to the relationship between the degree of fragmentation and zooarchaeological indices (Marshall, Pilgram 1993). In this case, however, the overall picture of mammal use remains similar regardless of what index is used. The assemblage is dominated by roe deer with a broad range

of other species present in lesser numbers (Table 1 and Supplementary Information Appendix X). Measurements for individual specimens are given in Appendices XI and XII. All species are wild with the exception of the domestic dog, which is common at Stone Age sites (Aaris-Sørensen 1998). There are a minimum of three species of marine mammals, including at least two species of seal and the harbour porpoise. Much of the seal material was not identifiable to species, so seal specimens were assigned to the general class of 'seal'. However, this assemblage includes the grey seal (*Halichoerus grypus*) and at least one member of the genus *Phoca*. The particular taxon or taxa represented by the genus could not be confidently identified.

The most represented species is roe deer, comprising 66.5% of the identified material and a total of at least 19 individuals (MNI = 19). In order to establish MNI values, age classes were used in conjunction with the occurrence of elements in the mammalian body, as well as body side, to determine MNI in the simplest way possible, following Richter and Noe-Nygaard (2003). The next most common individual taxon is wild boar, making up only 6.3% of the assemblage and with a minimum of four individuals. Taken together, seals (Phocidae) comprise 7.4% of the identified material (MNI = 5), and are the second most common mammalian prey. Among the terrestrial mammals, six taxa which can be considered fur-bearing are found (beaver, fox, otter, pine marten, red squirrel, and wildcat), best represented by the pine marten. Martens are tied with seals for the second highest number of individuals with a total of five (MNI = 5).

Of the mammalian species, three (bank vole, water vole, and yellow-necked mouse) are often considered not to be archaeological remains when they are recovered at Mesolithic sites (Aaris-Sørensen, Andreasen 1995). In addition, these three species bear no evidence of human processing. The hedgehog represents a difficult case, as the species is one of the smaller mammals that may or may not have been utilized by man. At some Danish Mesolithic sites this species does exhibit clear evidence of human butchery (Aaris-Sørensen and Andreasen 1995, Gotfredsen 1998), but at Asnæs Havnemark they do not.

The only domesticated species in the assemblage is the dog, comprising 5.3% of the assemblage and an MNI of 4. At Asnæs Havnemark, dogs were probably kept as hunting companions, as was typical for the Ertebølle period (Aaris-Sørensen 1998, Richter and Noe-Nygaard 2003). In addition, however, one notable specimen is an arthritically fused right calcaneus and astragalus from a dog that would have been lame. This animal would have had limited utility in hunting and may be best interpreted as a favoured companion, or rather, a pet.

In total, 50 specimens of all mammal remains (2.2%) in the collection exhibit clear signs of being juvenile, determined by bone porosity, toothwear, deciduous teeth, or a body size clearly below the adult range. This number is surely an underestimate considering that not all parts of the mammalian body are useful for determining even approximate age.

The mandibular and maxillary remains among the collection were highly fragmented and when teeth were discovered *in situ*, they were most often single or few in number and the majority were loose teeth. It was not possible determine if most specimens were from different animals with any certainty, so in order to be conservative, it is possible only to say that a range of toothwear among the roe deer sample from Asnæs Havnemark is observed, from very little wear to very heavy wear. Therefore, a range of ages from young to old is present in the material.

Two wild boar individuals under 1 year old were aged based on known developmental rates of tooth eruption in conjunction with side-by-side comparison with specimens of known age at the Zoological Museum of the Natural History Museum of Denmark. One individual was around 5 months of age based on a first mandibular molar, which had just erupted (Matschke 1967), and the other was probably under a year of age given its unerupted second mandibular molar. This second individual was probably closer in age to its counterpart, given the extremely similar size and overall character of the specimens. Therefore, in all likelihood, this animal was between 5 and 8 months of age at death, although it could have been up to 1 year old. In addition to the tooth material, one roe deer calcaneus with undeveloped epiphyseal ends and extremely porous bone texture is indicative of a very young (less than ca. 3 weeks old) individual. Also among the material were the atlas and fused cervical vertebrae of the harbour porpoise, indicating an animal at least 6 years of age based on known rates of cervical fusion (Galatius and Kinze 2003).

A complete review of the biology, chronology, and uses of typical Ertebølle fauna has been published recently and is not repeated here (Richter and Noe-Nygaard 2003, Aaris-Sørensen 2009, Enghoff 2011). Overall, a notable observation with regards to the Asnæs Havnemark assemblage is that the wide variety of animals indicates diverse hunting techniques to procure animals for multiple purposes. The mammal assemblage is absolutely dominated by the presence of the European roe deer, a common species in Ertebølle assemblages, and also contains the other two large game species usually present at Ertebølle sites: the red deer and wild boar. In addition to the animals taken primarily for meat, at least six species of fur mammals (beaver, wildcat, red squirrel, otter, pine marten, and fox) would have been taken especially for their skins (Richter and Noe-Nygaard 2003).

Birds

Avian materials yielded 13 taxa (Table 1). Birds probably would have been hunted either with nets or with bow-and-arrow using specialized equipment such as

birding arrows that have been found at other Ertebølle sites (Andersen 1985). The presence of each species of bird is evidenced by finds of single or only several elements. With the exception of the extinct great auk (MNI = 2), all bird species are represented by an MNI of one. The birds can be characterized as waterfowl or birds of prey. Birds were likely taken either as a source of meat (waterfowl) or in the case of birds of prey, to procure feathers for fletching or bone for specialized uses (Clark 1948).

Assemblage composition and stable isotopes

Any discussion of subsistence strategy must consider all the animals that were exploited. A major impediment to understanding the importance of various classes of fauna at Ertebølle sites (i.e., fish, mammals, and birds) is meaningfully relating them to each other. While zooarchaeological units such as NISP and MNI are useful shorthand for reporting assemblages in a standardized format, they are not necessarily directly useful for archaeological interpretations concerning the relative importance of resources in the human diet. So, abundance in the archaeological record does not necessarily directly equate to importance in the diet of humans. Because of the challenges inherent in using zooarchaeological data in this way, isotopic studies of human (and dog) bone have become increasingly popular and complement more traditional methods.

Isotopic studies are not without their own issues. One difficulty with this approach lies in the use of multiple localities by individual groups of Ertebølle fisher-hunter-gatherers, such that any isotopic studies of diet will reflect the average of visits to any number of sites over the course of the year. On a single-site basis then, it is probably impossible to determine how the overall diet relates to what is recovered archaeologically at an individual Ertebølle site. Nevertheless, carbon and nitrogen isotopic analyses were undertaken to two ends: to determine the environments from which various prey species were taken and to investigate human diets. The focus of the isotopic studies was on the bones of wild animals and domesticated dogs from the site. Dogs are generally considered to

be a reliable proxy for human diet in Stone-Age southern Scandinavia and are similarly used here (Noe-Nygaard 1988, Clutton-Brock and Noe-Nygaard 1990, Eriksson, Zagorska 2003, Fischer et al. 2007). Results are presented in Table 2. All listed samples listed fall within acceptable range of atomic C:N ratios for bone preservation indicating a low likelihood of diagenesis (White et al. 2001).

All wild animals show values that are within the normal ranges for southern Scandinavia (Fischer et al. 2007). Terrestrial roe deer show highly consistent values, indicative of an herbivorous diet in very similar environments. The wild boar specimen indicates slight enrichment relative to the deer, probably due to its omnivorous dietary preferences. The grey seal is highly enriched, as expected for a marine carnivore. The dogs present isotope ratios that indicate they were eating an almost entirely marine diet similar to the single highly enriched dog found at nearby Smakkerup Huse (Price and Gebauer 2005). Further, the nitrogen values indicate at least one trophic level of enrichment compared to herbivores. The single human mandible recovered from Asnæs Havnemark did not yield sufficient collagen for the analysis of stable isotopic ratios or radiocarbon dating. Therefore, assuming that dogs are indeed a good proxy for human diet, the two individuals analysed here indicate that the people were subsisting almost entirely on marine protein. This does not necessarily mean that terrestrial resources were unimportant – the large amount of bone material from these types of animals proves that they had a role – but the dog isotope data underscores that marine resources were the staple part of the diet over the longer term.

Seasonality

The faunal remains from Asnæs Havnemark offer a compelling means of identifying the seasons when the site was in use. Multiple lines of evidence including animal behaviour patterns, oxygen isotope analysis of cod otoliths, and ontogenetic aging of select species indicate use of the site in all seasons of the year.

The presence or absence of migratory birds and fish at specific times of the year can be a useful tool for

Table 2. Stable isotopes of carbon and nitrogen from Asnæs Havnemark.

Number	Species	Lab #	%C	%N	Atomic C:N	VPDB	AIR
AH24-49	*Capreolus capreolus*	258,926	21.78	7.2	3.53	−22.99	4.76
AH40-19	*Capreolus capreolus*	268,260	16.41	5.24	3.66	−22.94	5.47
AH74-15	*Capreolus capreolus*	268,261	18.45	5.82	3.70	−23.07	5.90
AH70-14	*Capreolus capreolus*	268,262	20.07	6.58	3.56	−22.81	5.80
AH73-16	*Sus scrofa*	268,266	17.24	5.74	3.50	−20.90	5.18
AH84-1	*Sus scrofa*	284,462	35.46	12.70	3.26	−20.86	5.41
AH70-20	*Halichoerus/Phoca* sp.	268,269	18.88	6.37	3.46	−9.58	14.20
AH85-4	*Canis familiaris*	268,272	15.06	4.88	3.60	−11.94	10.13
AH83-10	*Canis familiaris*	268,273	14.30	4.60	3.63	−13.24	11.87

establishing the season of occupation at archaeological sites. Seasonal information for birds is restricted to the presence of individual species in conjunction with knowledge of their migratory patterns. The golden eagle, mute swan, white-tailed eagle, herring gull, red-breasted merganser, great crested grebe, red-necked grebe, and common blackbird provide no information about seasonality due to the possibility of their year-round presence in Denmark (Génsbøl 2006). The song thrush must similarly be treated as a year-round visitor, because while it is usually present from late February until around November, some individuals stay in Denmark all year (Génsbøl 2006). The osprey is present in Denmark in all seasons except winter. The whooper swan is an autumn, winter, and spring visitor to Denmark, present between September and April. Finally, red-throated loons seasonally migrate through Denmark between March and May, and again between late August and November (Génsbøl 2006). To be conservative, no conclusions are made about the seasonal presence of the extinct great auk due to the paucity of observations made by naturalists concerning its migratory patterns while it was extant (Bengtson 1988).

Based on these observations, the bird evidence provides the possibility of site use in all seasons. Due to the fact that most bird taxa are represented by a single individual, it is best to use the presence of seasonally migratory species to reinforce other, more concrete seasonal indicators.

Migratory behaviour is also important for the fish evidence, especially with regards to garfish and mackerel that are present in Danish waters from the late spring to early fall. The presence of bones from both of these species in the assemblage, albeit in limited numbers, strongly supports summer occupation at Asnæs Havnemark. Three diadromous fishes (eel, shad, and salmon/trout) provide some evidence for site use during spring and fall based on the idea that they were most easily caught during their migrations, but individuals could also have been taken at other times of the year (Muus and Dahlstrøm 1964).

In contrast with the evidence from migratory fish, the predominance of gadids in the assemblage (including large individuals of cod and haddock) may be evidence for winter occupation based on comparison with the Danish fishery in the nineteenth century (Drechsel 1890, Moustgaard 1987). To test this idea, a pilot study using a recently developed methodology was conducted on four cod otoliths to determine in which season these fish were caught. The method relies on three factors (1) that fish otoliths grow incrementally throughout the life of the fish, (2) that they incorporate isotopes of oxygen in ratios that reflect their surroundings, and (3) that the ratio of ^{16}O and ^{18}O in their aquatic environment varies in response to water temperatures (see Hufthammer et al. 2010 for full details of the methodology). Thin sections were cut from across the core of the otoliths and then a series of samples were milled from the sections

with the aim of sampling the last year of the fish's life. A mass spectrometer measured $\delta^{18}O$ for each of the samples and, when plotted sequentially, these values should reveal the ambient water temperatures experienced by the fish during the period sampled.

By comparing the result from the sample taken from the outer edge of the otolith (the area being formed when the fish died) with the annual cycle of water temperature changes revealed by the complete series of samples, it is possible to determine at what time of year the fish was caught. Three of the four otoliths display clear patterns of cyclical variability that can be used to determine season of catch for the fish with confidence and one is less certain. The 48 cm fish was caught when water temperatures were just beginning to warm from their annual low, corresponding to a seasonality indication of late winter or early spring (Figure 6). One of the 49 cm fish shows a final reading midway between the coolest and warmest parts of the annual cycle, which indicates it was caught in the late spring or early summer (Figure 6). The smallest specimen, 35 cm, shows that it was caught when water temperatures were at their highest in the late summer (Figure 6). Because of two samples that were lost during measurement and the absence of a clear annual temperature pattern, interpretation of the results for the second 49 cm fish is problematic (Figure 6). Although not conclusive, the more positive measurements from the two samples closest to the edge of the otolith suggest a season of catch in the spring when water temperatures were just beginning to increase.

Although the sample size is small, these results show that while some cod were caught during the summer, winter and spring were also part of the fishery. It is of note that the one otolith that showed evidence for summer fishing was from the smallest of the fish that was sampled. From the growth rings evident in the polished thin-section of this otolith, the fish was aged at around 2 years – an age class that is known to remain close to shore during the summer months when the larger, older cod move into deeper waters in search of cooler temperatures.

Two lines of evidence are available for the estimation of season of occupation based on mammalian remains. The first is comparison of the antler casting stage of the archaeological examples of roe deer with the modern cycle in which roe deer cast their antlers in November and December (Richter 1982, Sempéré et al. 1992). Several roe deer frontal bones are present which represent different stages in the yearly antler casting cycle. Multiple specimens are present of skulls with uncast antlers and those that have recently cast their antlers. The skulls that have recently cast antlers have not yet started to regrow, and are therefore strong indicators of a November and/or December date of death. The uncast antlers are less useful for seasonality
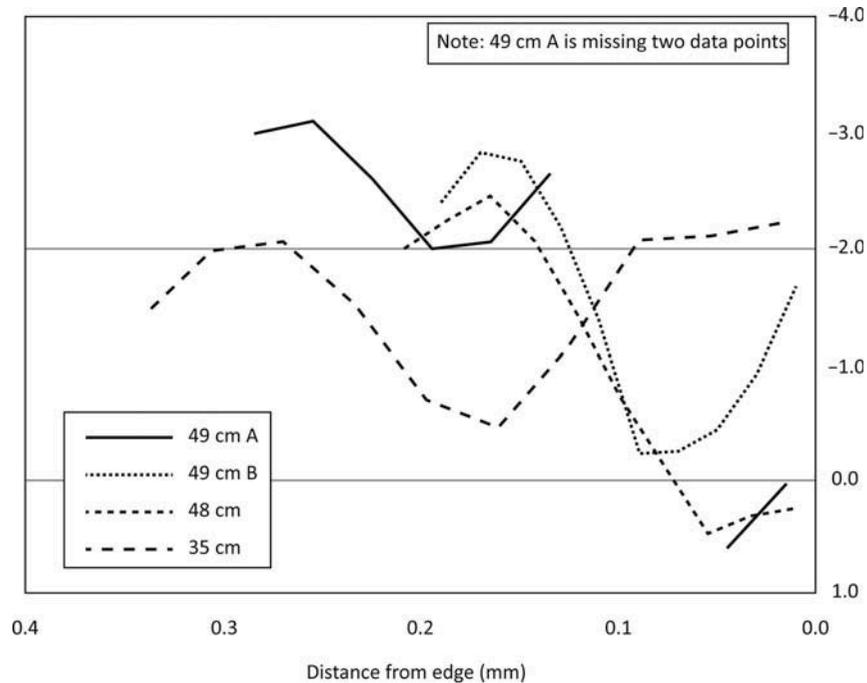
Figure 6.   Results from cod otolith isotope analyses. Results higher (more negative) on the *y*-axis indicate warmer temperatures and readings farther to the right on the *x*-axis are closer to the time of capture.

determination, as the deer possess antlers for the majority of the year. The second seasonality indicator from the mammal remains is roe deer and wild boar individuals under the age of 1 year. One roe deer probably died in June, based on rates of calcaneus development and fusion, its bone porosity, extremely small size, and likely timing of roe deer births during the Mesolithic (Richter and Noe-Nygaard 2003). Wild boar were most likely born from mid-April to mid-May during the Mesolithic in Denmark (Noe-Nygaard and Richter 1990). Of the two individuals that were aged at less than 1 year, one was around 5 months old based on a first mandibular molar which was just erupting (Matschke 1967), and the other was under a year of age given its unerupted second mandibular molar. This second individual was probably closer in age to its counterpart, given their extremely similar size and overall character, in all likelihood between 5 and 8 months of age. This places their deaths at September to November, and somewhere between September and probably January, respectively.

Figure 7 summarizes the seasonality information from animal remains for the site. Cumulative seasonality information indicates use during most, perhaps all, of the year. However, it is not possible to state whether this was the result of year-round occupation of the site or instead consisted of repeated visits in different seasons over the course of many years. It is, however, apparent that hunting and fishing took place at the same times of year, as

evidenced by the co-occurrence of mammal and fish indicators in the annual cycle.

Bone modifications
Food preparation
Burning, butchery and tool production are all in evidence as means by which animal bones were modified by human activities. Less than 1% of the mammal material is affected by burning, indicating that most cooking occurred after removal of meat from the bones. Burning is the principle manner in which the fish remains have been modified, although this should be understood as a fairly rare occurrence. Despite the fact that a total of 728 fish bones from the regular 4 mm sieving assemblage exhibit signs of burning (ranging from partial blackening to complete calcination), when considered in the context of over 44,000 identified specimens this is a small percentage (ca. 1.6%). Nevertheless, three observations need explanation: the discrepancy between abundances of fishes in the assemblage *versus* those that are burnt, the disproportionately high number of non-vertebrae elements that are burnt, and the spatial distribution of the burnt bones within the site deposits.

The large number of burnt bones from the gadid family (555 or 76% of the total) is unsurprising given the dominance of gadids in the overall assemblage (86%). Burnt eel bones (145) at almost 20% of the total are more numerous than would be expected from their
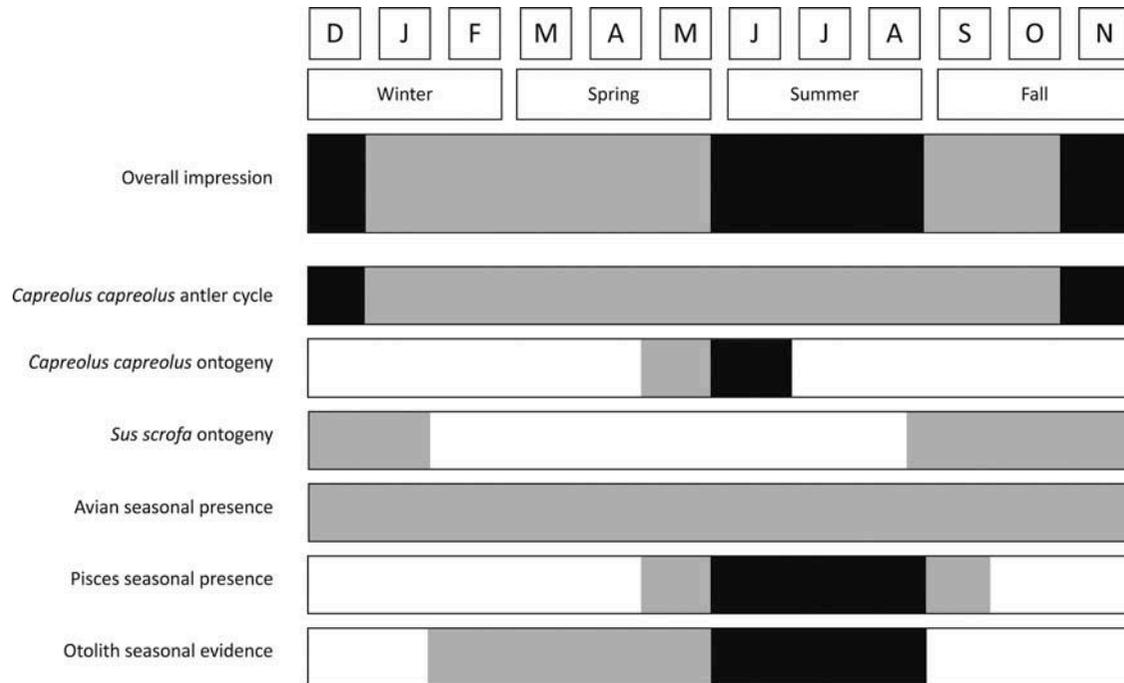
Figure 7. Seasonality at Asnæs Havnemark. Black indicates confidence, grey possibility, and white absence of indicators.

overall representation in the assemblage (9%), but still only roughly one out of every 27 eel bones is burnt. Eight bullrout, one herring, and one garfish bone are also burnt. These results do not seem especially meaningful on their own, but become more interesting when combined with the other two observations about burning.

More intriguing than the relative abundance of burnt bones amongst fishes is the distribution of burning between different skeletal elements. Specifically, while elements other than vertebrae comprise less than 15% of the overall assemblage, 561 (77%) of the burnt specimens are non-vertebra. Two possible explanations for the unexpectedly high number of burnt non-vertebra relate to the fact that these elements are in the head of the fish. Either fish were directly exposed to fire during preparation and the head elements were more likely to be scorched because they lacked the soft-tissue protection enjoyed by vertebrae, or fish heads were considered refuse and disposed of in the fire. Other scenarios can be constructed to explain the differential burning, but whatever the cause, the fact that almost 9% of the non-vertebra elements at the site are burnt *versus* less than one half of one percent of the vertebrae strongly suggests that much of the burning seen on the bones is the result of a deliberate decision by the site's occupants and is not merely the result of chance exposure to fire.

The spatial distribution of the burnt fish bones at the site is also of note, but here there is perhaps less reason to attribute the anomalous results to prehistoric behaviour. Vertical distribution of the burnt bones shows 182 from

the shell layer, 193 from the culture layer, 342 from the brown layer, and eleven from other contexts. The large number of burnt bones in the brown layer represents almost 47% of the total burnt specimens, while this layer only makes up 10% of the total assemblage. About one in thirteen bones in this layer are burnt. Burning occurs on just over 3% of the specimens in the shell layer, but these 182 specimens constitute one quarter of the burnt bone total despite the NISP from this layer providing only 13% of the overall assemblage. At nearly three quarters of the total assemblage the culture layer is by far the largest, but with 27% of the burnt specimens it is underrepresented compared to the brown and shell layers.

Interpreting these differences is complicated by the limited number of squares that provided (burnt) fish bones from layers other than the culture layer. Of the two squares that have fish remains from the brown layer, only 124E 135N has burnt bones and it has a lot of them. Indeed, so do the shell and culture layers from this square. In fact, a total of 582 (80%) burnt specimens come from this single square. While a possible cultural explanation cannot be ruled out, in light of the general lack of variability in the deposits described above a more likely solution might relate to taphonomy. Specifically, the extraordinary care taken to recover fish remains from this unit may well have resulted in the recognition and recovery of many more burnt specimens than would normally have been obtained during excavation.

Evidence of butchery and tool production marks (including sawing, cut-marks, scrape marks, etc.) was

present on some mammal bones (NISP = 94, 4.2%), although the location of most of these marks is not further interpretable due to the highly fragmented nature of the material and the relatively low occurrence of these modifications. Other than the previously described burning, osteological evidence for how fish were prepared for consumption is scant. There were almost no cut-marks observed during the analysis and skeletal element representation provides little additional information about butchery methods.

Nearly all of the appropriate mammal bones were fractured to gain access to marrow, in particular those of the roe deer, but also those from both wild boar and red deer. This is important to mention as it does not appear that differential overall representation in terms of relative abundance of red deer, roe deer, and wild boar is due to differential treatment of the bone; bones from all three species were marrow fractured to similar extents. Examples of fracturing include larger skeletal elements, such as longbones, as well as smaller elements, including first and second phalanges, which were snapped in half.

Considering the location of the site far out on a peninsula and the high frequency of roe deer in the terrestrial faunal material, it is important to establish whether individuals of this species exhibit any differential body-part representation which may indicate provisioning of the site from elsewhere. In conjunction with Minimum Number of Element (MNE) data, Minimum Animal Unit (MAU) data was calculated per element by taking the total number of elements, dividing by the occurrence of each element in the body, and then normalizing to establish %MAU (Gron in press), graphically depicted in Figure 8.

The relative abundances of each element in the skeletons of roe deer makes it clear that not all elements are equally well represented. However, there is no clear pattern that suggests only certain portions of the carcasses were brought to the site. Importantly, elements of the cranium are present, as are elements of the axial skeleton. Roe deer are most likely being butchered at the site, and therefore procured nearby (Gron in press). This assumes that a whole, unprocessed carcass would not have been carried to Asnæs Havnemark from any great distance, although the use of canoes for transport would render this conclusion moot. In any case, elemental representation data demonstrate that butchery of roe deer was one of the activities that took place at the site. Unfortunately, the small red deer and wild boar samples preclude similar analyses of these species, but among the available samples there is no clear evidence for any specific butchery pattern.

Tool production

In general, few bone specimens were unequivocally worked or prepared for the manufacture of tools (*N* = 14). However, one aspect particularly worthy of note is the number and placement of working traces found on domestic dog bones. Nearly every identifiable fragment of dog longbone is worked in an almost identical way, with minor differences evident between different types of bones.
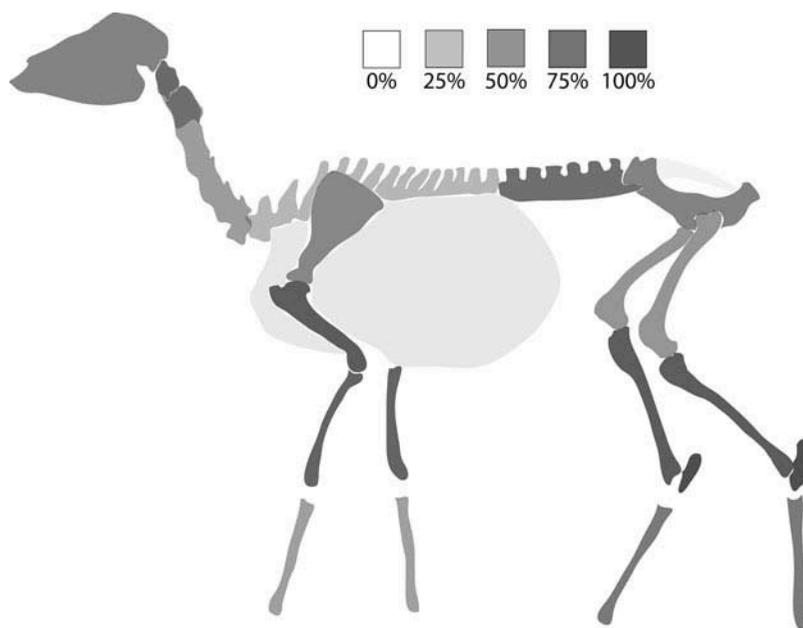

Figure 8. %MAU-roe deer. Carpals, tarsals, and other small elements omitted for illustrative purposes due to their small size (data from Gron in press).

In total, 119 fragments of bone are attributable to dog, comprising 5.3% of the identified material. Of the dog bone material, eleven fragments (9.2%) show unequivocal evidence of working for tool manufacture. Elements showing evidence of working include radii, tibiae, femora, and humeri, and belong to at least two individuals (possibly three). Both fused and unfused proximal femora are present, indicating both adult and subadult dogs were worked. In contrast, roe deer make up 66.5% of the recovered sample but less than one percent of the bones (ten specimens) shows definite or *possible* evidence of being worked in any way. None of the working traces are unequivocally for tool manufacture. However, 36.2% of the roe deer material (making up 24.1% of the entire sample from the site) shows clear evidence of fracturing to get marrow. No dog remains show evidence of such fracturing. Presumably, the size and density of comparable skeletal elements in roe deer and dogs are broadly similar. As such, they should have similar mechanical properties for the manufacture of tools. The high incidence of worked dog bones, coupled with the almost complete lack of evidence for the working of bones of similar-sized mammals, shows a clear preference in raw materials for tool manufacture. Ultimately, the reason for preferentially selecting dog bones for tools remains enigmatic.

Worked fragments usually consist of the end of the element, worked nearly up to the area of fusion at the epiphyseal end. Linear cuts are made on opposite sides of the bone, usually perpendicular to the flattest and straightest edge of the individual element in question (Figure 9). For example, considering the working pattern of distal tibiae, a groove is incised into the lateral and medial surfaces of the distal shaft of the bone providing an opportunity to separate and split the flat anterior and posterior surfaces of the bone, while cutting into the more rounded surfaces. Then, the flat

Figure 9. Working groove parallel to the longitudinal axis of dog tibia.

Figure 10. Perpendicular working so as to snap off a section of prepared flat surface.

segment of the long bone is thinned to provide a uniform and flat surface (Figure 10).

Because of these traces of working and subsequent treatment to perpendicularly snap the prepared flat surfaces, it is suggested that such working is for the manufacture of fishhooks. A minimum of 21 whole or partial bone fishhooks and at least six preforms were recovered during excavation. Of special interest is the preform
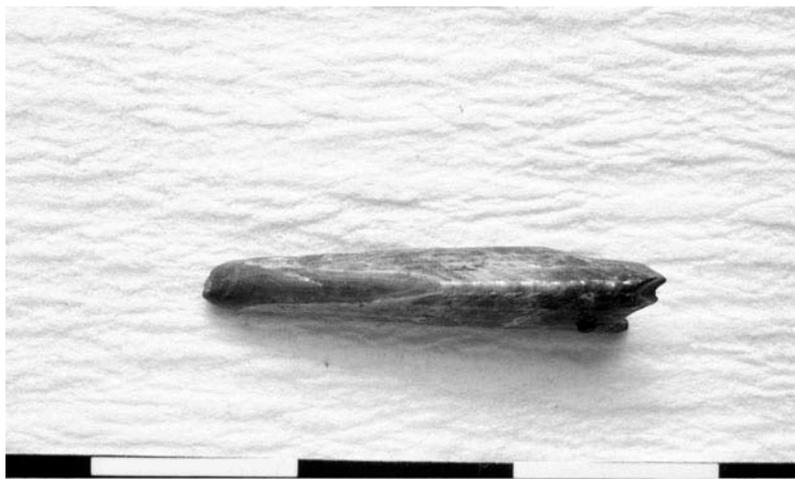

Figure 11. Spurdog spine showing probable traces of use/working.

fashioned from a swan ulna (*Cygnus* sp.), this being the first known evidence of the use of bird bone for fishhook manufacturing in the Danish Ertebølle.

Spurdog spines represent the only observed instances of fish remains that were used as tools. Of the ten spines that were recovered, one shows strong evidence (Figure 11) and three others show possible evidence of having been used as some type of tool based on wear of the ventral surface of the distal region of the spines (cf. Noe-Nygaard 1971). It is interesting to note that the ten spines indicate a minimum of five fish despite the fact that only 30 vertebrae were identified. While this could be the result of special treatment of the spines, it is also true that spurdog vertebrae are poorly ossified and do not preserve as well as the spines.

Interpretations

The site location, faunal assemblage, and tool technology all point to the conclusion that the people who lived at Asnæs Havnemark oriented their lives towards the sea. Isotopic evidence indicates that seafood was the most important part of the diet although the relative contribution of marine *versus* terrestrial foods is not completely clear. The overall impression of animal use at the site is one of both focus and breadth. In this sense, the diet of the inhabitants appears to be similar to the pattern known from many other Ertebølle sites. While the assemblage is strongly dominated by gadids and roe deer, there is a wide range of other species present.

In regards to the fish, the fact that at least 22 types of fish from 18 different families are present in the assemblage shows that there were many fishes available that the inhabitants could choose to target. While fishes were locally available in higher or lower numbers depending on the type of fish, the many bones of gadids (and to a lesser extent eel) demonstrate that they were the preferred catch. The rocky, exposed shoreline near the site, dominance of gadids (including large individuals of cod and haddock), and recovery of numerous fishhooks and preforms suggest that angling (possibly offshore in boats) played a major role in the fishery. This interpretation is supported by the very low incidence in the assemblage (0.1%), of weever, a species that is often used as a marker of fishing with stationary structures (Enghoff 1994). A further indication of the importance of the cod fishery is the otolith evidence showing that they were caught at different times of the year. That most of the eel are larger than 50 cm and thus presumably females, points to eel fishing in the fall when they were migrating from freshwaters into the sea (Muus, Dahlstrøm 1967). Some of the smaller fishhooks could have been used in this fishery, but it is also possible that nets, traps or spears were employed during this event. Access to good cod fishing grounds and migrating eels in the fall

may have been the reasons behind why the site is located far out on the Asnæs peninsula, a setting that was the location of an important historical fishery for several different species (Drechsel 1890). With availability of these primary food sources ensured, other animals could be incorporated into the subsistence regime as opportunity presented.

The mammal assemblage is absolutely dominated by roe deer (ca. 2/3 of the identified fauna) although the reasons for their abundance are less than clear. These animals were probably killed on the peninsula and not butchered elsewhere and selectively transported to it, an assessment supported by the relative ubiquity of various skeletal elements and also by the rather tight distribution of isotopic values, which likely indicate that these roe deer lived in extremely similar, if not the same habitat. This is not to say that the possibility of transport of whole carcasses by boat to the site can entirely be excluded.

Based on their dominance in terms of relative abundance, roe deer were the most important terrestrial game. In terms of size, however, even assuming a deliberate and very generous underestimate of the ratio of overall body weight between a roe deer and a red deer (using values from Geist 1998), an adult red deer is at least four times heavier than a roe deer, indicating that the MNI values for roe deer (MNI = 19) and red deer (MNI = 3) are not that dissimilar in terms of meat content. The conclusion is that while they dominate the assemblage, roe deer were not necessarily the most important mammal species in terms of subsistence.

The location may also explain the rather lower numbers of red deer at the site relative to other Ertebølle sites in the region (Møhl 1971, Skaarup 1973, Noe-Nygaard 1995, Gotfredsen 1998, Price and Gebauer 2005, Enghoff 2011), as limited land area may have restricted the numbers of such a large animal (Geist 1998, Kamler et al. 2008). The location would have less affected the abundance of the much smaller roe deer, a species that often lives at higher population densities than red deer (see reviews in Gill et al. 1996, Kamler et al. 2008). In fact, aside from the large representation of roe deer, one of the most notable aspects of this assemblage is the markedly depressed occurrence of red deer. Meat importance aside, there are proportionally fewer red deer found at this site than in Ertebølle assemblages from elsewhere on Zealand.

Asnæs Havnemark is located near the tip of the Asnæs Peninsula, a finger of land jutting approximately ten kilometres into the Storebælt in western Zealand with a width of about one kilometre. The peninsula would have looked similar in the Stone Age, as even with a likely overestimate of sea-level rise of five meters during the Littorina transgressions the general outline and shape of the landform would have resembled today's peninsula (Noe-Nygaard and Hede 2006: 92). In fact, it may even have been somewhat longer.

Table 3. Families of fish present at six Ertebølle sites. Callionymidae, Cichlidae, Labridae, Rajidae, and Triakidae are omitted as they are each represented by only a single specimen.

	Anguillidae	Clupeidae	Cottidae	Gadidae	Pleuronectidae	Scombridae	Squalidae	Gasterosteidae	Scophthalmidae	Belonidae	Cyprinidae	Gobiidae	Salmonidae	Triglidae	Zoarcidae	Trachinidae	Esocidae	Percidae	Ammodytidae	Syngnathidae	Carangidae	Moronidae	Sparidae
Asnæs Havnemark	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X			
Bjørnsholm	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Nivågård	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X		X	X	
Smakkerup Huse	X	X	X	X	X	X	X			X	X						X	X					
Tybrind Vig	X	X	X	X	X	X	X	X	X			X	X	X	X					X			
Vængesø III	X	X	X	X	X	X	X	X	X					X	X	X							

The location of the site on this peninsula likely explains the presence of species that are not as common on Ertebølle sites, particularly the seals, as they generally prefer secluded locations when they haul out (Riedman 1990). Such localities may include islands or other isolated areas such as the end of long coastal peninsulas. The seal remains may be the result of clubbing seals while on land at a haul out location near the site, although hunting with harpoons from boats probably occurred as well. Of particular note is the number of seal remains and extensive cut-marks on some of the elements (NISP = 19), which indicate the importance of seals to the hunters at the site. Overall, this seal assemblage is broadly similar to that from Ølby Lyng in terms of relative importance of seals. Their presence at Ølby Lyng was interpreted to have been at least in part a deciding factor in the location of the site (Møhl 1971), and the same is probably true for Asnæs Havnemark.

Fur animals (beaver, fox, otter, pine marten, red squirrel, and wildcat) were found in numbers that indicate they were of considerable importance to the site's occupants. With at least five individuals of pine marten represented, obtaining these animals must be considered a significant economic activity. The purpose of taking these species was likely to obtain furs, a valuable resource for the cold winter months; a probability reinforced by finds of pine marten in appreciable numbers at other Ertebølle sites in Denmark. Unfortunately, there is no direct evidence for how this species was used.

Birds appear to have been taken opportunistically, as they are sparsely represented. Two general types of birds were taken, waterfowl and raptors, probably by different hunting strategies specific to the class of bird desired by the Ertebølle hunters. Birds were taken for food as well as possibly to obtain raw materials – feathers for fletching, and bone for other uses (e.g., decoration, fishhooks, bone awls/points). The large number of species is indicative of a lack of a clear interspecific focus on birding at the site.

Different skills and procurement strategies are required to obtain terrestrial game, fur animals, seals, raptors, waterfowl, and the various species of fish. The wide variety of animals represented in the Asnæs Havnemark assemblage indicates that the people who lived there were proficient in a number of different hunting and fishing techniques. The predominance of roe deer in the mammal material and gadids in the fish material does indicate a certain degree of economic specialization, but perhaps more of a *de facto* variety based on the unique set of circumstances accompanying the site's location. However, it is important to remember that the inhabitants of Asnæs Havnemark were not so much constrained by the availability of animals in the vicinity of the site, as drawn there because of the prey that was present.

Conclusions

We contend that a degree of variability is present in Ertebølle faunal use that has not generally been recognized. While the same species of animals are generally present in the assemblages, their ranking in terms of importance varies widely among sites. For comparative purposes, we selected five other sites from Denmark (Bjørnsholm on the Limfjord in northern Jutland, Vængesø III in east-central Jutland, Tybrind Vig on Funen, Nivågård in northeastern Zealand, and Smakkerup Huse in northwestern Zealand) that have reasonably large faunal assemblages and were excavated with methods appropriate for recovering a good sample of the faunal remains (Bratlund 1993, Price and Gebauer 2005, Andersen 2009, Enghoff 2011). The assemblages from these sites help to demonstrate that within the larger framework of available resources, broad differences in subsistence practices existed.

Examining the different families of fish makes it apparent that generally the same types of fish were caught (Table 3). Despite this exploitation of common species, the fisheries were actually quite variable when relative abundances are considered (Table 4). At most sites, a majority of the specimens are from one type of fish, but that type varies between gadids, flatfish, and eel (though it is most often gadids). The fact that mostly the same types of fish are found at Ertebølle sites throughout Denmark, but in widely varying abundances, points to fully developed fishing capabilities that were tailored to local conditions.

The same pattern is seen with the mammal assemblages. The same mammals are generally present at the sites (Table 5). Where dissimilarity does occur, it can often be attributed to the local availability of species. This is particularly true of the species locally absent on Zealand during the Ertebølle period such as badger, polecat, and lynx (Aaris-Sørensen 1980). However, the relative abundance of species

Table 4. Relative abundances of fishes at six Ertebølle sites.

	Total NISP	Gadidae	Pleuronectidae	Anguillidae	Other
Asnæs Havnemark	44,461	86%	2%	9%	3%
Bjørnsholm	11,490	10%	1%	56%	32%
Nivågård	4966	30%	56%	2%	11%
Smakkerup Huse	9332	70%	18%	2%	10%
Tybrind Vig	2423	77%	15%	1%	8%
Vængesø III	6478	49%	34%	0%	16%

Table 5. Presence or absence of mammals. Small rodents omitted except for *Sciurus vulgaris*.

	Canis familiaris	*Canis lupus*	*Capreolus capreolus*	*Castor fiber*	*Cervus elaphus*	*Erinaceus europaeus*	*Felis silvestris*	*Lutra lutra*	*Martes martes*	*Phocoena phocoena*	*Sciurus vulgaris*	*Sus scrofa*	*Vulpes vulpes*	*Bos sp.*	*Seal*	*Lynx lynx**	*Meles meles**	*Mustela putorius**
Asnæs Havnemark	X		X	X	X	X	X	X	X	X	X	X	X		X			
Bjørnsholm	X	X	X		X		X	X		X	X	X	X	X	X	X	X	X
Nivågård	X		X	X	X	X	X	X	X		X	X	X	X	X			
Smakkerup Huse	X		X	X	X	X	X	X	X		X	X	X	X	X			
Tybrind Vig	X		X		X		X	X	X	X		X	X	X	X			X
Vangesø III	X		X		X		X	X	X	X	X	X	X	X	X		X	X

Note: *species not present on Zealand.

Table 6. Relative abundances at six Ertebølle sites. Small rodents omitted except *Sciurus vulgaris*/all doubtful or mixed identifications omitted except for marine mammals/all *Sus* sp. considered wild boar.

	Total NISP	Red deer	Roe deer	Wild boar	Domestic dog	Fur mammals	Marine mammals	Other
Asnæs Havnemark	2208	6%	68%	6%	5%	6%	8%	1%
Bjørnsholm	364	28%	35%	24%	1%	9%	1%	1%
Nivågård	2469	36%	49%	10%	1%	2%	1%	0%
Smakkerup Huse	1787	41%	38%	16%	2%	2%	0%	1%
Tybrind Vig	1744	22%	8%	11%	3%	53%	2%	0%
Vængesø III	841	3%	11%	19%	9%	17%	42%	0%

is quite different at individual sites (Table 6), as with the fish remains. Variability is observed particularly among the three main terrestrial game animals (red deer, roe deer, and wild boar), as well as sea mammals and fur-bearing mammals. The faunal material from Asnæs Havnemark highlights this variability and underscores the reality of differences among certain classes of resources.

These comparisons show that within almost all classes of animals exploited by Ertebølle hunters and fishers there is a great deal of inter-site variability. While the same animals generally occur in all assemblages, the focus of subsistence at each site represents a specialized adaptation to local conditions. Recognizing and explaining this variability are key goals for understanding the late Mesolithic.

In the case of Asnæs Havnemark, the location of the site may explain to some degree the preponderance of just a few species in the archaeological material. However, a major caveat is that while this is the case, the range of animals utilized remains quite impressive, indicating an ability to employ multiple hunting and fishing strategies to fully exploit local resources. We take this to strongly indicate that in the face of either seasonal or atypical environmental stresses, Ertebølle fisher-hunters at Asnæs Havnemark had the knowledge and skills to readily switch between vastly different classes of resources as needed.

In other words, despite the preponderance of roe deer and gadid remains, the Asnæs Havnemark assemblage is the result of a highly flexible hunter-gatherer subsistence strategy able to adapt to local, seasonal, and longer-term shifts in resource availability. In turn, this means that environmental stresses would have less ability to create major changes in general subsistence patterns. Because of this flexibility, we contend that substantive environmental changes could not have been the major causal force for the introduction of agriculture at the end of the Ertebølle period. The evidence we have presented greatly weakens such arguments.

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