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Freshwater Fishing from a Sea-Coast Settlement –

the Ertebølle *locus classicus* Revisited

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INTRODUCTION

In the classical work on Danish shell middens (Madsen *et al.* 1900) Herluf Winge published results of investigations of fish and other bones from the shell midden at Ertebølle – the type site of the Ertebølle Culture. The present paper presents an analysis of the fish bone material recovered during the recent excavations of the Ertebølle shell midden during 1979–84 by S.H. Andersen and E. Johansen. See Andersen & Johansen 1986 for background information on these new excavations.

The Ertebølle shell midden is situated in northern Jutland, south of the small town Ertebølle at the Limfjord. When the settlement was inhabited during the late Atlantic period, it lay on the shore of a small bay. This bay was delimited by Ertebølle Hoved which extended further into the sea then, and by a system of beach ridges connecting a small island to the shore (Petersen 1986) (Fig. 1). The Ertebølle people had easy access to sea water in the bay, where they collected oysters and other shellfish, and in more distant waters. At that time, the water in the Limfjord was more saline than today, as there were more direct connections to the North Sea, i.a., in Vester Hanherred directly north of Ertebølle (Petersen 1986 and references therein). But there was also easy access to freshwater: the geology of the area indicates the presence of two now disappeared lakes within a few kilometres' distance of the settlement (Petersen 1986 and pers. comm.): one about a kilometre south-east of the shell midden, and another, larger one immediately east of Strandby, about three kilometres southeast of the shell midden; see Fig. 1.

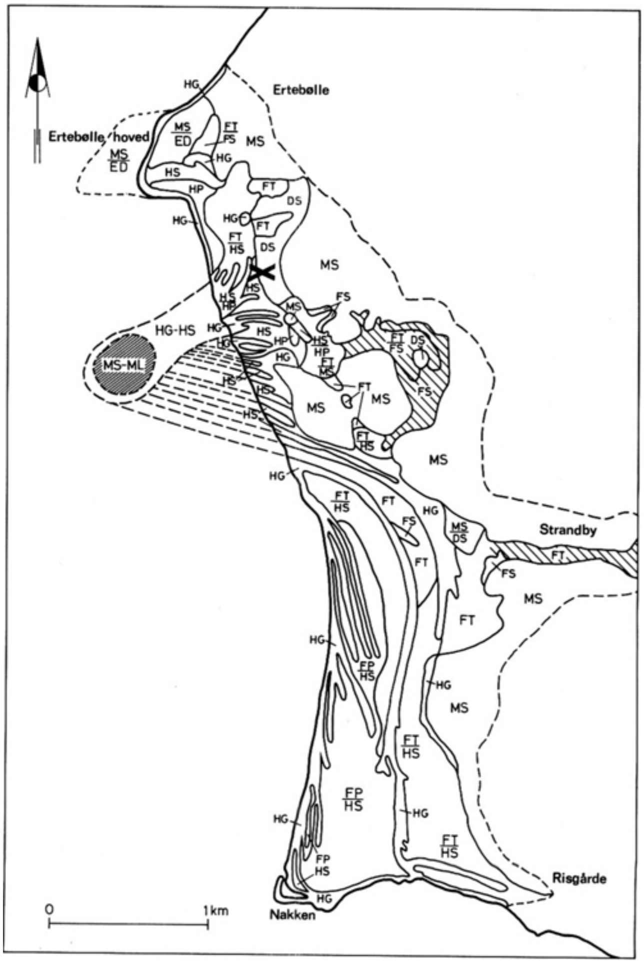

Fig. 1. Geological map showing the situation of the shell midden at Ertebølle in Atlantic times, at the shore of a small bay delimited by stippled lines. – cross: the shell midden, open hatching: Atlantic lakes (now dried out, the main part of the easternmost lake is outside the map), dense hatching: former island, FT: freshwater peat, FP: freshwater gyttja, FS: freshwater sand, HP: marine gyttja, HS: marine sand, HG: marine gravel, DS: meltwater sand, ML: till, clayey, MS: till, sandy, ED: mo-clay. Map provided by K.S. Petersen, Geological Survey of Denmark.

MATERIAL

The shell midden is at least 141 m long, up to about 20 m broad, and about 1.9 m thick (Andersen & Johansen 1986). The fish bone material analyzed derives partly from a 1 m broad and 29 m long trench cutting east-west through the midden. In addition some material is from a column sample (in the following referred to as the N-column) taken in connection with the trench in square N (Fig. 2). Excavations outside the midden proper revealed no fish bones.

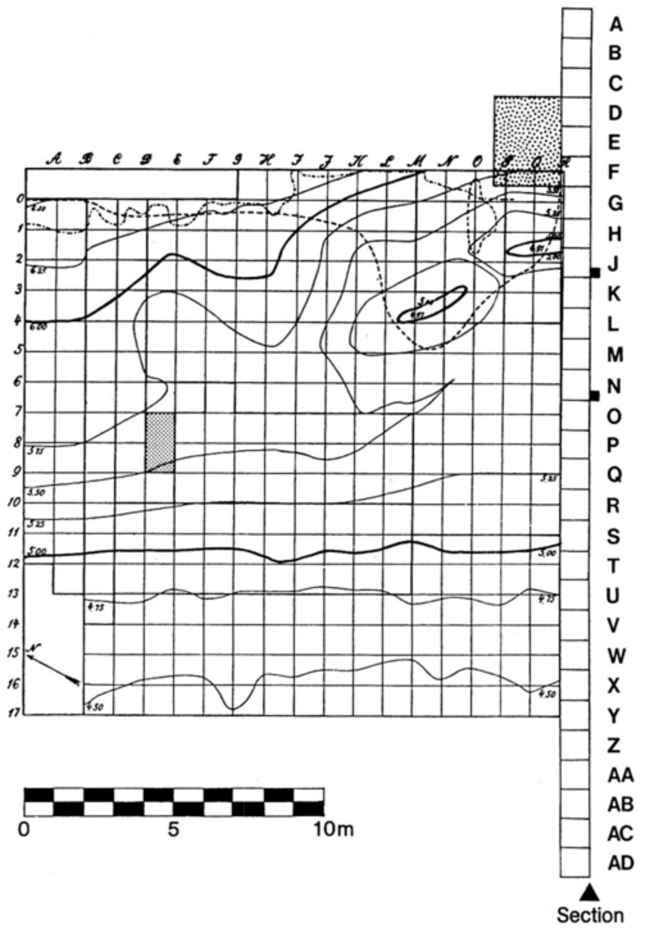

Fig. 2. Map of excavated areas in and around the Ertebølle shell midden. The newly excavated trench is shown superimposed on the map from Madsen *et al.* (1900). The positions of the column samples are indicated at squares J and N. The J-column was not analyzed for fish bones.

The trench was excavated during the years 1980, 1983, and 1984. C_{14}-analyses of material sampled from the trench wall yielded datings ranging from 4060±95 b.c. (K-4318) to 3120±90 b.c. (K-4307) (conventional C_{14} years, like all datings cited in the present paper). The layers with fish bone material, however, covered a narrower interval, viz., ca. 3800–3100 b.c., and were mainly concentrated between 3600 and 3200 b.c. The fish bones in the trench occurred partly in an ash layer with scattered fish bones and in two pronounced fish bone layers, all of limited extent, partly scattered throughout the trench in small groups (see p. 68 and Andersen & Johansen 1986). The fish bones were frequently found under large oyster shells or in association with large mammal bones. The groups of fish bones were plotted on a three-dimensional system of co-ordinates, collected *in toto* and submitted for examination. Fish bones were sorted from the samples under the stereo microscope and identification of all bones was attempted.

The N-column (dimensions: 20 × 20 × ca. 121 cm) was taken from the southern trench wall in square N. The column was divided into 27 samples, as far as possible following the geological layers in the trench, otherwise with intervals of 5 cm. With three exceptions, where the samples were too small, 2000 g of each sample were sieved through progressively finer screens (8 mm, 4 mm, 2 mm, and 0.5 mm mesh). The three small samples were sieved in full. Fish bones were sorted from each fraction, and an attempt was made to identify all bones. Three of the samples, however (N 13, 14, 15) contained very large numbers of bones, and from these samples, subsamples were analyzed. For all column samples, the numbers of fish bones were converted to numbers per 2000 g. See Table 5.

The fish bones from both trench and column were mostly well preserved, some were even excellently preserved. Most fine processes etc. were, however, broken. Only 3 fish bones in total showed signs of having been burnt.

The Ertebølle shell midden appears always to have been situated on the beach, exposed to wave action and changing sea levels, for a detailed discussion, see Andersen & Johansen 1986. Without doubt, some of the bones in the midden were transported over short distances by the water. The studies by Petersen (1986) of the mollusc shells in the J- and N-columns show that there are "no reasons to assume that the midden was inundated by the sea for any length of time during the millenium of its accumulation". The presence of large,

	Species	Trench	N-column	N-column, disregarding *Gasterosteus*
	Cyprinids (Cyprinidae), including	67.31	31.13	61.74
w	Roach (*Rutilus rutilus*) and			
w	Rudd (*Scardinius erythrophthalmus*)			
w	Eel (*Anguilla anguilla*)	17.31	8.75	17.35
	Gadids (Gadidae), including	8.42	0.57	1.13
w	Cod (*Gadus morhua*) and			
	Saithe (*Pollachius virens*)			
w	Perch (*Perca fluviatilis*)	2.77	3.66	7.25
w	Garpike (*Belone belone*)	1.30	0.18	0.35
w	Plaice/flounder/dab (*Pleuronectes platessa/Platichthys flesus/Limanda limanda*, including	1.08	3.54	7.02
	Flounder (*Platichthys flesus*)			
	Herring (*Clupea harengus*)	0.53	1.46	2.90
w	Three-spined stickleback (*Gasterosteus aculeatus*)	0.52	49.57	–
w	Pike (*Esox lucius*)	0.27	0.21	0.41
	Eelpout (*Zoarces viviparus*)	0.13	0.84	1.66
	Salmonids (Salmonidae), including	0.13	0	0
	Salmon/Trout (*Salmo* sp.) and			
	Whitefish (*Coregonus* sp.)			
	Gobiids (Gobiidae)	0.06	0	0
	Bullhead (*Acanthocottus scorpius*)	0.04	0	0
	Sea stickleback (*Spinachia spinachia*)	0.04	0.09	0.18
	Grey gurnard (*Eutrigla gurnardus*)	0.02	0	0
	Turbot (*Psetta maxima*)	0.02	0	0
	Ray (*Raja* sp.)	0.02	0	0
	Spurdog (*Squalus acanthias*)	0.02	0	0
		99.99	100.00	99.99

Table 1. The species of fish in the Ertebølle material and their relative frequencies (in %) in the trench and in the N-column. The species are arranged according to decreasing frequency in the trench. Species also recorded by Winge (in Madsen *et al.* 1900) are marked with a "w". Based on 9462 identified bones from the trench and 6697 (converted numbers, see text) from the N-column.

apparently undisturbed parts of the midden is another indication that the midden was not significantly affected by the sea. For example, around the large fireplaces, fine stratification shows that the same fireplaces were used for extended periods of time (Andersen & Johansen 1986). The fish bones studied derive almost exclusively from these undisturbed parts of the midden. For example, the N-column cuts through one of the fireplaces. It is therefore reasonable to assume that the fish bones which are object of this analysis owe their presence in the midden to activities of the inhabitants and were not washed ashore from the sea.

The material is kept in the Zoological Museum, Copenhagen.

SPECIES OF FISH AND THEIR RELATIVE FREQUENCIES IN THE MATERIAL

The fish bones were identified by using the comparative osteological collection of fish in the Zoological Museum, University of Copenhagen. Almost all bones were studied with a stereo microscope, because of their small size.

The results are shown in Table 1, where bones from the trench and bones from the column are kept separate. The relative frequencies of each species shown in the table were calculated on the basis of 9462 identified bones from the trench and 6697 identified bones from the column. The latter number is the sum of identified bones from each column sample, converted to numbers per 2000g of sediment. The real number of identified bones from the column was somewhat lower. The number of unidentified bones cannot be stated, as there was a gradual transition from well preserved bones through progressively smaller fragments to a homogeneous mass of pulverized bones.

Among the species on the list, those that were reported by Winge (in Madsen *et al.* 1900) from Ertebølle are marked with a "w". The new list comprises 21 species, that of Winge listed 9 species. In the following, the species will mostly be referred to by their Latin generic names only.

Table 1 gives a general survey of species and frequencies from the trench material. The dominant group of fish was the cyprinids, including *Scardinius* and in particular *Rutilus*. The cyprinids alone constituted 67% of the total number of identified bones. They were followed by *Anguilla* (constituting 17%), gadids, including *Gadus* and *Pollachius* (8%), *Perca* (3%), *Belone* (1%), and the *Pleuronectes/Platichthys/Limanda* group, including *Platichthys* (1%). The remaining species: *Clupea*, *Gasterosteus*, *Esox*, *Zoarces*, salmonids (including *Salmo* and *Coregonus*), gobiids, *Acanthocottus*, *Spinachia*, *Eutrigla*, *Psetta*, *Raja*, and *Squalus*, amounted to barely 2%.

The N-column included fewer species than the trench. Furthermore, there were apparently great differences in the relative frequencies of the species. *Gasterosteus* alone constituted about 50% of the identified bones. If, however, *Gasterosteus* is disregarded and the relative frequencies recalculated (Table 1, right column), a distribution very similar to that in the trench material appears. Cyprinids and *Anguilla* now constitute 62% and 17%, respectively. This indicates a local concentration of *Gasterosteus* bones in the N-column, with the other species occurring in largely the same frequencies as in the trench.

A survey of the numbers of different kinds of bones of each species/species group is given in Table 2 (only trench material).

The identification of several of the species demands further comments:

Spurdog – *Squalus acanthias*. Two half, hourglass-shaped vertebrae were assumed to derive from this species because of the proportions of the vertebrae and the width of the *canalis centralis*.

Ray – *Raja* sp. Two dermal denticles from a species of ray were found. They could not be identified to species, but as their basis was smooth, the common starry ray, *Raja radiata*, could be excluded. The dermal denticles most probably derive from the thornback ray, *Raja clavata*.

Salmonids – Salmonidae. Twelve vertebrae were identified as deriving from salmonids. Of these, three were referred to salmon or trout (*Salmo* sp.), and one to whitefish (*Coregonus* sp.).

Cyprinids – Cyprinidae. Including roach, *Rutilus rutilus*, and rudd, *Scardinius erythrophthalmus*. Most kinds of cyprinid bones are difficult or impossible to identify to species. However, identification is possible on pharyngeal bones (*os pharyngeum inferius*) and basioccipitals (*processus pharyngeus ossis basioccipitalis*). These two kinds of bone were identified to species, and the remaining cyprinid bones were presumed to belong to the same species as revealed by the pharyngeal bones and basioccipitals. A total of 295 cyprinid bones was identified to species, and of these, 98% were from *Rutilus* and 2% from *Scardinius* (see Table 3).

Gadids – Gadidae. Including cod, *Gadus morhua*, and saithe, *Pollachius virens*. Species identification of the gadid bones in the material was difficult because most of the bones were from very small individuals (total length from less than 20 cm and up to 30 cm) whose bones are less species-specific than bones from larger individuals. Two species were recognized, viz., *Gadus morhua* and *Pollachius virens*, on bones as, e.g., premaxillary, dentary, vomer, parasphenoid, and hyomandibular, and there were no indications of further species. 28 bones belonged to *Gadus morhua* and 41 to *Pollachius virens*. A further 74 bones could be identified as belonging to either *Pollachius virens* or pollack, *Pollachius pollachius*. As *Pollachius pollachius* was not otherwise indicated in the material, these bones were presumed to be from *Pollachius virens*, making the preponderance of this species even more pronounced. See also Table 4.

Gobiids – Gobiidae. Vertebrae and basioccipitale appeared to derive from black goby (*Gobius niger*), whereas keratohyale was not diagnostic to species. The genus *Pomatoschistus*, however, could be excluded.

Turbot – *Psetta maxima*. Two dermal denticles were identified to this species. The other Danish species of the family Scophthalmidae do not have such denticles.

Plaice/flounder/dab – *Pleuronectes/Platichthys/Limanda*. Including flounder, *Platichthys flesus*. These three species (in the following referred to as "pleuronectids") are difficult to distinguish on skeletal characters. Fortunately, the material included 67 dermal denticles

	Cyprinids	*Anguilla*	Gadids	*Perca*	*Belone*	Pleuronectids	*Clupea*	*Gasterosteus*	*Esox*	*Zoarces*	Salmonids	Gobiids	*Acanthocottus*	*Spinachia*	*Eutrigla*	*Psetta*	*Raja*	*Squalus*
HEAD BONES																		
Parasphenoideum	14	1	12	1					1	1								
Vomer		7	8	4														
Mesethmoideum		1																
Frontale														1				
Supraoccipitale			1					1										
Basioccipitale	19	4	6									1						
Prooticum							9											
Circumorbitalia	1																	
Otolithi	5		12															
Neurocranium unspecified							4							1				
Praemaxillare		10	18	4	8	1												
Maxillare	39		13	1														
Dentale	100	32	8	4	16				2				1					
Articulare	81	7	21	3			2											
Quadratum	50	1	24	3														
Palatinum			12						1									
Entopterygoideum						1												
Ectopterygoideum			15			3												
Praeoperculare	16		11	10														
Interoperculare			13															
Suboperculare													1					
Operculare	48	1	5	4														
Symplecticum			27															
Hyomandibulare	12	7	36		1		1											
Hypohyale	53		11															
Keratohyale	154	28	21	1			2					1						
Epihyale		5	18	1														
Stylohyale			3															
Urohyale	28	7	7			1												
Basibranchiale			4															
Hypobranchiale			8															
Os pharyngeum inferius	604		28	2														
Epibranchiale			15															
Pharyngobranchiale			29			8												
Detached teeth[1]	434								10									

(modified scales) of a very characteristic appearance (Fig. 3), deriving from *Platichthys*. *Pleuronectes* and *Limanda* do not have such denticles, which thus provide a means for indicating presence of *Platichthys* in subfossil materials.

Bones from all body regions are present for those species which are well represented in the material, see Table 2.

The list of species comprises the following freshwater fishes: *Esox*, *Rutilus*, *Scardinius*, *Perca*, and *Gasterosteus*. These are all very common in the vegetation belt in lakes. *Esox* and *Perca*, however, require water which is not deficient in oxygen. They all can furthermore be found in slowly running and brackish water. *Scardinius*, however, does hardly tolerate other than very low salinities. By contrast, *Gasterosteus* also occurs in salt water where it may form big schools near the coast during the summer.

	Cyprinids	*Anguilla*	Gadids	*Perca*	*Belone*	Pleuronectids	*Clupea*	*Gasterosteus*	*Esox*	*Zoarces*	Salmonids	Gobiids	*Acanthocottus*	*Spinachia*	*Eutrigla*	*Psetta*	*Raja*	*Squalus*
SHOULDER GIRDLE																		
Posttemporale			64	3	1													
Supracleithrale	9		54	6	3													
Cleithrum	3	33	2	1														
Postcleithrale			1															
Scapula	70				1	1	1											
PELVIC GIRDLE																		
Basipterygium	70			3				8										
VERTEBRAE	4449	1494	290	211	97	15	31	11	4	10	12	4	2	2	2			2
OTHERS																		
Tripus	22																	
Os suspensorium	88																	
Os anale						1												
Dorsal and ventral spines								7										
Dorsal scutes								8										
Lateral scutes								10										
Scales etc.[2]	+			+		67			+							2	2	
unspecified bones								4	8									
Total	6369	1638	797	262	123	102	50	49	26	12	12	6	4	4	2	2	2	2

Table 2. Specification of the 9462 identified bones from the trench. Numbers of identified bones of each kind and each species are given. Regarding cyprinids and gadids, see Table 3 and 4, respectively, for more information. – Notes: [1] Detached teeth of cyprinids derive from os pharyngeum inferius, those of *Esox* from oral bones. [2] "+" means that scales were found but not counted. The entry under Pleuronectids refers to dermal denticles of *Platichthys*, under *Psetta* and *Raja* also to dermal denticles.

The following species are marine: *Squalus*, *Raja*, *Clupea*, *Belone*, *Pollachius*, *Gadus*, *Zoarces*, gobiids, *Eutrigla*, *Acanthocottus*, *Spinachia*, *Psetta*, pleuronectids (including *Platichthys*). Of these, *Pollachius*, e.g., requires a high salinity, whereas others, e.g., *Zoarces* and *Platichthys*, are also numerous in brackish water. Several of these species: *Zoarces*, gobiids, *Acanthocottus*, and *Spinachia*, are characteristic of shallow water (the eel grass zone) near the coast. This habitat is also suitable for young individuals of the remaining marine species. The gadids and pleuronectids in the material are small individuals which must have lived near the coast during the summer half of the year. *Belone* visits Danish waters from April/May until autumn and spawns in shallow water in the eel grass zone. *Squalus* occurs from shallow water to 400 m depth, during summer it may be met with in the eel grass zone. *Clupea* lives pelagically on up to 250 m depth; juveniles occur in very shallow water.

Salmonids and *Anguilla* are migratory and may therefore occur in salt, brackish, and fresh water.

All species on the list occur commonly in Danish waters nowadays.

The above information on fish biology was mainly taken from Muus & Dahlstrøm (1964, 1967).

The relative frequencies of the species on the list give an impression of what kind of fishing the Ertebølle people practised. The frequencies cannot, however, be directly used as a measure of the importance of each species. Different species have different numbers of bones: *Anguilla* has ca. 115 vertebrae, whereas *Gadus* has ca. 50. Also, the species do not have equal chances of preservation in the soil (Höglund 1972: 52, Lepiksaar 1983, Lepiksaar & Heinrich 1977): some of the species on the list, especially *Anguilla*, pleuronectids, *Clupea*, and salmonids, have very fatty bones with a tendency to disintegration, when the fat transforms to fatty acids.

(The fatty bones are furthermore preferred by dogs and foxes.) *Clupea* bones are of a delicate structure, salmonid bones are poorly ossified (this is also true of many *Esox* bones). The cartilaginous fishes (*Squalus* and *Raja*) have particularly poor chances of preservation. At the other extreme, bones of *Perca* and *Gadus* are poor in fat and are usually well preserved in archaeological deposits. Cyprinid bones, too, have fairly good chances of preservation. This is illustrated by the present material which not only contains huge numbers of cyprinid bones but also a large number of different kinds of bones from the entire skeleton (Table 2), in spite of their small size.

	Rutilus	*Scardinius*
Basioccipitale	14	
Os pharyngeum inferius	275	1
Detached pharyngeal teeth		5
	289	6

Table 3. Cyprinid bones from the trench, identified to species.

	Gadus	*Pollachius virens*	*Pollachius* sp.
Parasphenoideum	2	2	
Vomer	2	1	
Basioccipitale	1		3
Otolithi	1		5
Praemaxillare	3	1	
Maxillare	1		5
Dentale	1	1	
Articulare	1	6	3
Quadratum	1		9
Palatinum		3	2
Ectopterygoideum	1		
Symplecticum		3	
Hyomandibulare	1	13	
Keratohyale		1	4
Urohyale		1	
Posttemporale	3	2	24
Supracleithrale	1		
Postcleithrale		1	
Vertebrae	9	6	19
Total	28	41	74

Table 4. Gadid bones from the trench, identified to genus/species.

DISTRIBUTION OF FISH BONES IN TRENCH AND COLUMN

The finds of fish bones in the trench were plotted on a section drawing of the southern trench wall. The fish bones occurred throughout the shell midden zone, i.e., from square D and westwards. They were, however, missing from the parts of the midden, where traces of marine activity were present. Fish bones were distinctly concentrated in the middle layers, from where their concentration abruptly declined both upwards and downwards. This general pattern was well illustrated by the distribution of fish bones in the N-column, where a concentration in the samples N 13, N 14, and N 15 was evident, see Table 5.

As mentioned earlier, the fish bones partly occurred in small groups, in an ash layer with scattered fish bones, and in two pronounced fish layers. The layers were in squares H-K, M-N, and P, respectively, and were of the following approximate horizontal extents: 170 cm, 120 cm, and 80 cm, respectively.

Squares L to O (especially M and N) contained particularly large numbers of fish bones: about two thirds of the 9462 identified bones from the trench.

The species of fish were thoroughly mixed up throughout the trench. Freshwater and marine species occurred together in the same small groups through the entire section. That is, no separate occurrences of, or phases with bones from freshwater and marine fishes could be recognized. The individual species also occurred throughout the section, with the exception of *Belone* and *Gasterosteus*. *Belone* was absent from the eastern part of the trench: it was present from square M and westwards with the exception of one vertebra in square G. *Gasterosteus* had a strongly localized distribution in the trench: from the middle of square M, through square N, and a little into square O, except for four bones in square E. The N-column cut through this local occurrence of *Gasterosteus* and therefore was strongly dominated by this species.

SIZE OF THE FISH

The fish bone material from Ertebølle was characterized by the remains of small fish. Some was from small species of fish, e.g., *Gasterosteus* (and *Rutilus*), part was from small individuals of species which may grow large, e.g., pleuronectids and gadids. Most gadid bones were from individuals of less than 20 cm to 30 cm total length, with a few from fish of 40–50 cm. Some of the

Clupea bones were from juveniles of about 5 cm, while others were from full-grown individuals.

Only *Anguilla* (see below) and in particular *Belone* bones were from longer fish. All *Belone* bones represented individuals of about 70 cm or more.

These considerations of fish size are based on simple comparison of the subfossil bones with recent fish skeletons of various sizes.

Only *Anguilla* and *Rutilus* bones were so numerous that construction of size-frequency diagrams was warranted.

The size of the subfossil *Anguilla* and *Rutilus* was estimated by means of regression equations, based on recent materials covering the size range of the species in question. Logarithmic equations were computed which expressed total length of the fish as a function of bone measurements. Measurements of subfossil bones were then substituted in the equations, resulting in estimates of total length of the subfossil fish (cf. Casteel 1976, Enghoff 1983). The recent base material for the equations was partly found in the collection of the Zoological Museum, Copenhagen, partly collected for the purpose.

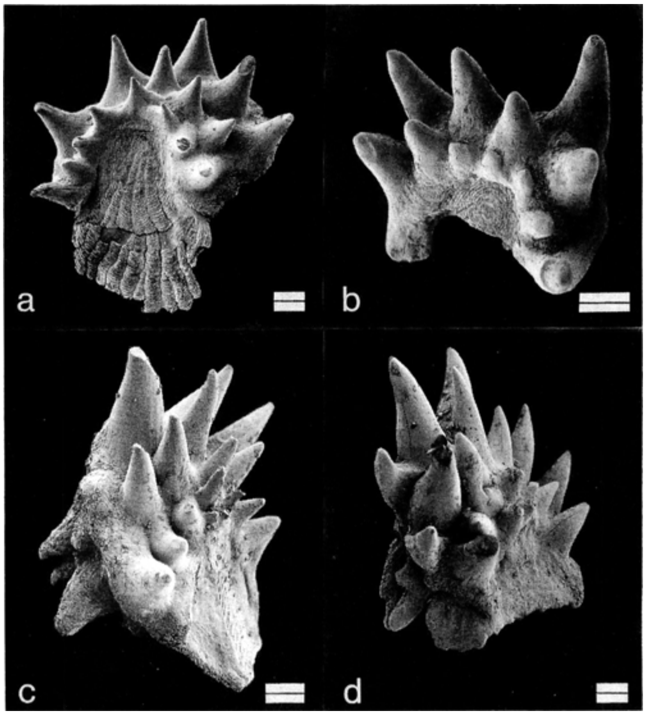

Fig. 3: Recent and subfossil dermal denticles from flounder (*Platichthys flesus*). – a,c: recent fish, b,d: Ertebølle material. Notice unmodified part of scales, especially prominent in a. – Scales 0.2 mm. Scanning electron micrographs.

Eel – *Anguilla anguilla*

Total length of *Anguilla* was estimated on the basis of four kinds of bone, viz., cleithrum, keratohyale, dentale, and first vertebra. It was not possible to find a single suitable bone (see Enghoff 1983, Höglund 1972) which was abundant in the subfossil material.

The bones were measured as follows:

Cleithrum: largest width at the elbow, as shown in Fig. 4.

Keratohyale: width as shown in Fig. 4.

Dentale: largest width in the front end, as shown in Fig. 4.

First vertebra: largest width of posterior face, according to Casteel (1976).

The measuring points were chosen on robust parts of the bones, known by experience to be mostly well preserved. The correlation between these measurements and total length of the fish was good. Measurements were taken with a slide caliper.

The relation between total length of *Anguilla* and the four abovementioned bone measurements is given by the following regression equations:

1. Equation for estimating total length in mm (TL) of *Anguilla* from width of cleithrum in mm (W_{cl}):
$$TL = 287.4749 \times W_{cl}^{0.7657} \ (r = 0.9904, n = 12)$$
2. Equation for estimating total length in mm (TL) of *Anguilla* from width of keratohyale in mm (W_{ke}):
$$TL = 345.2232 \times W_{ke}^{0.7460} \ (r = 0.9830, n = 14)$$
3. Equation for estimating total length in mm (TL) of *Anguilla* from width of dentale in mm (W_{de}):
$$TL = 279.2544 \times W_{de}^{0.8969} \ (r = 0.9720, n = 14)$$
4. Equation for estimating total length in mm (TL) of *Anguilla* from width of first vertebra in mm (W_{fv}):
$$TL = 225.2683 \times W_{fv}^{0.7832} \ (r = 0.9781, n = 14)$$

In all four equations the variables are highly correlated (r close to 1). All measurable bones of the four kinds in question were measured (none was burnt or deformed), and total length of the subfossil *Anguilla* was estimated according to the equations 1–4.

The resulting size-frequency diagram, Fig. 5, shows

Sample No.	Cyprinids	*Anguilla*	Gadids	*Perca*	*Belone*	Pleuronectids	*Clupea*	*Gasterosteus*	*Esox*	*Zoarces*	*Spinachia*	total identified bones per 2000 g
N-1, N-2, N-3 (superficial layers)												0
N-4												0
N-5	1											1
N-6	1											1
N-7												0
N-8	4	2		1				2				9
N-9	2	11						2		1	1	17
N-10	1	3	1			1				1		7
N-11	29	32		2		9		1		2		75
N-12	7	13						7				27
N-13	94	57	4	34		15	3	332	4	1		544
N-14	569	190	22	78	1	148	85	2608	10	28		3739
N-15	1329	238	7	129		63	7	368		17	5	2163
N-16	6	3								1		10
N-17	9	5		1								15
N-18	3				2					3		8
N-19	18	13	2		9	1	2					45
N-20		1										1
N-21	5	3	1				1					10
N-22	3	1	1									5
N-23	1	2										3
N-24												0
N-25		7										7
N-26		2										2
N-27	3	3								2		8

Table 5. Vertical distribution of identified fish bones in the N-column. Each sample consists of 2000 g of sediment, except N-4 (1450 g), N-12 (1340 g), and N-27 (1220 g). Of sample N-13, only 60% of the 0.5 mm fraction was analyzed; of samples N-14 and N-15, only 20%. Numbers of bones from these samples were converted to number per 2000 g.

that *Anguilla* in the Ertebølle material was fairly evenly distributed over the size range from ca. 30 to ca. 70 cm, with a few smaller and larger outliers.

Roach – *Rutilus rutilus*

Total length of *Rutilus* was estimated on the basis of first and second vertebrae. The vertebrae are robust, are easy to measure accurately, and were abundant in the subfossil material. The largest width of the posterior face of the vertebrae was measured, according to Casteel (1976). Owing to the small size of the vertebrae they were measured by means of an ocular micrometer.

The vertebrae, admittedly, were not identified to species, but as shown above, the cyprinid material at hand contained 98% *Rutilus* and 2% *Scardinius*. Thus a 2% contamination with *Scardinius* vertebrae may be expected among the *Rutilus* vertebrae; this can be regarded as negligible.

Furthermore, the cyprinids can be divided into two groups according to morphology of the second vertebrae (Le Gall 1984). All second vertebrae in the material belong to the group consisting of *Rutilus*, *Scardinius*, chub (*Leuciscus cephalus*), dace (*Leuciscus leuciscus*), and bleak (*Alburnus alburnus*); several possibilities of confusion are hereby eliminated.

The relation between total length of *Rutilus* and the vertebral widths is given by the following regression equations:

5. Equation for estimating total length in mm (TL) of *Rutilus* from width of first vertebra in mm (W_{fv}):

$$TL = 76.4364 \times W_{fv}^{0.8331} \ (r = 0.9961, n = 19)$$

6. Equation for estimating total length in mm (TL) of *Rutilus* from width of second vertebra in mm (W_{sv}):

$$TL = 77.7141 \times W_{sv}^{0.8900} \ (r = 0.9898, n = 18)$$

In both equations the variables are highly correlated. All measurable first and second *Rutilus* vertebrae were measured (none was burnt or deformed), and total length of the subfossil *Rutilus* was estimated according to equations 5–6.

The resulting size-frequency diagram, Fig. 6, turned out to be very interesting because the *Rutilus* individuals are grouped into clearly distinguished size classes. There is a great maximum at ca. 9 cm and a smaller one at ca. 13 cm. Indications of maxima at ca. 5 cm and ca. 16 cm are also evident. This size distribution is very similar to size distributions of *Rutilus* obtained by recent fishing over a short period in Danish lakes. A representative example of such a size-frequency diagram has been inserted on Fig. 6. The maximum representing the smallest size class is low in the "recent" diagram, like the 5 cm maximum on the Ertebølle diagram, because fish of this size are only rarely retained by the fishing tackle – otherwise this maximum would have been higher than the others. In the case of recent *Rutilus* each maximum is known to represent an age-group. The maxima on the Ertebølle diagram are therefore interpreted as age-groups as well.

The very pronounced division into age-groups of *Rutilus* from Ertebølle may be interpreted in two ways. Fishing may have taken place over a short period of the year, same period each year. If fishing had been extended over a long part of the growth season, the intervals between the maxima would have been filled up owing to the growth of the fish. The other possible interpretation is that fishing took place during winter, where the fish do literally not grow. (Fish are poikilothermic and their growth rate therefore depends on the temperature of the surrounding water: they grow during the summer half of the year, where the water is warm, but the growth almost ceases during winter, where the water is cold.)

The diagram, Fig. 6, is based on all measurable first and second vertebrae from the trench material. This implies that the size distribution pattern is characteristic of all of the phase of the settlement represented in the trench. The constancy of the pattern is supported by subdiagrams based on first and second vertebrae from larger, isolated groups of bones in the trench. These subdiagrams show exactly the same size distribution pattern, with the maxima at the same places.

The size frequency diagram cannot tell us at which time of the year the *Rutilus* were caught because the growth of *Rutilus* varies widely according to the environment. A growth ring analysis, on the other hand, might give an indication of the fishing season. Unfortunately, a growth ring analysis of the vertebrae which formed the basis of the size-frequency diagram was not practicable. Of *Rutilus* scales (which are regarded as generally well-suited for growth ring analysis (Cragg-Hine & Jones 1969)) only 7 fragments were found which were

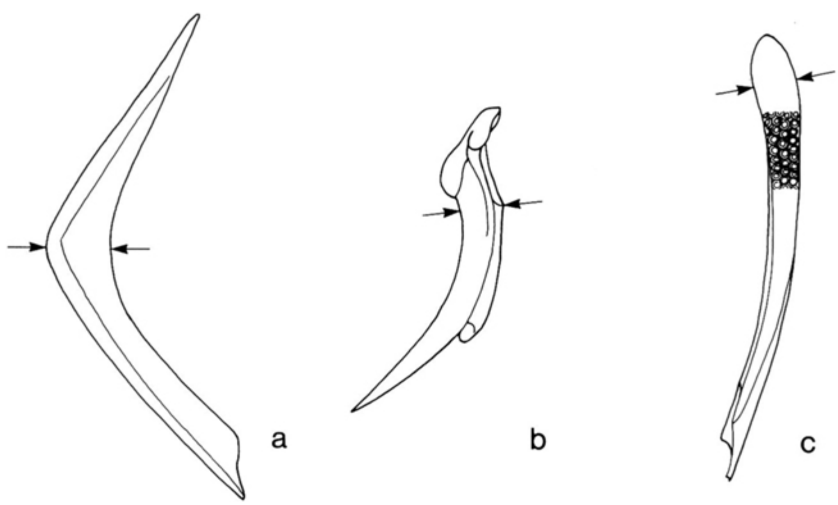

Fig. 4. Eel (*Anguilla anguilla*), definition of bone measurements. – a: right cleithrum, lateral view, largest width measured at the "elbow", b: right keratohyale, lateral view, c: right dentale, dorsal view, largest width measured in the front end (tooth sockets only shown on part of dentale).

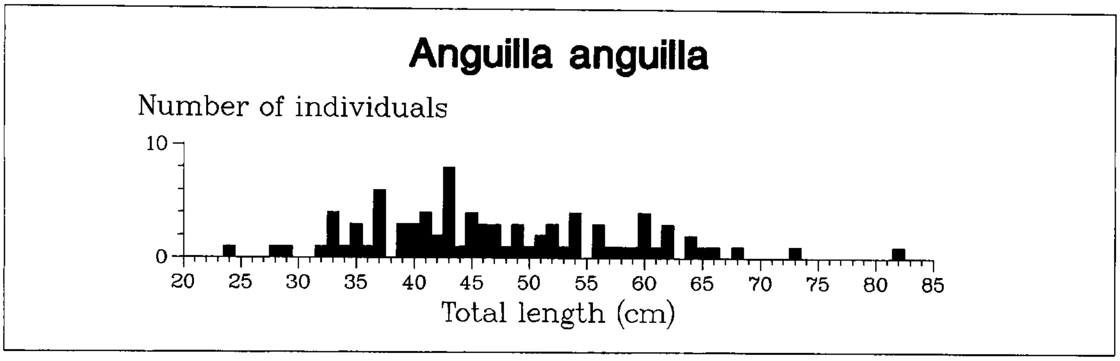

Fig. 5. Size-frequency diagram of eel (*Anguilla anguilla*) from Ertebølle. Total length estimated on the basis of measurements of cleithrum (N=32), keratohyale (N=28), dentale (N=15), and first vertebra (N=12).

sufficiently well preserved for analysis. These fragments, which all derived from one group of fish remains (from which no first and second vertebrae were recovered), were analyzed by Birgit Therkildsen and indicated capture through the period from spring to autumn, in conflict with the abovementioned interpretations of the size distribution.

DISCUSSION

The location of the Ertebølle settlement was convenient for exploitation of fish from both sea water, for example in the bay, and fresh water, for example in the two nearby lakes.

As far as the number of identified fish bones from Ertebølle is concerned, freshwater species dominate the assemblage, constituting 71% of the trench material. Marine species constitute only 12%, and migratory species, 17%. Many marine species were present in the material, but they were each represented by only few bones.

The relative frequencies of bones of different species provide an opportunity to estimate the fishing policy of the Ertebølle people. In spite of the reservations listed above (p. 67), the preponderance of freshwater fish bones is so overwhelming that it must be regarded as real. The fish species which were most important for the inhabitants of this settlement were mainly *Rutilus* (by virtue of its abundance) and *Anguilla* (by virtue of its size and high nutritive value). From the outset larger numbers of bones from marine species, especially gadids, were expected, considering the maritime situation of the settlement. The fish bone material from Maglemosegård, a roughly contemporaneous, coastal Danish settlement, thus included 2500 *Gadus* bones out of a total of 3000 (Aaris-Sørensen 1980). The Tybrind Vig material, also roughly contemporaneous with Ertebølle, was also dominated by bones of marine fishes, especially gadids (Trolle-Lassen 1984). The paucity of gadid bones in Ertebølle cannot be ascribed to poor chances of preservation (cf. p. 68).

The fish bone material forming the basis of Winge's results was excavated during 1893–97 and covers a large area of the Ertebølle shell midden (see Fig. 2). This material, which is in the Zoological Museum, Copenhagen, has been re-examined and shows the same tendency: dominance of freshwater fishes, in particular *Rutilus* and *Anguilla*. Winge (in Madsen *et al.* 1900) also noticed this. The pattern indicated by the newly excavated material thus seems to be of general validity for the Ertebølle shell midden and not to be a local phenomenon in the trench area.

The fish bones recovered during the old excavation (1931) of the Bjørnsholm shell midden, situated a short way north of Ertebølle, represent *Esox*, *Scardinius*, and *Anguilla* only (Rosenlund 1976). This may be a hint that the fishing of freshwater fishes from a sea-coast settlement was not unique to Ertebølle but was perhaps characteristic of a larger area. The recent excavations at Bjørnsholm (by S.H. Andersen and E. Johansen) will hopefully throw light on this problem.

At Ertebølle, all species except *Gasterosteus* and *Belone* occurred throughout the part of the trench cutting through the midden, and freshwater and marine species occurred together in the same small groups of bones. Several of the species may also occur in brackish water, but there is no indication of a nearby brackish water area, and furthermore, it is difficult to imagine a body of water holding at the same time truly marine species like *Pollachius* and *Psetta* and pronounced freshwater species like, e.g., *Scardinius*. It must therefore be concluded that two different fisheries were conducted at the same time: one freshwater and the other marine. The freshwater species were probably caught in the vegetation zone in one or both of the nearby lakes. The range of marine species and their sizes indicate that they were caught in shallow water near the shore, probably in the small bay at which the settlement was situated. The migratory species, i.e., salmonids and *Anguilla*, may have been caught in either fresh or salt water. The size-frequency diagram over *Anguilla* is of no help here, as differences between size distributions in fresh and salt water are not assumed to exist (I. Boëtius, pers.comm.).

The range of species (i.a., the many *Anguilla*) and the general small size of the fish suggest that fishing took place with fish traps at shallow water. Using fish traps during summer near the coast of Skagerrak the author caught *Anguilla* (mostly small, minimum 28 cm), *Limanda* (17–23 cm), *Platichthys* (18–21 cm), *Gadus* (13–30 cm), *Pollachius virens* (21–28 cm), and *Zoarces* (22–30 cm).

Remains of fish traps have not been found at Ertebølle. However, a study of the unretouched blades from Ertebølle by Helle Juel Jensen indicated that they were used for splitting thin branches or osiers – these might very well have been used for the manufacturing of fish traps. Remains of fish traps and wattles are known from several other, contemporaneous settlements. The only fishing tools found at Ertebølle were 5 fishhooks (length 2.5–3.9 cm). They were, of course, also used for catching, e.g., *Perca*, *Esox*, *Salmo*, and gadids, to mention the most likely species from the list. All these species, however, may also be caught in traps.

Belone is a seasonal fish and must have been caught during the summer half of the year. The other marine species in the sizes concerned will also most easily have been caught within the summer half where they live near the coast.

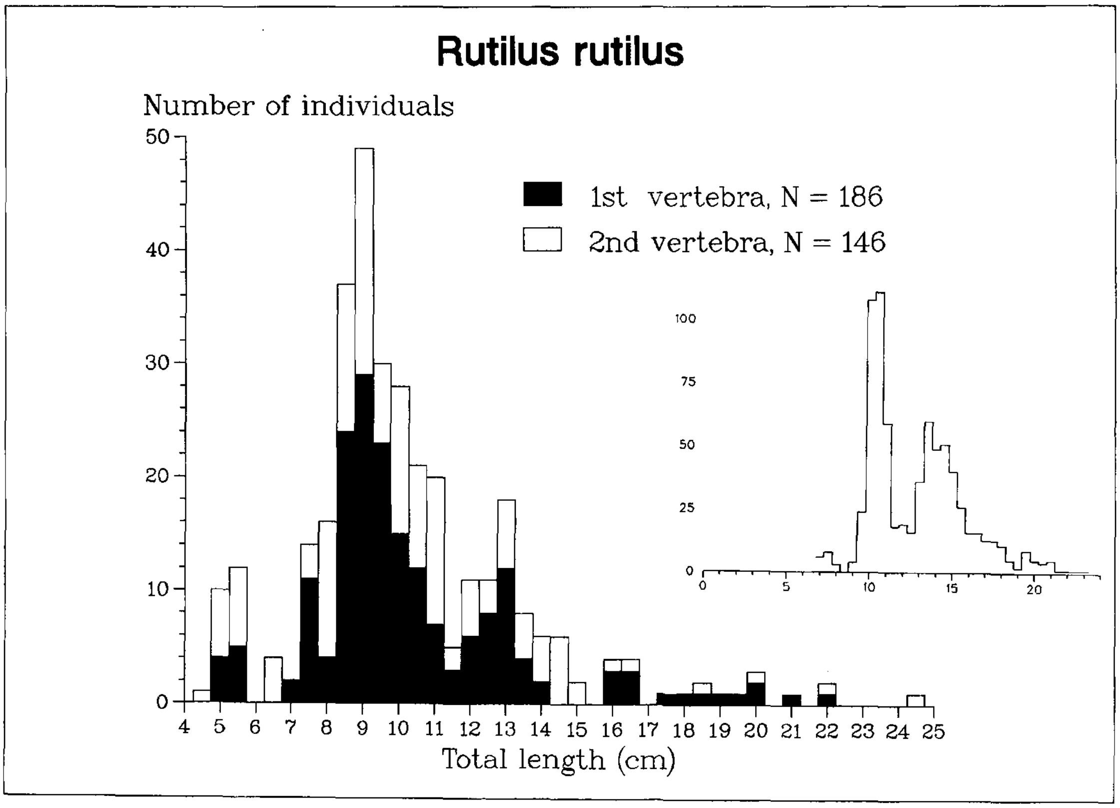

Fig. 6. Size-frequency diagram of roach (*Rutilus rutilus*) from Ertebølle. Total length estimated on the basis of measurements of first vertebra (black columns) and second vertebra (white columns). Inset: size-frequency diagram (total length) of recent *Rutilus* caught in a seine net during June 10–14 in Skjoldenæsholm Gårdsø, a Danish lake of 10.7 ha., depth 2–2.5 m (from an unpublished report by J. Dahl, 1969).

The clearly separated age-groups in the *Rutilus* size-frequency diagram, Fig. 6, supported by a similar pattern in subdiagrams (not shown) indicate that *Rutilus* was caught over quite a short period of time each year, or during wintertime (cf. the interpretation of *Pollachius* otoliths from the Oronsay shell middens (Mellars & Wilkinson 1980)). It is impressive that a size-frequency diagram with so nicely separated age-groups – not distinguishable from a diagram based on a recent, short-time investigation – can be obtained from a subfossil material (about 6000 years old). This indicates that the subfossil bones were well preserved, and that it was possible to measure them with a great degree of accuracy.

The results of the growth ring analysis are in conflict with the size-frequency diagram. With the reservations that follow from the small (7 scale fragments) and hence hardly representative material and from the sources of error inherent in growth ring analysis (Casteel 1976, see also Cragg-Hine & Jones 1969), the growth ring analysis indicates that *Rutilus* was caught throughout the summer half of the year. If the opposing results concerning *Rutilus* are weighted against each other, the numerically well-founded size-frequency diagram probably stil warrants the conclusion that the majority of *Rutilus* fishing took place during a short period of time each year – or during winter.

On the face of it, it appears peculiar that the Ertebølle people consequently conducted fishing after *Rutilus* during a particular, short period of the summer half year, where food of all kinds was abundant (the Atlantic period is considered to have been a very rich period in terms of food availability). But perhaps the short-time fishing each year was directed chiefly towards *Anguilla* rather than *Rutilus*. Very many *Anguilla* bones (1638, i.e., 17% of the trench material) were found, and *Anguilla* fishing is highly seasonal. In the autumn, when *Anguilla* migrates to the sea, there is a period with chances of great catches. In this case, *Rutilus* should be regarded as a secondary catch which was most probably exploited as well (see below). However, the possibility that the *Rutilus* size distribution reflects fishing during winter cannot be ruled out.

The fish bones were concentrated in the middle layers of the midden (Table 5). This could reflect a period of intense fishing, but there are other possible explanations: secondary diggings, present in the upper layers, may have caused oxidation of the bone material, and the low number of recovered bones from the lower layers may be in part caused by precipitation of manganese compounds and ochre obscuring bones. However, the N-column, which was sieved through a 0.5 mm mesh, showed the same low concentrations of fish bones in the lower layers. The conditions in the lower layers are further complicated by marine activity, which is particularly evident here.

The Ertebølle shell midden is characterized by small fish, *Belone* and *Anguilla* apart. It might be argued that the small fish, i.a., all the small *Rutilus* which constitute two thirds of the fish bone material, and the *Gasterosteus*, were too small to have served as food for the inhabitants.

In the "Material" section it was argued that the majority of fish bones in the midden could not have been washed ashore from the sea (and most of them were from freshwater fish which must have been caught inland). An explanation for their presence, especially in the small, delimited groups, which does not necessarily involve human activities, is that they represent gull pellets. Gull bones were numerous in the midden (Madsen *et al.* 1900). However, each delimited group of bones often contained remains from about ten species of both freshwater and marine fishes, whereas about ten recent gull pellets examined all contained remains from a single individual of fish only. This explanation is therefore little probable. It is also possible that the small fish were discarded as rubbish when fish traps were emptied for *Anguilla* or other species.

However, it appears far more plausible that also the small fish were eaten by the inhabitants. Today small fish are an important and constant source of food for many peoples all over the World. Furthermore, many of the graves (13 out of 85) in Skateholm, Scania (Sweden) (Jonsson 1986) contained fish remains which have partly been interpreted as preserved stomach-gut contents, and as food offerings consisting of a stew made from, i.a., *Anguilla*, *Rutilus*, *Scardinius*, and *Gasterosteus*. Many of the fish were small (up to 20 cm) individuals. *Gasterosteus* was numerous: one of the graves contained *Gasterosteus* bones representing more than 300 individuals. As in Ertebølle, the Skateholm material was characterized by the occurrence of several (up to 8) species of fish in each small group of bones. The vessels from Tybrind Vig, W Funen (Denmark) also should be considered. The food crust inside one of these vessels contained, among several other fish remains (presumably all from gadids), an opercular bone from a ca. 20 cm long *Gadus* (Andersen & Malmros 1984), that is, a gadid of similar size of most of those from Ertebølle.

In the light of the observations from Skateholm and Tybrind Vig it is considered that the Ertebølle people also ate small fish and that the groups of fish bones in some way represent remains from their meals. Winge (in Madsen *et al.* 1900) reported feces-like objects containing, i.a., bones from small fish. No objects suggesting such an interpretation were found in the present material, nor were any noted in the field during the excavation. (Fish bones may be found in excrements of both humans and dogs, although many bones are dissolved by digestive juices or destroyed mechanically during passage of the alimentary canal (Jones 1984)).

CONCLUDING REMARKS

Fishing at the Ertebølle settlement appears to have been conducted at two different places.

Surprisingly enough – we are dealing with the classical Ertebølle shell midden which was situated on the sea shore – the main fishing (represented by at least 71% of the bones from the trench) took place in fresh water, presumably in one or both of the nearby lakes. The numerically dominant species was *Rutilus*, which was caught during a short period of the year, same period each year, or during winter. The most reasonable explanation for this consequent behaviour may be that the freshwater fishing was done by means of fish traps set for migrating *Anguilla* in the autumn, with *Rutilus* as a secondary catch.

A less important fishing took place from the sea coast, presumably in the small bay, where the marine species were caught in shallow water, probably within the summer half of the year. Fish traps were probably the main tool for this fishing, too.

Presumably, both small and larger fish were eaten by the inhabitants of the settlement at Ertebølle.

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REFERENCES

ANDERSEN, S.H. & JOHANSEN, E. 1986: Ertebølle Revisited. *Journal of Danish Archaeology* Vol. 5.

ANDERSEN, S.H. & MALMROS, C. 1984: "Madskorpe" på Ertebøllekar fra Tybrind Vig. *Aarbøger for nordisk Oldkyndighed og Historie* 1984: 78–95.

CASTEEL, R.W. 1976: *Fish remains in archaeology and paleo-environmental studies*. Academic Press, London etc.

CRAGG-HINE, D. & JONES, J.W. 1969: The growth of dace *Leuciscus leuciscus* (L.), roach *Rutilus rutilus* (L.) and chub *Squalius cephalus* (L.) in Willow Brook, Northamptonshire. *Journal of Fish Biology* 1: 59–82.

ENGHOFF, I.B. 1983: Size distribution of cod (*Gadus morhua* L.) and whiting (*Merlangius merlangus* (L.)) (Pisces, Gadidae) from a Mesolithic settlement at Vedbæk, North Zealand, Denmark. *Videnskabelige Meddelelser fra dansk naturhistorisk Forening* 144: 83–97.

HÖGLUND, H. 1972: On the Bohuslän herring during the great herring fishery period in the eighteenth century. *Reports of the Institute of marine Research, Lysekil, Series Biology* 20: 1–86.

JONES, A.K.G. 1984: Some effects of the mammalian digestive system on fish bones. *C.N.R.S. Centre de Recherches Archéologiques, Notes et Monographies techniques* 16: 61–65.

JONSSON, L. 1986: Fish bones in late Mesolithic human graves at Skateholm, Scania, South Sweden. *B.A.R. International Series*. 294: 62–79.

LE GALL, O. 1984: L'exploitation de l'ichthyofaune par les paléolithiques. Quelques examples. C.N.R.S. *Centre de Recherches Archéologiques, Notes et Monographies techniques* 16: 89–112.

LEPIKSAAR, J. 1983: Djurrester från den tidigatlantiska boplatsen vid Segebro nära Malmö i Skåne (Sydsverige). *Malmöfynd* 4: 105–128.

LEPIKSAAR, J. & HEINRICH, D. 1977: Untersuchungen an Fischresten aus der frühmittelalterlichen Siedlung Haithabu. *Berichte über die Ausgrabungen in Haithabu* 10: 9–122.

MADSEN, A.P., MÜLLER, S., NEERGAARD, C., PETERSEN, C.G. JOH., ROSTRUP, E., STEENSTRUP, K.J.V. & WINGE, H. 1900: *Affaldsdynger fra stenalderen i Danmark.* C.A. Reitzel, København.

MELLARS, P.A. & WILKINSON, M.R. 1980: Fish otoliths as indicators of seasonality in prehistoric shell middens: the evidence from Oronsay (Inner Hebrides). *Proceedings of the Prehistoric Society* 46: 19–44.

MUUS, B.J. & DAHLSTRØM, P. 1964: *Havfisk og fiskeri i Nordvesteuropa.* G.E.C. Gad, København.

– & – 1967: *Europas ferskvandsfisk.* G.E.C. Gad, København.

PETERSEN, K.S. 1986: The Ertebølle 'køkkenmødding' and the Marine Development of the Limfjord with Special Regard to the Molluscan Fauna. *Journal of Danish Archaeology* Vol. 5.

ROSENLUND, K. 1976: *Catalogue of subfossil Danish vertebrates. Fishes.* Zoological Museum, University of Copenhagen.

TROLLE-LASSEN, T. 1984: A preliminary report on the archaeological and zoological evidence of fish exploitation from a submerged site in Mesolithic Denmark. *C.N.R.S. Centre de Recherches Archéologiques, Notes et Monographies techniques* 16: 133–143.

AARIS-SØRENSEN, K. 1980: Atlantic fish, reptile, and bird remains from the Mesolithic settlement at Vedbæk, North Zealand. *Videnskabelige Meddelelser fra dansk naturhistorisk Forening* 142: 139–149.