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Evidence for a Natural Deposition of Fish in the Middle Neolithic Site, Kainsbakke, East Jutland

by JANE RICHTER

INTRODUCTION

In evaluating the food economy on a site, it is necessary to distinguish between two types of thanatocoenoses resulting from natural deposition and deposition made by man. This is especially so when fish bones constitute a major part of the material.

Fish as part of the diet at Danish prehistoric sites is well documented (e.g. Rosenlund 1976; Aaris-Sørensen 1980; Noe-Nygaard 1983; Enghoff 1983). Carbon-13 investigations have increased the comprehension of the importance of marine food in relation to terrestrial food items (Tauber 1981).

If not elevated, the Danish kitchen middens and other refuse layers at the coastal settlements have been exposed to inundation caused by tide and storm with a resulting deposition of sediment and various organic material. This organic material, including zoological remains, is often incorporated in the discharge from the site and might cause misinterpretations of the bone assemblage, particularly if the deposition is caused by a short term flooding with only minor deposition of sediment.

The dimensions of the fish fauna, by measuring the vertebrae, and the gastropod fauna have been studied. A combination of these factors together with an investigation of the fish bone collagen might be useful when an attempt is made to separate fish bone assemblages of possibly mixed origin, partly caused by human activity and partly by a natural deposition.

The submergence of the middle Neolithic site, Kainsbakke by the Subboreal transgression is indicated by the population structure of the fish bone accumulations. Independent investigations of the gastropod fauna show alternating terrestrial and marine assemblages. The sediment covering the site after or contemporary with the termination of human occupation are clearly dominated by a marine snail fauna thus confirming the conclusion reached by the fish investigations.

Experiments with heated and non heated fish bone collagen lead to the conclusion that the structure of the collagen fibers changed at temperatures above 60°C. These observations were applied to the subfossil bone material and indicated that part of the fish bone material had not been subjected to any heating and a natural way of deposition was thus more likely.

THE KAINSBAKKE SITE

The excavation of the Kainsbakke site took place 1980–1982. Kainsbakke is situated on the north-eastern part of Djursland, close to Skærvad Å, Ginnerup sogn, Djurs Nørre-Herred, Jylland. The settlement was originally located on a small island (Rasmussen and Boas 1982). The bone material was refuse from the settlement, which had been thrown into pits. The one dealt with here is A47. It is placed at the 7 m contour. Beach deposits were observed at about 4,5 m (Rasmussen 1984). Radiocarbon dating of bone material from A47 have been obtained. Bone of aurochs (K4465) is dated 4030 ± 80 before 1950 (Rasmussen, in press).

The pit is $4 \times 5 \times 1$ m^3, only half of which has been excavated. The concentration of finds is enormous. Apart from the archaeological material, consisting of flint and ceramics, the pit contained bones and mollusk. An estimated number of mammal bones is 10.000 and of fish bones at least 50.000. The bones cannot have been exposed for very long, since they bear little sign of physical destruction and weathering. The mammals i Kainsbakke are partly game and partly domesticated animals.

		x 2148	x 2243	x 2279	x 2393	x 2846
MARINE/BRACKISH						
Littorina obtusata L.	Littoral zone. Fucus	3	–	1	1	1
Littorina littorea L.	Littoral zone. Stones, sand, mud flats etc.	29	–	11	3	7
Littorina saxatilis Olivi	Littoral zone. Shallow brackish water	5	–	1	7	2
Hydrobia ulvae Pennant	Littoral zone. Shallow mud flats.	25	28	1	20	3
Cingula semicostata Montagu	Hard bottom or shell gravel	1	–	–	–	–
Rissoa sp.		1	–	–	–	–
Bittium reticulatum da Costa	Muddy sand slopes under Zostera	221	108	10	45	1
Nassarius reticulatus L.	Muddy sand. Zostera	16	2	4	–	11
Odostomia sp.		–	5	–	–	–
Indet.		3	–	–	–	–
		304	144	28	76	25

		x 2148	x 2243	x 2279	x 2393	x 2846
TERRESTRIAL						
Cochlicopa lubrica Müller	Moderately damp places.	4	30	1	33	–
Vertigo alpestris Alder	Moderately dry places. e.g. open woods	–	–	–	8	–
Pupilla muscorum L.	Dry calcareous places	1	34	–	135	–
Sphyradium edentulum Charpentier	Damp shady places	–	8	–	–	–
Vallonia costata Müller	Exposed calcareous places	16	206	–	916	1
Vallonia excentrica Sterki	Open calcareous places	1	–	–	–	–
Clausilia sp.		–	3	–	24	3
Clausilia parvula Studer	Damp calcareous places	–	–	–	6	–
Retinella nitidula Drapernaud	Damp places	30	298	7	216	19
Hyalinia sp.		–	–	–	–	8
Hyalinia alliaria Miller	Unsheltered places	–	8	–	–	–
Hyalinia nitidula Drapernaud	Moist places, e.g. rubbish heaps.	–	1	–	–	–
Euconulus fulvus Müller	Woodland, marshes etc.	–	4	–	91	–
Indet.		–	92	–	97	–
		52	689	8	1526	31

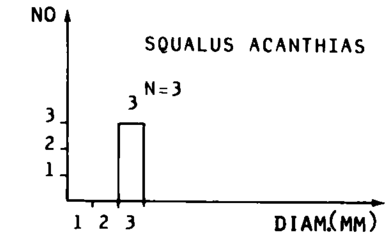
Table 1. Census of gastropods from five samples. The preferred habitat of each sample is recorded. Marine and terrestrial species are differentiated. – Data from Rasmussen (1973), McMillan (1968) and Thiele (1931).

MATERIAL

The fish bones have primarily been retrieved through sieving soil samples with 1 mm meshes. Although this contributed with tiny bone elements and fragments, it did not add to the number of species found through sieving samples to 3 mm.

The preliminary results presented are based on app. 12% of the material. Only vertebrae have been examined, as these are the best preserved skeletal elements. The cranial elements are generally broken into small pieces, obviously due to post-depositional compactional destruction. This also seems to be the cause of the deformation of the vertebrae of the mackerel, Scomber scombrus. The remaining vertebrae are, however, in an excellent state of preservation.

6048 fish vertebrae have been examined, 5416 of which could be determined. Twelve species are represented: spurdog *Squalus acanthias L.*, herring *Clupea harengus L.*, trout *Salmo trutta L.*, common eel *Anguilla anguilla L.*, garfish *Belone belone L.*, cod *Gadus morhua L.*, whiting *Merlangius merlangus L.*, horse mackerel *Trachu-*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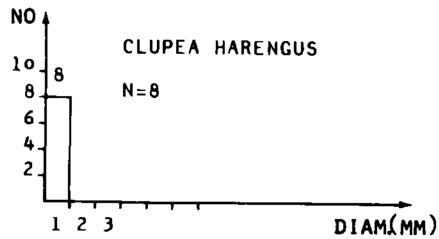
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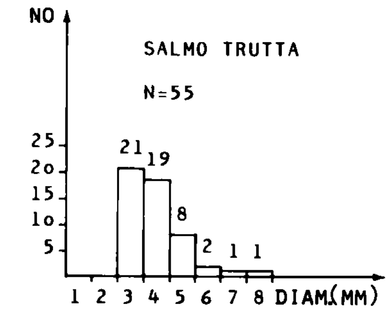
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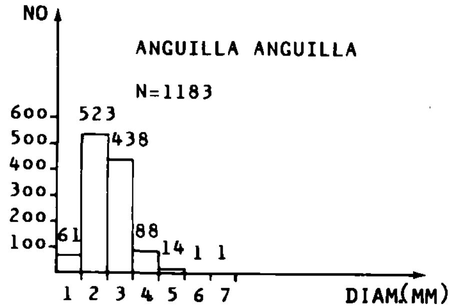
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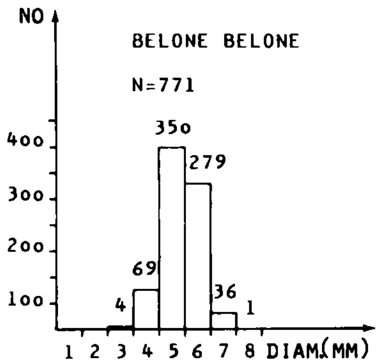
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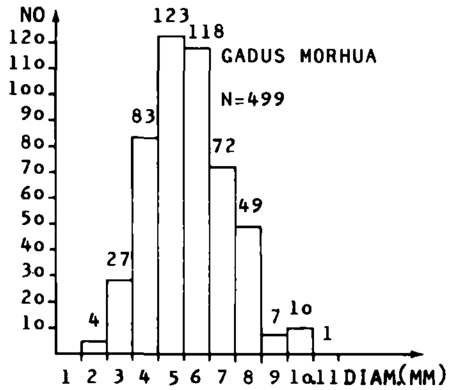
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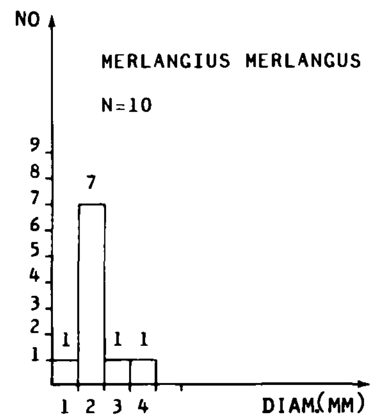
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1 2 3 4
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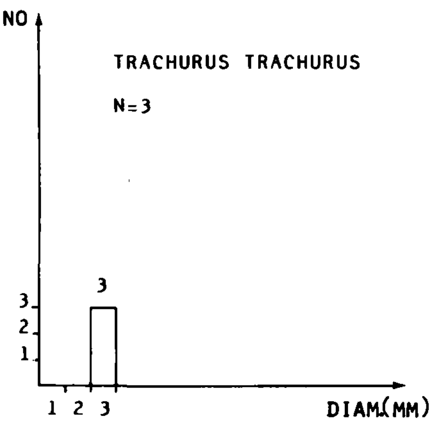
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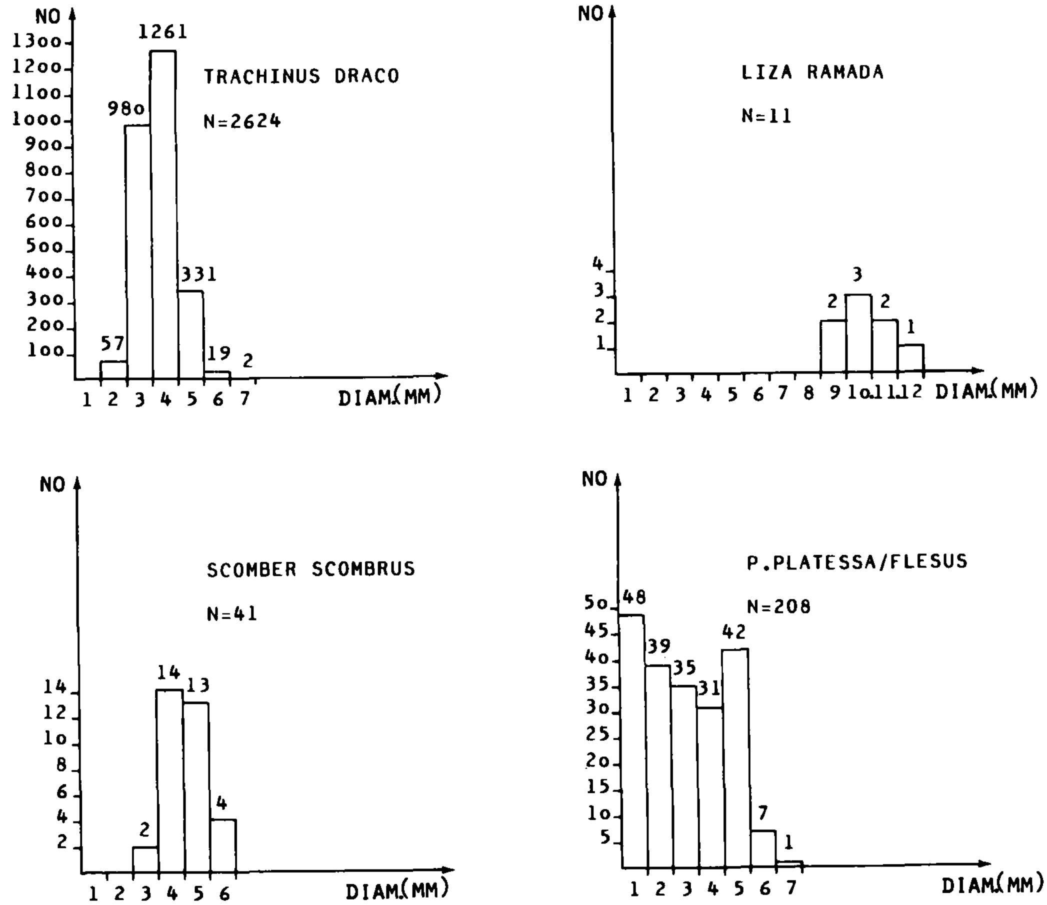

Fig. 1. Size distribution and number of vertebrae of the represented fish species in Kainsbakke.

rus trachurus L., greater weever *Trachinus draco L.*, thinlipped mullet *Liza ramada Risso*, mackerel *Scomber scombrus L.* and plaice/flounder *P. platessa/flesus*. Fig. 1 shows the distribution of the fish vertebrae of the various species. – Traces of burning could be seen on 32 vertebrae.

The vertebrae of thinlipped mullet seem to have belonged to one individual. There are only three other Danish finds of this species: Vejleby (Ertebølle ?), Ordrup Næs (Ertebølle) and Kolind (Ertebølle) (Rosenlund, pers. comm. 1984).

The greatest medio-lateral breadth of the centrum on the anterior articular face of all vertebrae have been measured according to Morales and Rosenlund (1979).

It must be emphasized that the investigated vertebrae derive from all parts of the vertebral column. The terminal part is, however, scarcely represented.

This midden contains thousands of mollusk, bivalves and gastropods. The bivalve fauna is dominated by oysters *Ostrea edulis L.*, mussels *Mytilus edulis L.*, and cockels *Cerastoderma edulis L.*

Eleven samples of gastopods have been studied. Each sample represents ¼ m^2. Table 1 is a systematic listing of the species found and summarizes their biotopes.

DISCUSSION

The majority of the fish bones derives from human activity. At the time of occupation Kainsbakke was a coastal site having access to brackish and marine areas. Therefore marine food constituted part of the diet. Carbon-13 values, however, confirms that Kainsbakke was a typical Neolithic coastal site, based on a mixed food source, consisting of hunting – fishing – gathering and agricultural food. In fact, it is estimated that the

Fig. 2. Electron micrograph of a collagen fiber of x3076-I, vertebra of plaice/flounder. Note the native state of the collagen. Contrasted. App. x17000.

terrestrial food constituted around 50% of the diet (Noe-Nygaard, in prep.). In Kainsbakke the marine portion not only consists of fish but also bivalves and seals. Thus fish contributed to the food, but was not the major food item.

In Kainsbakke several different fishing techniques must have been applied in order to catch surface swimming pelagic fish such as garfish and mackerel and demersal fish such as plaice and flounder. The greater weever, which according to the number of vertebrae is the most dominant species of the material, could, however, easily have been collected by hand. During summer they live in very shallow water, buried in the sand (Muus and Dahlstrøm 1968).

The total length of cod from Kainsbakke have been estimated on the basis of atlas widths according to Enghoff (1983). 15 cod atlas are represented and the estimated total length varies between 36 and 53 cm. This small size correspond to the dimensions of cod found at the Mesolithic settlements. Enghoff (1983) suggests that the cod were caught in traps, placed in shallow water during spring, perhaps summer, and autumn. Such traps could have been placed in the inlet to Kainsbakke or off the coast.

Eel and trout can be caught in freshwater, brackish and marine areas, all of which the Kainsbakke people had access to. The fish species found at Kainsbakke suggest fishing not far from the coast. Even spurdog, which is the most common Danish shark, can be caught in shallow water (Poulsen 1946).

The presence of garfish and mackerel indicate that fishing in any case took place during summer. Both are summer visitors. Today mackerel arrives in April or May and leaves in September or October, while garfish arrives in April and leaves in the autumn (Jensen 1946).

The entire collection of fish bones from archaeological excavations are normally interpreted as having been part of the feeding economy of a site. In some cases, however, the deposits may have a mixed origin. But it can be very difficult to separate a natural deposition from a deposition of human origin.

Size distribution. In Kainsbakke twelve species of fish have been recovered (fig. 1), all of which are eatable. The dimensions of the vertebrae are, however, remarkable, especially in the case of plaice/flounder, common eel, herring and whiting (fig. 1). The diameter of some of these vertebrae are as small as 1 and 2 mm. This bias could be the result of several taphonomic processes such as excavation technique, non-selective catch, fish offal or natural deposition.

The small individuals can hardly be meal remnants, as bones of this size are so soft they would be eaten along with the rest of the fish.

Histology. In order to evaluate whether this subfossil bone material has been subjected to heating (and are therefore possible meal remnants), morphological changes of collagen fibers of modern material of plaice have been studied after thermal and hydrothermal denaturation (Richter 1986). Intact vertebrae either scraped free of adhering tissue or with tissue still attached were subjected to thermal and hydrothermal denaturation. Not until after heating were the fibers isolated. The collagen of the untreated control bone material appeared as long fibrils with a normal band spacing. Thermal denaturation of the bone at 60°C caused melting of the collagen in local areas both at the

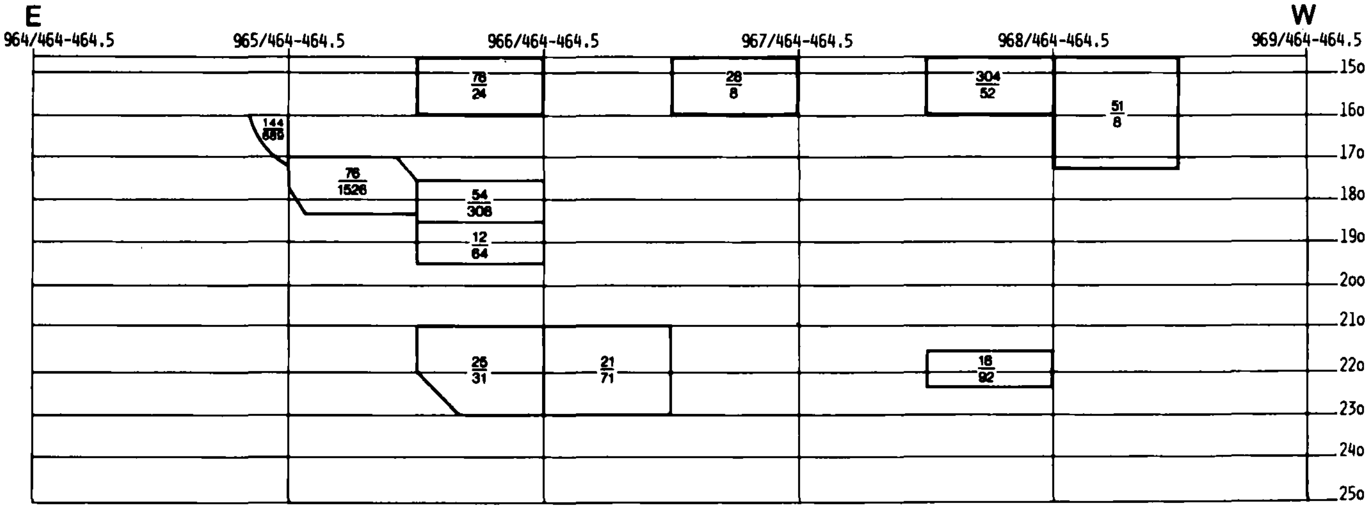

Fig. 3. The stratigrafic position of eleven gastropod samples from Kainsbakke. For each sample the number of marine gastropods (numerator) and terrestrial gastropods (denominator) is recorded. – Vertical scale in cm.

ends and along the fibril. The melted regions appear to be amorphous while the rest of the fibril resembled native collagen.

Melting progresses with higher temperature and a decreasing fraction of the fibrils is native collagen so that at 80°C only small fragments of collagen fibrils with melted (swollen) ends can be seen. Vertebrae heated to 100°C showed no signs of any fibers which could be identified as collagen, neither when it was heated with nor without tissue attached.

Seven subfossil vertebrae of plaice/flounder have been examined, none of which showed any superficial signs of heating of burning. Of the seven vertebrae six were small with a diameter of 1 mm (x3076-I, x3076-II, x3076-III, x3076-IV, x3073-I and x3073-II) and one had a diameter of 5 mm (x2148). In the case of x3076 and x3073 the collagen appeared as long fibrils with a normal band spacing and no melted areas (fig. 2). The collagen of these vertebrae is in an excellent condition. They have neither been subjected to heating in connection with meal preparation, nor have they been exposed to diagenetic factors such as high ion concentration, low acidity or microorganisms which might influence the morphology of the fibrils.

Examination of x2148 did not present anything which could be identified as collagen fibrils. This lack of identifiable collagen fibrils is not likely to have been caused by diagenetic factors as the primary cause. The excavated area is very limited ($4 \times 2{,}5 \times 1$ m^3) and homogeneous with no signs of local variation in preservation.

With x3076 and x2148 being found within app. 2 m of each other, the decomposition of the collagen was therefore most likely initiated before burial, possibly caused by heating in connection with meal preparations. The study of the collagen indicates that the very small fishes found at Kainsbakke were not meal remnants.

The gastropod fauna is represented by marine (or brackish) and terrestrial species. The gastropods preferred habitat is recorded (table 1) together with the stratigrafic position of the samples in the pit (fig. 3). All of the samples from the uppermost layer show dominance of marine species, while the remaining samples are dominated by terrestrial species (fig. 3).

Only *Littorina littorea* might have been collected for human consumption, being the only eatable gastropod present. The accumulation of the remaining marine species could hardly have been due to human activity as they are very small and thus have very little nutritional value, although they occur in great numbers. The small marine gastropods present in this shell accumulation are usually found in shallow water on a hard substratum (Rasmussen, 1973). The preferred habitat of the two most common species *Bittium reticulatum* and *Hydrobia ulvae* are similar. *B. reticulatum* lives on muddy sand under Zostera beds on slopes along the shore and *H. ulvae* prefers to live on the bottom of shallow mud flats (Rasmussen, 1973). This evidence would seem to

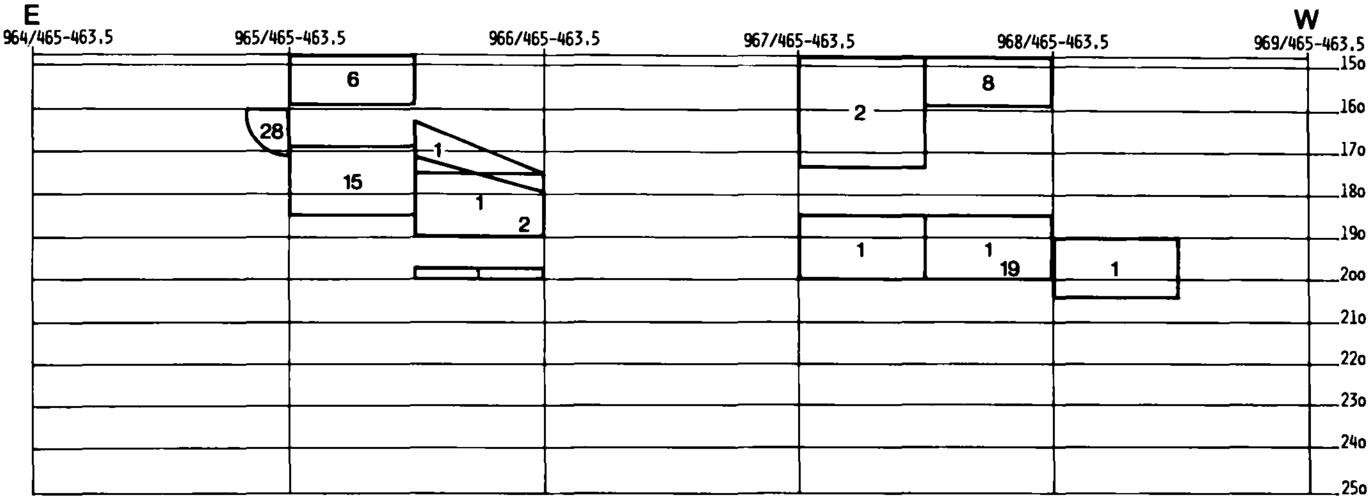

Fig. 4. The stratigrafic position of the small vertebrae of plaice/flounder. Number in each sample indicate number of vertebrae having a diameter of 1 mm (middle) and 2 mm (right). – Vertical scale in cm.

contradict the suggestion put forward by Petersen (1980) that small marine snails were introduced to sites attached to the byssal threads of mussels. The presence of the small snails is much better explained, however, by inundation of the site when they could have invaded the area and some empty shells might as well have accumulated.

Terrestrial gastropods are known to invade middens (e.g. Petersen, 1980 and Jensen, 1981). The preferred habitat of the terrestrial fauna represented here is dry to moderately damp, often calcareous places (Kerney and Cameron, 1979).

A meticulous excavation technique was applied at Kainsbakke and all samples sieved to 1 mm. This has reduced collecting bias to a minimum.

The very small fish individuals and the marine gastropods on the site might be accounted for by an inundation of the area, whereby they could have been naturally deposited.

Non-selective catch associated with the use of a beach seine could be an alternative possibility for introduction of the small fish and marine gastropods to the site. However, if this was the case, the mesh size must have been unrealistically small and the whole net and its entire content must have been brought to the site instead of being sorted on the beach. This process would have caused considerable damage to the net.

The investigation of the collagen confirms that the small fishes were not meal remmants from heated dishes. However, fish can be dried, salted and smoked or even eaten raw. In any case, the dimensions of these vertebrae make it unlikely that they should not have been eaten along with the dish. If the vertebrae were in fact separated from the dish, it would seem even more unlikely that an effort would be made to transport vertebrae the size of one and two millimeters from the settlement to the dump. They could have been fish offal, sorted out because of size or as stomach content of larger individuals. Fish offal is, however, readily removed by animals e.g. gulls, dogs and foxes.

The dominance of marine gastropods in the uppermost layer and the presence of the small fish indicate a transgression of the area. The stratigraphic position of the small vertebrae of e.g. plaice/flounder is, however not as firmly based as the gastropods (fig. 4), although the majority has been found in the upper half of the pit. As the majority of these vertebrae are considerably smaller than the smallest gastropods present, *Bittium reticulatum* (fig. 5), and as the vertebral processes are damaged or lacking, they could easily have been transported through this extremely permeable shell accumulation. Bones of microvertebrates do possess a considerable potential for dispersal in moving water (Dodson, 1973) and in the present case even rainwater could have aided dispersal of the very small vertebrae.

At the time of occupation the IV. Littorina-transgression was at its maximum. The area could have been temporarily flooded in connection with a spring-tide combined with an easterly wind. The presence of the small fish and the marine gastropods in the uppermost layer is more logically explained as the result of a natural deposition, perhaps caused by a temporary flooding, rather than being brought to the site by man.

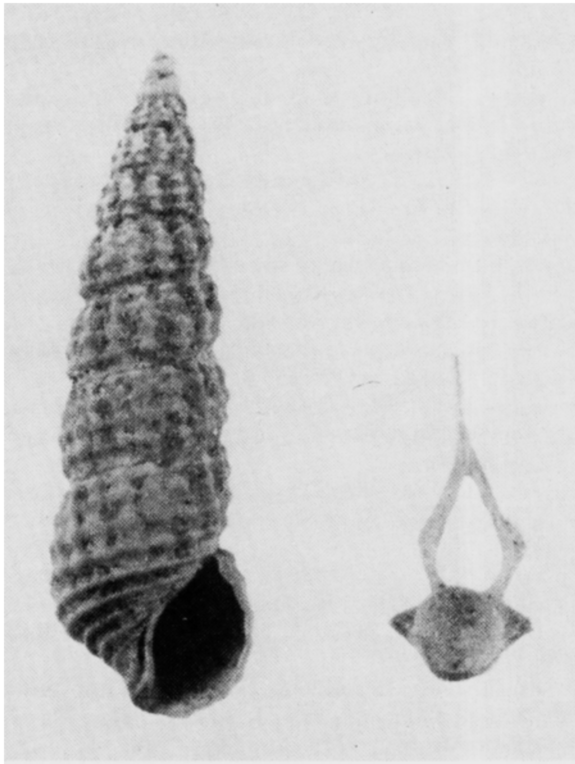

Fig. 5. Bittium reticulatum (left) and vertebra of plaice/flounder, diameter 1 mm (right). App. x9.

CONCLUSIONS

The fish bone assemblage includes vertebrae of very small individuals, which did not belong to the refuse of the settlement. Their deposition was contemporary with the termination of the human utilization of the midden.

The pattern of the distribution of marine and terrestrial gastropods confirms this. In the uppermost layer of the shell pit the small marine gastropods outnumber the terrestrial, unlike the rest of the shell accumulation, which is dominated by terrestrial gastropods.

Analysis of the bone collagen demonstrates that the small fish have not been heated, confirming that they are not meal remnants.

It is thus suggested that a temporary flooding of the site occured associated with the maximum of the IV. Littorina-transgression and that the small fish and marine gastropods could have been deposited naturally at this occasion.

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