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On the fringe of Neolithic Europe:

excavation of a chambered cairn on the Holm of Papa Westray, Orkney

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Part II

REPORTS ON ARTEFACTS AND HUMAN AND FAUNAL REMAINS

INTRODUCTION

The main reports on the pottery, human bones and animal bones were completed in the 1980s and 1990s (Audrey Henshall, David Williams, Mary Harman and Frances Lee). Additional work on the human and animal bones was undertaken after 2000 (Anne Tresset, Marie Balasse, Rick Schulting, Mike Richards and Carrie Wright), along with work on the bird bones, vole bones, fish bones, marine mollusca and radiocarbon dates (Christine Lefèvre, Thomas Cucchi, Ross Barnett, J Searle, Keith Dobney, Jennifer Harland, Rachel Parks, Monika Malezska-Ritchie and Patrick Ashmore).

THE POTTERY

Audrey Henshall

During his brisk investigation of the outer three compartments of the chamber in 1854, Petrie recovered one 'small piece of a clay vessel' from a low level on the E side of compartment 3. A quantity of sherds belonging to at least six vessels was found during the 1980s excavations (illus 25).

More survives of pot no 1 than of the other vessels. The sherds were mostly in the chamber filling, some were in the upper floor deposit with a join between sherds from these two levels, and one rim sherd was in the primary floor deposit. Sherds which almost certainly all belong to no 2 came from all three levels.

There was relatively little pottery from the primary floor level: besides the sherd of no 1, there were only two sherds of no 3, some thick sherds no 6a probably from a rounded base, and rather surprisingly no 7 from the angle of a flat-based pot. In terms of quantity there were roughly equal amounts from the upper floor deposit and the chamber filling, but the latter consisted largely of no 1 with a few small sherds of no 2, six sherds of no 3 and the single sherd no 5. Thus, with the exception of no 1, most of the pottery was in the upper floor deposit. It also appears that there was only limited horizontal scattering (illus 11c). Almost all the pottery came from the E sides of compartments 2 and 3, the exceptions being two sherds of no 1 in the E side of compartment 1, one sherd of no 3 in the W side of compartment 2, and three sherds (nos 5, 6b and unlisted) from compartment 4. The only sherd in the filling of the cell was small and undiagnostic (not listed in the catalogue).

Plain pottery

The pottery from the chamber is all undecorated. The fabrics are buff-pink-brown and extensively scorched with only a few sherds remaining dark grey-black. The fabric of nos 1 and 2 is quite hard with a considerable amount of shell temper which shows on the surface. The thick damaged sherds no 6a are probably from near the base of a large bowl, possibly no 1 or no 2. The fabric of nos 3 and 4 has a sandy texture and includes sparse but quite large pieces of shell.

The sherds are small, most are worn, and some are friable due to burning. Only the profile of no 1 can be reconstructed, and even the angles of the rims of nos 2, 3 and 4 are uncertain. The assemblage is inadequate for an extended discussion, but it is not typical of the Unstan Ware which has been recovered from most of the excavated Orkney–Cromarty-type chambered cairns in Orkney, in particular lacking sherds from the distinctive Unstan Ware bowls (Davidson & Henshall 1987, 64–5; Henshall 1963, 106–9). Pot no 1 is a simple open bowl with a rounded internally bevelled rim. It is difficult to parallel closely amongst the large number of uncarinated bowls from Orcadian tombs, for these bowls are mainly of deep proportions (though admittedly many bowls are too fragmentary for reconstruction) and the rim sections are usually square or sharply bevelled. The few shallower bowls generally have expanded rims, and none is of the graceful shape of no 1. The small sherds of no 3 include some from the gently bevelled rim, and the form seems to have been a somewhat open bowl. The expanded flanged rim of no 2 is unusual in Orkney, known on one bowl in each of the small tripartite chambers, Bigland Round (ORK 2), Knowe of Craie (ORK 27) and Sandhill Smithy (ORK 47) and on several bowls in the stalled chamber at Point of Cott (MacSween 1997, 27–9). These bowls are decorated and of an open form. It may be noted that at none of these sites nor at Holm are there any Unstan-type bowls which are so characteristic of finds from Orcadian tripartite and stalled cairns.

It is unfortunate that so little survives of no 4 and that in poor condition. Some sherds suggest a bowl with a shallow collar and slight carination which has been emphasised by working up the clay on the outside, an unusual pot but perhaps somewhat like Midhowe pot no 5 (ORK 37). Other sherds suggest a simple uncarinated bowl similar to several from Taversoe Tuick (ORK 49) and from the domestic site, Knap of Howar (Henshall 1983b, 70–1).

The proximity of this last site raised the expectation that there might be ceramic links between it and the tomb (Ritchie 1983, 59). The considerable quantity of pottery from Knap of Howar belongs to the Unstan Ware tradition though it includes some unusual elements. On the limited evidence from the tomb the resemblance is not particularly close. At Knap of Howar open bowls are a very minor type (eg no 76), and there are no parallels for the rim forms of Holm of Papa Westray nos 1 and 2. Yet the occurrence of cordons at the former site, particularly pot no 31, might provide a parallel for no 4 at the latter site. The use of shell temper occurs at both sites but is in any case quite widely used by the makers of Unstan Ware and related pottery, producing the familiar 'corky' fabrics when the shell decays.

The form of pot no 1 from the tomb, the rim profile of no 2, and the lack of decoration on nos 1–4, suggest an early Neolithic ceramic tradition. Yet the features diagnostic of the Grimston-Lyles Hill tradition in NE Scotland, open carinated bowls and fluting of the surfaces, found in early contexts in Caithness, are still unknown in Orkney (Henshall 1983a, 19–31; 1984, 59–62).

Grooved Ware

A number of fragmentary sherds from several pots represent secondary activity round the tomb. One sherd in the group no 10a is immediately recognisable as Grooved Ware, having applied cordons probably forming triangles. The brown fabric is rather soft, fine and sandy in texture. These sherds came from the cairn material and outside the cairn, and sherds of similar fabric and including the angle of a flat base came from the passage filling. Sherd no 7, from the sharply defined basal angle of another small pot of similar but harder fabric, must also be classified as Grooved Ware, though found in the primary deposit in the chamber. Confusingly, the fabrics of nos 10 and 7 are similar to that of nos 3 and 4 except for the lack of shell temper found sparely in the latter. Two large pots, nos 8 and 9, made of heavily gritted friable fabric with a fine surface, are represented by a single sherd and two sherds respectively. The sherds bear lightly scored decoration. These appear also to be Grooved Ware and were found outside the cairn. A few coarse undecorated wall sherds from secondary contexts may also be included with the Grooved Ware. The activity indicated by this Grooved Ware pottery may well be linked with the building and use of the Maes Howe type cairn at the south end of the island.

Beaker pottery

Lastly, three sherds with impressed cardial decoration came from outside the rear of the cairn on the west and south, two of them joining and thus demonstrating the link between these two deposits (pot no 11). The decoration includes horizontal lines and multiple chevrons. The vertical section is concave, and the fabric is thick and heavily gritted with a fine outer surface. The sherds are almost certainly from the neck of a coarse beaker. Beaker pottery is scarce in Orkney, the only parallel for cardial decoration being sherds from a finer domestic beaker found in disturbed contexts outside the entrance to the chambered cairn at Howe (Ross 1994, 238–9). Elsewhere cardial decoration appears spasmodically at domestic beaker sites, for instance in the Outer Isles and Shetland (Simpson 1976, 222; Calder 1956, 382–3, 390). The technique probably has limited significance at coastal sites, shells providing ready-made substitutes for combs and thus imitating comb-impressed decoration.

Pottery catalogue (illus 25)

Trench references are in Roman numerals, and layers in the chamber are given following the Arabic number of the compartment, and E for east, W for west or axial for the centre of the compartment (eg 3E3). Small find number is indicated by SF followed by Arabic numeral.

1. Many sherds comprising about half of the rim and upper body of a bowl of rather variable profile, rim diameter about 240mm; also some detached sherds. A few sherds are dark grey fabric, but mostly they are scorched buff to pink and some have a chalky texture; conspicuous white (bone or shell) temper and small grits. The wall thickens from 5mm just below the rim to 12mm near the base.

   SF14/SF20/SF41/SF42/SF49, SF48, SF50 (3E1, 3E2, 3E3, 3E4), SF48 (1E3).

2. Two rim sherds, four fragments of rim edge and wall sherds; hard dark grey to buff fabric, tempered with grits and white ?shell, a black outer surface remaining on some sherds.

   SF34/SF46, SF35, SF29 (3E2), SF20 (3E3).

3. Nine rim sherds and wall sherds all probably from the same pot. Fairly hard fabric with sandy texture including sparse ?shell temper, buff with dark core.

   SF30/SF45, SF31, SF33, SF54, SF55, SF56, SF90, SF91 (2E2, 2E3, 2E5) and SF43 (2W3).

4a. A group of small greatly damaged sherds including three from the rim, one of which expands below for a cordon or shoulder, and a wall sherd with a cordon. Fabric similar to no 3 but the surfaces tending to split apart.

SF54 (2E3).

4b. Five small wall sherds, three of them from a shoulder, but retaining only one surface; scorched red. Probably the same pot as no 4a.

SF53 (2E3) (not illus).

4c. Three small wall sherds, hard thin dark grey fabric with fine surfaces, possibly the same pot as no 4a/b.

SF29 (3E3) (not illus).

5. Rim sherd lacking outer surface; dark grey fabric with quite large grits.

   SF17 (4 axial 1) (not illus).

6a. Five sherds, friable heavily tempered fabric up to 15mm thick, dark grey with scorched pink outer surface and protruding grits.

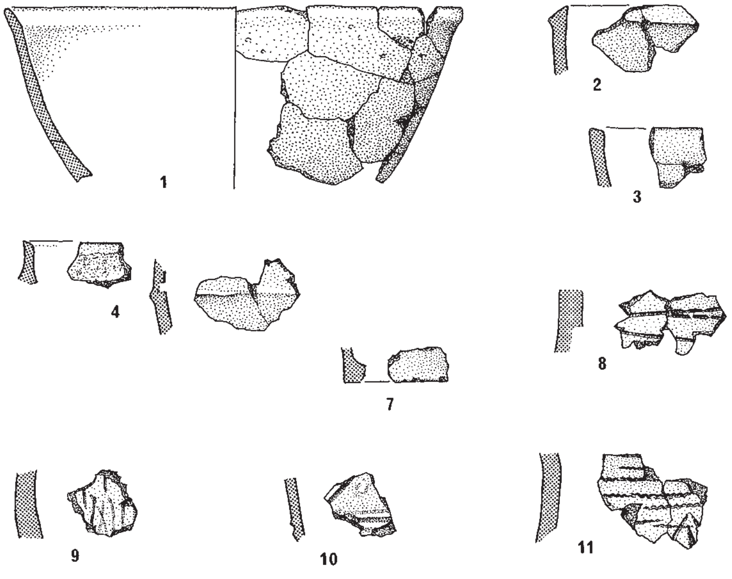
SF50 (3E4) (not illus).

6b. Wall sherd lacking inner surface, the outer surface curved as if adjacent to a shoulder or carination. Similar fabric but with smaller grits than no 6a.

SF16 (4SW2) (not illus).

7. Sherd from the basal angle of a small pot, diameter about 1000mm; fine hard sandy fabric, dark grey, buff outer surface.

   SF50 (3E4).



Illus 25
Pottery (scale 1:4)

8. Wall sherd, fine outer surface with lightly incised lines, friable fabric heavily tempered with large grits, the surfaces breaking apart.

   SF59 (IV.1).

9. Two wall sherds, fine outer surface with lightly incised lines; fabric similar to no 8 but with smaller grits.

   SF59 (IV.1).

10a. Group of small worn sherds, the largest with applied cordons probably forming triangles and

possibly with an applied pellet, another with a fragment of a cordon, and one sherd from the flat base; fine rather soft sandy brown fabric.
SF62, SF78, SF79, SF81 (VI.1, VI.2).

10b. Group of small sherds, one bearing a fragment of decoration, possibly from the same pot as no 10a, another from the basal angle.
SF74, SF86 (EP2, EP3) (not illus).

11. Three wall sherds, impressed cardial decoration; heavily tempered fairly hard dark fabric with fine buff outer surface.
SF71/SF5, SF60 (IV.1).

(Report submitted 1987.)

A NOTE ON THE PETROLOGY OF FOUR NEOLITHIC SHERDS

David F Williams

Three sherds from open bowls of early Neolithic type (nos 1, 2 and 3) and one Grooved Ware sherd (no 9) were submitted for a detailed fabric analysis in thin section under the petrological microscope. All the sherds were initially studied macroscopically with the aid of a binocular microscope (×20). Munsell colour charts were used for reference together with free descriptive terms. The island of Papa Westray is composed predominantly of Middle Old Red Sandstone formations: Rousay Flags and Fish-beds, with the Holm lying just off the east coast (Geological Survey 1" map of Scotland sheets 121 and 122).

Petrology and fabric

Pot no 1. Soft roughish fairly fine-textured fabric with pieces of white shell scattered in the paste, light red (between 2.5YR 6/6 and 6/4) throughout. Thin sectioning showed a groundmass of small subangular grains of quartz, with the average size below 0.20mm, flecks of mica, fragments of sandstone ranging up to 2.5mm across, a little iron ore and some pieces of shell.

Pot no 2. Softish sandy fabric containing small white pieces of shell when viewed in fresh fracture, light grey (5YR 5/1) surfaces, darker grey core with a thin lighter grey zone running through the centre. In thin section this sherd appeared to be a coarser version of the fabric of pot no 1.

Pot no 3. Soft roughish sandy fabric with occasional pieces of white shell, reddish-grey (5YR 5/2) outer surface and margin, buff (7YR 7/4) inner surface and margin, grey inner core. Thin sectioning showed frequent well-sorted subangular grains of quartz up to about 0.40mm in size, some with undulose extinction. Also present are flecks of mica, some quartzite, discrete grains of felspar and a little shell.

Pot no 9. Soft roughish sandy fabric with small inclusions of rock in the paste, greyish-buff (between 5YR 5/1 and 7YR 7/4) throughout. Thin sectioning showed a groundmass of frequent quartz grains, flecks of mica, some quartzite, clinopyroxene, large discrete grains of plagioclase feldspar and fragments of a lamprophyric-type rock. The latter is composed of porphyritic plagioclase felspars and olivines and can probably be defined as an olivine-basalt.

Discussion

The range of non-plastic inclusions present in the three samples from the open bowl forms consists principally of sandstone, shell and quartz, which can all be found to hand in the Holm or in Papa Westray, and there is no reason to suspect anything other than a local origin for the pottery. This view seems to be confirmed by comparing the fabrics from the tomb with those from Knap of Howar (Williams 1983). Almost the same range of non-plastic inclusions was encountered at the settlement site, with four fabric groupings consisting of shell/sandstone, sandstone, mudstone and quartz. A sample of local clay from Knap of Howar was found to contain crushed fresh shell, sandstone and frequent grains of quartz. A similar origin for the pottery recovered from both sites, or at least the use of similar raw materials, appears a distinct possibility.

The same cannot be said with respect to the Grooved Ware sherd from the tomb site. The fragments of lamprophyric-type rocks present in the paste of this vessel suggest a possible origin close to one of the basic dykes that occur in Orkney. However, none of these dykes is to be found in Holm of Papa Westray or in Papa Westray itself. The majority of these basic dykes in Orkney are situated in Mainland and Rousay and consist mainly of camptonite and monchiquite rocks (Mykura 1976, fig 25). Olivine-basalt dykes are fewer in number and appear to have a fairly restricted distribution. Mykura mentions outcrops in Mainland at Firth, near Finstown, and at the Loch of Harray (ibid, 99). There are also outcrops of olivine-basalt lavas in northwest Hoy and on the south coast of the island, and related rocks occur in Deerness and at Haco's Ness in Shapinsay (Kellock 1969).

Previous petrological work on Orcadian Neolithic Grooved Ware from Skara Brae, Rinyo, Quanterness and Stones of Stenness has shown that much of this pottery contains inclusions of basic dyke rock (Williams 1982). Most of the lamprophyric rocks present in this pottery can be classified as camptonite, with slightly less monchiquites and a few vessels which contain olivine-basalt. I have suggested that the majority of this pottery was probably made fairly close to the particular find-spots involved. However, this does not seem to have been the case with the Grooved Ware sherd no 9 from Holm of Papa Westray North, for the island is lacking in basic dykes. Moreover, the angular texture of the igneous rocks present in the sherd and the lack of variety of other types of inclusions seem to argue against an origin in the local drift. Taking all this into account, this vessel appears to have been an import to the site, though it is not possible at this stage to tie down the source with any precision.

(Report submitted 1987.)

CATALOGUE OF BONE AND STONE ARTEFACTS (ILLUS 26 & 27)

12 Point made from a sliver of sheep long bone, 59mm long, max 11mm wide. II.1, SF1 (illus 26)

13 Point made from a sliver of sheep long bone, 84mm long, max 14mm wide. IV.1, SF69 (illus 26)

14 Point made from a bird bone with articulate head, 44mm long, max 8mm wide. VI.1, SF39

15 Bead cut from a sheep long bone, 11–14mm in diameter, 11mm long, ends externally bevelled. 4NE1, SF19 (illus 26)

16 Cetacean ?tethering peg, 198mm long, 33–49mm in diameter, waisted, broken at both ends. II.4, SF61 (illus 27)

17 Flint scraper, buff colour, 30mm × 28mm, max 9mm thick. VI.1, SF76 (illus 26)

18 Flint scraper, cream colour, 20mm × 18mm, max 5mm thick. VI.1, SF77 (illus 26)

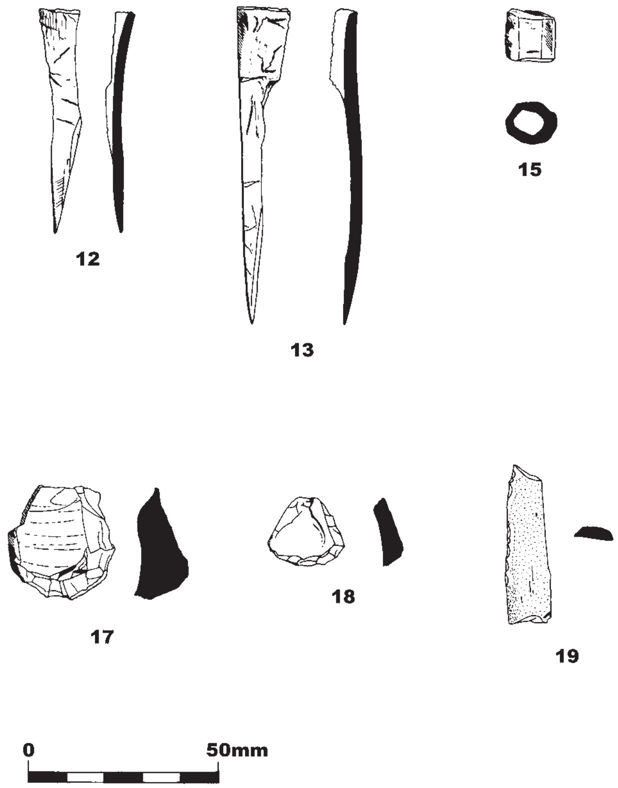
19 Flint flake with cortex and secondary working along one edge, dark grey colour, max 42mm long, 11mm wide, 3mm thick, broken at both ends. 4SW2, SF15 (illus 26)

20 Flint core retouched as scraper, slightly burnt, 25mm × 15mm. VI.1, SF25

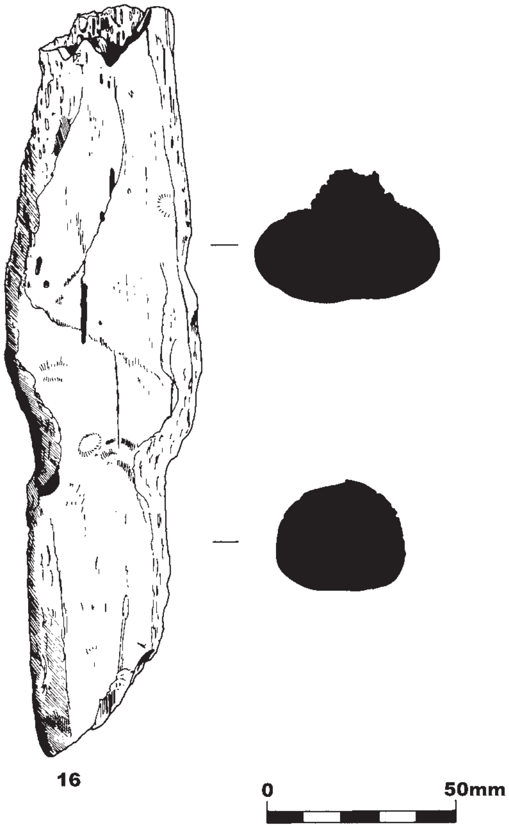
21 Quartz chip, heavily burnt, possibly a steeply flaked scraper, 25mm × 25mm × 20mm. 4 axial 1, SF13

22 Hammerstone, beach pebble with light wear at both ends, damaged, 200mm × 85mm × 64mm. II.1, SF6

23 Pebble flake, no secondary working, 80mm × 55mm, max 13mm thick. VI.2, SF83



Illus 26
Bone and stone artefacts



Illus 27
Cetacean object

24 Pebble flake, no secondary working, 98mm × 65mm, max 12mm thick. VI.2, SF84

25 Stone pot lid, roughly chipped edge, 175mm × 160mm, 11mm thick. IV.1, SF72

Five possible beads made from perforated fish vertebrae were recovered from 4NW4, 2W2, 5.1, II.1 and V.1.

Nine small unworked chips of cream, grey and brown flint were recovered from the following contexts: 1W1 (SF8); 3E2 (SF21); 3W3 (SF3); IV.1 (SF24; SF64; SF65; SF68); VI.1 (SF27; SF28). A single chip of unworked chert was recovered from VI.1 (SF22).

Eight small pieces of unaltered pumice were recovered from the following contexts:

> 4E1 (SF2, 2 pieces); 3W2 (SF4); 4E1 (SF12); 2W3 (SF38); 3E4 (SF50); V.1 (SF57); V.1 (SF58).

Two small nodules of unaltered ?haematite were recovered from the following contexts: 4NE1 (SF9); 4SW2 (SF18).

THE HUMAN AND ANIMAL BONES

Mary Harman

All the bones from the excavation were kept: all of the deposits within the tomb were sieved together with appropriate deposits outside and all the material from the coarse sieve (3mm mesh) has been scanned for removal of any identifiable fragments from the larger mammals and all bird bones. All of the bones are clean. Preservation is remarkably good, though many of the pieces are fragile and become very soft when damp. Some pieces are shattered and crumbly, especially some of those which were near the floor level, possibly a result of poorer drainage. The bones found in the tomb were bagged according to different layers distinguished in the entrance passage and compartment 5, and in the east and west sides of compartments 1 to 4. These were sorted initially into the different mammalian species (human, cattle, sheep, pig, horse, red deer, dog, otter and small rodents), and birds, amphibians and fish bones.

In addition to the bones collected from the 1982/3 excavations, a few bones survive from a 19th-century excavation carried out by George Petrie. In a brief report he describes finding large numbers of antler fragments together with several human skulls and other human bones, and bones of cattle, deer, sheep and pig, and some birds. Some of these he retained and deposited in the National Museum of Antiquities of Scotland (now the National Museum Scotland): a complete human skull, a human parietal and humerus head, a fragment of sheep's skull, a virtually complete skull from a young pig and mandible of another, a dog mandible and several antler fragments from red deer. The presence of human bones and antler fragments in Petrie's spoil demonstrates that he did not remove all the bones which he found; a few human bones were found on the surface of the cairn, suggesting that he did not backfill thoroughly, and it is impossible to tell how much may have been lost altogether.

The human bones

Methods of analysis

The human bones were laid out in the groups distinguished by trench, compartment and layer context, allowing comparison between the groups without mixing them. Most of the bones were from adults, but the size and texture of some pieces and the presence of unfused epiphyses showed that some were juvenile. It was probably easier to match juvenile bones than adult ones, and the number of matches and consequently the minimum number of individuals may be slightly biased in favour of juveniles. There was one deciduous tooth, and in some cases an approximate age could be assigned from the appearance of the teeth and from the lengths of largely complete diaphyses, based on information from Ferembach *et al* (1980, 517–49). Criteria from Ferembach *et al* were used in the few cases where the sex of adult skulls or pelves was decided: occasionally a particularly large and robust limb bone was tentatively identified as male, while a small and gracile bone was considered to be female, but the sex of these remains doubtful. Some of the jaws retained enough teeth for an assessment of adult age based on tooth wear, using the chart prepared by Miles from a series of Anglo-Saxon skeletons (1962, 881–6). A calculation of height was made from complete or virtually complete leg bones, using the formulae of Trotter and Gleser (Brothwell 1981, 101). A list of all the identified bones is in the excavation archive.

Number of individuals

The presence of pairs of bones, some of them in pieces scattered between several contexts and more than one compartment in the tomb, and of bones which appear to belong together (parts of a limb or hand) suggests that individuals are represented by parts of the body rather than by single bones. This presents a problem in trying to assess how many people were buried in the tomb. Since there are pairs and, probably, parts of limbs, the number of people is obviously not equivalent to the total number of human bone fragments or complete bones. Too many people are represented and the bones too few and fragmented to allow assembly of whole skeletons, and it is not possible to estimate closely the number of individuals. The minimum number of individuals present has been calculated from the bone that appears most frequently, with adjustments based on the number of pairs observed and differences in age.

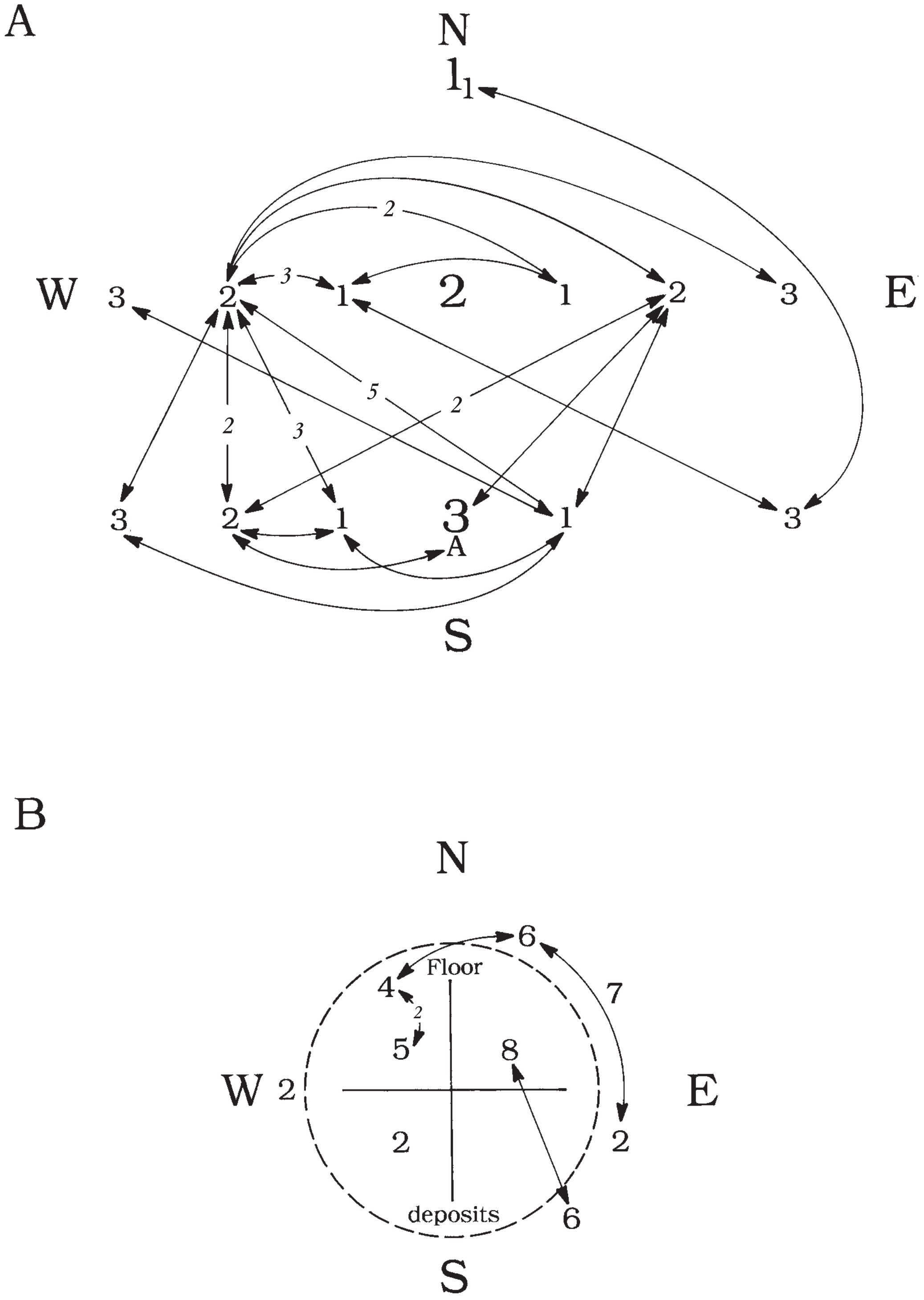
No pairs or joins were noted between compartments 5 and 4 and 3, 2 and 1, but within these three groups there were matches between sides of the compartment and contexts within them.

Very few bones were found in compartment 1, but in compartments 2 and 3 there were more and a number of joins and pairs in groups from different levels and sides of the compartments. One piece from a lower level in compartment 3 paired with a piece from the uppermost level in compartment 1, which is the greatest distance spatially and stratigraphically among the pairs and joins recognised but which is likely to represent displacement from compartment 3 during Petrie's activities. The number of matching bone fragments is shown in illus 28A; it was decided to treat all the bones from the first three compartments as a homogenous group. Compartment 4 had a complex stratigraphy but there are a few matches which suggest that the bones should be treated as a separate group. The joins and pairs observed are shown in illus 28B. In cell 5 joins between bones from contexts 2, 3 and probably 1 demonstrated that it was probably best to treat all the material as a single group.

There were a few bones from the entrance passage, and a few from trench V in the forecourt.

Compartments 1, 2 and 3

Most of the bones found in the first three compartments were in Petrie's spoil, and only in compartment 3 was there any quantity of undisturbed bone. In 3E3 there were parts of the left side of a skull, and a complete maxilla which may belong to it, and a fragment from the right side of the same skull was found in 1.1. There were also bones from a right hand and a right foot, as well as a few other odd bones and teeth. In 3W2 was a fragment of occipital which fits the skull in 3 axial 1, and a few fragments of a juvenile skeleton which probably belong together and to which the parts of legs found in 3W1 probably also belong. The rest of the deposits must really be considered as a single group as the number of joins and pairs indicates, though there is also a tendency for bones that belong together to occur together, most readily distinguished in juvenile remains. For example, the parts of a child's lower limbs already mentioned were mostly in 3W1 but also in 3E1, 2W2 and 3W2. In 3E1 was a pair of knees: the distal halves of both femora, a pair of patella and the proximal ends of left and right tibiae, which probably all belong together. A pair of tibiae, fragmented, was to be found in compartment 2, divided between E1 and W1 and W2. In 2W2 were groups of vertebral bodies from two children of slightly different ages, and a pair of child's shoulders. Thus although some fragments of the same bone or pair of bones were scattered, in other cases pieces which belong together were found in the same context, and it would appear that a lot of Petrie's spoil went back in close to its original location, though this depends upon the validity of certain assumptions about the deposition of the bones by the tomb users.



Illus 28
Numbers of joins and pairs between deposits in A, compartments 1, 2 and 3, and B, compartment 4. The smaller numbers indicate layer contexts and those in italic indicate the number of joins/pairs involved if more than one (© Mary Harman)

Table 7
Minimum number of human individuals

Glenoid fossa	*Sex*	*Age in years*
NMS ET 21 virtually complete skull	?female	30–35
3 axial 1 virtually complete skull	?male	15–20
2W, 2 L + R	?female	–
3E, 1 L = R 1 1	–	–
3E, 1 R	–	–
2E, 2 L ?= R 2W, 2	–	–
Maxilla	*Sex*	*Age in years*
2W, 1 L + R	?female	40+
3E, 3 L + R	–	30–35
2E, 1 L	–	30–35
2W, 2 L fragment	–	?adult
3E, 3 L + R upper molars	–	15-25

The minimum number of individuals is best estimated for adults from the number of skulls represented, and this is most easily based on the number of glenoid fossae and maxillae (Table 7). It is possible that the upper molars in 3E, 3 belong with the fragment of maxilla in 2W2. The separate maxillae could each belong with any pair of glenoid fossae. This gives a minimum of six, possibly seven, adults. A detailed listing of all the other bone elements (shoulder and pelvic girdles and individual limb bones), taking into consideration observed joins and pairs, produces no greater number but a consistent impression of five or six, possibly seven, adults as a minimum number represented. There are only a few instances where the sex of the individual can reasonably be suggested, but the ages based on the maxillae and teeth give two people aged between 15 and 25 years, three aged between 30 and 35 years, one aged more than 40 years and possibly one of unknown age.

Two bones, a tibia and a fibula, which are measurable, give heights of 1.65m and 1.63m if they are from men and 1.61m and 1.58m if they are from women.

The maxillae and mandibles show that dental health was good: of 76 teeth, both in the jaws and loose, one may have had gingival caries. Of 95 tooth sockets, four have abscesses: two in the mandibular fragment from an adult of unknown age in 3E1 and two in the maxillary fragment from a person of unknown age in 2W2. Of 97 tooth sockets, two had lost the teeth before death, the alveolus closing: these were the two second molars in the mandible in 3E1, belonging to a person aged more than 40 years.

Several vertebrae in 3E1 have minor osteophytes round the margins of the vertebral bodies, and the pair of knees in 3E1 also has very slight growth around the edges of the articular surfaces. Part of a right wrist in 3E3 is similarly affected, as is a first metacarpal and two first metatarsals.

There are the remains of at least two children, one aged between 12 and 14 years and another probably under 10 years. There are also some bones from a person of between 15 and 20 years which could belong with the skull listed above from 3 axial 1.

Compartment 4

Compartment 4 was not disturbed by Petrie and, although it may be coincidence, no joins or pairs were observed between pieces in 4 and those in the first three compartments. Some groups of bones were probably deposited as articulated parts of limbs: in 4SE6 there were the distal ends of a tibia and fibula, parts of a calcaneum, astragalus and scaphoid which were probably part of one right ankle; in 4NW4 and 4NW5, in which most of the other bones from this compartment were found, there were several joining fragments and at least one pair of bones. Apart from these, none of the bones can be said definitely to belong together, but there is a possibility that two left arms and a left leg are represented in this group, together with other bones, and thus they were from at least two people.

In compartment 4 there are the remains of at least three adults and one bone (in 4NW4) from a child of less than 13 years. The few teeth found loose in compartment 4 are mostly from persons of over 35 years. One tooth from 4SW2 is either a second molar from a younger person or a third molar from a person of almost any age, since wisdom teeth are often retarded and this tooth is barely worn. There are several vertebrae with signs of osteophytes. Two fragments of mandibles have all the teeth now missing, though they were present at death.

Cell 5

There were not many bones from cell 5, also undisturbed by Petrie, and there are no joining or pairing bones in any of the other parts of the tomb. The bones include a skull, probably female, and upper and lower jaws from different adults, several vertebrae, part of a pelvis (male) and some arm and leg bones, including two femora which belong to different adults. These bones could represent only two adults, one probably male and one female, and a single tooth remaining in the mandible shows that one was probably over 40 years of age. A nearly complete femur and a nearly complete tibia may be from female and male skeletons respectively, and, if so, they would have heights of about 1.5m and 1.65m. There were also four barely worn tooth crowns and one immature phalanx, possibly from one child aged probably between 10 and 13 years. The maxilla had all the teeth present at death except for the right first premolar which had been lost some time before, for the alveolus had closed. There were abscesses associated with the left and right first molars, and possibly with the left second incisor. The mandible, which does not belong with the maxilla, retained only the left third molar, and of the other teeth six were lost before death and abscesses were associated with the right first premolar and second left premolar. One lumbar vertebra had osteophytes on the body.

Entrance passage and forecourt

The few human bones from the entrance passage are almost all juvenile and could be from one child.

A further few juvenile fragments were found outside the entrance passage in the forecourt in trench V and could be from the same child, aged less than 13 years. There was also the skull of an adult, probably female, in a hole outside the entrance; all the teeth are missing, though only one was lost some time before death, and there is evidence of an abscess at the foot of the first upper molar.

The human bone assemblage as a whole

Petrie records the discovery in compartment 1 of part of a human skull, in compartment 2 parts of two skulls, in 3 three headless skeletons and three separate skulls. It is probably one of the latter that he gave to the Museum in Edinburgh. The other two might then be that with the left side remaining in 3E3, and the fragment in 3W2 to which belongs the skull in 3 axial 1, the latter of which has parts of the frontal and parietal missing in a manner that suggests that one of Petrie's diggers skimmed off a portion with the spade. Thus the number of skulls identified from the first three compartments is consistent with Petrie's account, though there may be parts of a seventh. Petrie does not mention the presence of juvenile bones, and it is possible that, since there is no skull or jaw from a child, he did not realise that there were immature human bones, despite the fact that some are so complete as to be readily recognisable as human but too small to be adult. He recognised ox, sheep and deer but failed to mention the dog mandible that was among the bones that he retained.

Although no joins were seen between the bones in the first three compartments and those in the fourth, there is no reason why they may not have been derived from the same skeletons, and similarly the bones in cell 5 may belong to skeletons in the main chamber. Some of the otter bones in cell 5 belong with bones in compartment 4 and probably compartment 3. Thus, although the numbers of people represented have been assessed separately for the three major groups of bones, for the tomb as a whole the minimum number of people represented is best estimated from all the human bones together.

In addition to those adults in compartments 1–3, there are another two skulls from cell 5 and the forecourt; the latter has the maxilla attached, and there is a second maxilla from cell 5. In compartment 4 and cell 5 there are three mandibles, two of which are incomplete. As there is some doubt about the pairing of two glenoid fossae in the first three compartments, all these skull parts give a minimum of eight or possibly nine adults or semi-adults, three of whom were probably male and one probably female. Similarly the maxillae, complete and fragmentary, indicate that there was one person aged between 15 and 20 years, three probably between 30 and 35 years, one probably over 30, one over 40, and two other adults. Loose teeth may belong to one of the latter or to a ninth person, and they give an age of between 25 and 35 years. There are also parts of at least six, possibly seven, mandibles, two from persons over 40 years. Evidence from the postcranial bones is consistent with a total of eight or nine adults. There are several postcranial bones from a person in late adolescence, which may belong with the skull of a person aged between 15 and 20 years, and there are other postcranial bones from a child aged 12–14 years and one of less than 10 years (but probably more than 5 years).

There are too few skulls or skull fragments to establish the incidence of any of the usual cranial variations, but it is worth recording that in two cases in which the lambdoid suture is present one skull has two wormian bones, but none is present in three sagittal sutures or in three coronal sutures. One loose wormian was found. There are no inca bones in four cases where it might have been observed, and in five frontals or parts of frontals the metopic suture is closed as usual. Two skulls have no orbital osteoporosis.

The young person in compartment 3 has no development of the upper left wisdom tooth, and it is possible that the one on the right side had not developed either. Five and a half other maxillae have all their wisdom teeth as do four mandibles. Total or asymmetrical lack of wisdom teeth in either jaw is not unusual. Dental heath was extremely good: of a total of 88 teeth, one may have had caries, of 149 tooth sockets nine showed evidence of abscesses, and of 159 socket sites the teeth are lost from ten (six of which are in one mandible).

Discussion

It would be unwise to speculate on the nature of the population from which these people came, but several points are worth noting. If it is reasonable to compare the rate of tooth wear of an Anglo-Saxon group in the English midlands with that of a Neolithic people in Orkney, some of the latter were living to forty years or more (Miles 1962). No very small children or infants were placed in the tomb, though there was probably a high mortality rate among infants and children under five. As there are bones from small lambs in the tomb deposits, it is probable that human infants are genuinely absent and have not simply decayed altogether.

Although Petrie's account suggests that he found skulls and substantially complete skeletons, this was not the case in the undisturbed areas of the tomb. There were four articulated limbs in compartment 4, and three parts of a hand and foot in compartment 3, showing that when the tomb was finally sealed there were some limbs or parts of limbs which had either not totally decomposed or not been disturbed after decay of flesh and ligaments. Most of the bones were however disarticulated, and in the compartments disturbed by Petrie some pieces of the same bones were found in different contexts. On the assumption that the lowest deposit should represent the last ancient location of the body part and the fragments in higher levels will represent Petrie displacement, it is possible to suggest that bones from 2W3 were displaced into 3E1, bones from 3W3 into 3E1, bones from 3 axial 3 into 2E2, bones from 2E3 into 2W2, 3E1 and 3W1. Most teeth had fallen out of the jaws after death, which implies that the skulls had been moved. None of the bones showed evidence of gnawing or chewing.

PATHOLOGICAL LESIONS AMONG THE HUMAN BONES

Frances Lee

There were very few pathological lesions recorded from the human skeletal material excavated. Pathological changes may lead to a reduction in the density of the bone making it more susceptible to weathering and physical damage. The ends of the bones, particularly the long bones, are particularly susceptible to damage, and this is the area where pathological lesions, particularly degenerative changes, are to be found. The disturbed and fragmentary nature of the assemblage also makes the patterning of pathological lesions problematic. As a result the lesions have simply been recorded where present. The only opportunity for looking at pathology at an individual level presents itself in burials A, B C & D. A synopsis of the pathology is contained in Table 8.

Dental pathology

Ante-mortem tooth loss was noted in three individuals and in one had occurred some time before death as the mandible was totally resorbed between the premolars and second permanent molar. Hypercementosis was recorded on three teeth from two individuals and maybe associated with non-functional teeth, which is definitely the case in one of the individuals (3E1/2W2). Enamel hypoplasia was present in three of the dentitions. Enamel hypoplasia may be due to a variety of causes including nutritional deprivation, which maybe secondary to parasitic infection, and systemic disease. Defects are visible macroscopically as lines or pits on the surface of the teeth and are considered an indicator of stress during early life.

Trauma

There is very little evidence for direct ante-mortem injury. The majority of injuries occurring in daily life would be in the form of cuts, bruising, muscle strains and tears, few of which will be visible on the skeleton. A single rib showed evidence for a recent fracture with new bone still being remodelled. A first metacarpal had a fracture to the proximal end of the shaft. A left ulna was found to have severe osteoarthritis to

Table 8
Pathology of the human bones

Pathology	*Bone*	*Comment*	*Age*	*Sex*	*Skeleton*
Trauma	1st M.carpal	Fracture to the proximal end	Adult	–	–
	Rib	Remodelling and new bone, result of recent fracture	–	–	–
Infection	Lumbar vertebra	Destructive infective process to vertebral body, non-specific infection	17–19 yrs	–	B
	Fibula	Periostitis to large area of the shaft	Adult	Male	D
Minor periosteal reaction	Fibula	Raising of periosteum to small area of shaft	17–19	–	B
	Tibia & fibula	Raising of periosteum and distal end & new bone to shaft of tibia	17–19	–	B
	L&R clavicle	Periosteal reaction lateral aspect of bone	17–19 yrs	–	B
	Tibia	Periosteal reaction at attachment of interosseal ligament	Adult	Male	D
	Tibia	Periosteal reaction at attachment of interosseal ligament	Adult	–	–
Spinal lesions					
Schmorl's Nodes	Lower thoracic	Superior surface	13–15 yrs	–	C
	Lumbar	Superior surface	17–19 yrs	–	B
Intervertebral Osteochondrosis	Cervical × 5		Adult	–	D
Osteoarthritis	Cervical	R artic surface (Grade 2–3)	Adult	–	A
Osteophytosis	Lumbar		adult	–	–
	Lumbar		adult	–	–
	Sacrum	o/phytes 1st sacral vertebrae	Adult	Female	–
Appendicular skeleton					
Osteoathritis	1St & 2nd M.tarsal	Enlarged facet & degenerative change between 1st & 2nd M. Tarsal	Adult	–	–
	Trapezium	Eburnation of artic surface with scaphoid	Adult	? Male	–
	Ulna	Eburnation & resorption of styloid process	Adult	–	–
	Navicular & Talus	Kissing lesion – not osteochondritis dissecans	Adult	–	E
	Mandible	Degenerative changes of the temoromandibular joint	Adult	–	–
Dislocation	Mandible	Extra facet &angle of joint incorrect. Probable recurrent dislocation	Adult	Male	–
Degenerative change	Innominate	Localised area of degeneration, sacroiliac joint	Adult	–	A

Table 8 (continued)
Pathology of the human bones

Pathology	*Bone*	*Comment*	*Age*	*Sex*	*Skeleton*
Degenerative change Osteophytosis (appendicular)	Scapula Femora Tibia Patellae Calcaneum Ribs 1st M.carpal	Lipping to artic surface	Adult	Male	–
Pathology unknown	R 1st M.tarsal.R Cuneiform	Punched out lesion – mirrored in opposite articular surface- ?? cyst	Adult	A	–
	1st Rib	Scalene Tubercle	–	–	–
	Prox 1st Phalanx	Lytic lesion on Xray – no visible swelling	Adult	–	–

the distal articular surface and an absent or damaged styloid process, which suggests that these changes were probably secondary to trauma.

Schmorl's Nodes were present in two vertebrae from immature skeletons B & C. Schmorl's nodes arise during adolescence and young adulthood and result from the protrusion of the disc into the adjacent vertebral body. Their frequency has been used to illustrate the degree to which manual labour was carried out in the past, based upon the suggestion by Schmorl and Junghanns (1971) that they are closely associated with strenuous activity. Unlike the degenerative conditions, Schmorl's Nodes do not appear to increase dramatically with age.

Acute trauma may also affect the soft tissue sometimes resulting in the raising of the periosteum and irregular ossification of bone at the site of the muscle or tendon attachments. A particularly common site for this is to the distal interosseous attachment of the tibia and fibula resulting from twist and strains to the ankle. At Holm of Papa Westray North this occurred in three tibiae.

Infection

Two lumbar vertebrae, from the same adult, exhibited evidence for a destructive infective process to the vertebral body. The cause of the infection is unknown.

Subperiosteal reactive new bone or periostitis is frequently seen in the archaeological record. It represents a non-specific reaction to inflammation or infection, which can be seen as a deposit of new bone on the surface of the bone. An adult male (skeleton D) had a large area of periostitis to the shaft of the fibula.

Degenerative joint disease

The degenerative diseases of the body reflect everyday wear and tear on the body, which are inseparable from a normal but vigorous life. Consequently these lesions appear to be closely associated with advancing age.

In the spine *Intervertebral osteochondrosis* was recorded in five cervical vertebrae (C2–6) all from the same individual (skeleton D). These lesions ranged from slight pitting or perforations of the vertebral body to destruction of the endplate with perforations and cyst formation. They are the result of pathological changes to the intervertebral disc and are found to increase in both frequency and severity with age. Also associated with degenerative change to the intervertebral disc is the presence of vertebral osteophytes, or projections of bone from the margins of the vertebral bodies which were noted in two adult lumbar vertebrae. The lower vertebrae are frequently involved, as this area corresponds with the maximum curvature of the spine where there is increased stress on the vertebrae.

Osteoarthrosis or degenerative joint disease is a common disorder of the diathrodial joints. The features present in bone are associated with the destruction of the articular cartilage. The main effect on the individual is pain, loss of function of the joint and stiffness. Osteoarthritis was found in both the appendicular skeleton and in the spine. In the spine the right apophyseal joint of a single cervical vertebra was affected.

Degenerative joint disease of the temporo-mandibular joint was present in an adult male, associated with an extension to the articular surface, and the angle of the joint appeared to be abnormal. This is most probably the result of a recurring dislocation of the jaw. In modern clinical practice most osteoarthritis of the temporo-mandibular joint occurs in women, with a preponderance of 4:1.

Osteoarthritis was also present to the wrist of one adult with evidence for eburnation between the trapezium, and scaphoid articular surface. Osteoarthritis to the ulna of possibly the same individual has already been discussed and was considered to be secondary to trauma.

Summary

The pathological changes seen in the assemblage are those one would expect in a population, reflecting everyday wear and tear as well as minor injuries.

Additional note on the human bones

Anna Ritchie

An independent assessment of the human bones was undertaken by Frances Lee to provide comparanda for her work on the human bones from the chambered cairn at Point of Cott in Westray (Lee 1997) and as part of her MA dissertation (1985). Some differences arise between the analyses of Lee and Harman which to some extent highlight the problems inevitable in the identification of fragmentary skeletal remains (as did the re-examination of the bone assemblage from Isbister by Laurence 2006). Lee and Harman agree on the assemblage containing a minimum number of 9–10 individuals, but are at slight variance with the relative ages and sexes of those represented. Whereas Harman identified seven adults aged between 25–40 years, one juvenile 15–20 years and two children one of less than two years and one 12–14 years. Lee found five adults aged 18–35 years, two teenagers of 13–15 years and 17–19 years, and two children (one under 5 years and one over 5 years). In terms of sex Harman recognised three probable males and one probable female, whereas Lee identified three males and one female skull. Both specialists agreed over the absence of infants of less than 2 years, which is in contrast to the bone assemblage at Point of Cott, where six of the 13 individuals represented were infants. Harman found no evidence of joins between bones from the first three compartments and the fourth, or between bones in cell 5 and those in the main chamber, whereas Lee identified fragments of the same two individuals in compartments 2, 3, 4 and cell 5, and another individual in cell 5 and compartments 4 and 2W2. Both recognised fragments of the same skull in compartment 4NE8 and 4SE6, and Lee paired them with a fragment from cell 5.3. The question of joins is clearly crucial to relative chronology within the tomb and to burial rite, and in particular the recognition of parts of the same individuals in the main chamber and the cell demonstrates that the material selected to fill and seal off cell 5 was derived from the early deposits within the main tomb. Harman recognised joins between floor deposits and disturbed filling in compartments 2 and 3, which represent the activities of Petrie's workmen (illus 31A). In compartment 4, Harman recognised joins between bones in floor deposits 4NW5 and 4NW4 (two bones), between bones in floor deposits 4NE8 and 4SE6 (same skull), and between 4NW4, 4NE6, 4NE7 and 4SE2 (illus 31B).

The animal bones

Mary Harman

(incorporating comments on abnormal bones
by J R Baker)

In considering the mammal bones, it is worth remembering that when the tomb was built and in use, the Holm may have been joined to Papa Westray, and, in turn, Papa Westray may have been joined to Westray, as suggested by Ritchie (1983, 40). South Wick, between the Holm and Papay, is a shallow sound, and at the north end there are the extensive skerries of Big Less and Little Less, which are exposed at low tide leaving only a narrow (but quite deep) channel between. There is a tradition on Papay that the shore has receded opposite the north end of the Holm.

The mammalian bones other than human can be considered as being found in three different major contexts: within the tomb (all those in trench I), within the forecourt area (trenches III and V) and around the outside of the tomb at the back (trenches II, IV and VI). Of the two areas outside the tomb, a larger area and greater volume of soil were excavated in the forecourt than at the rear of the cairn, and thus the total numbers of bones from these two areas do not reflect the density of bones in similar volumes of soil.

Although some of the lowest layers in the tomb were regarded by Anna Ritchie as floor deposits, the bones in them did not appear trampled or crushed and in this report they have been considered together with the layers above.

A large quantity of animal bones were found in the chamber, the majority from sheep of various ages, though red deer, otter and vole bones were numerous, and there were also fish and bird bones.

Methods

Most of the bones were identifiable, but there were some small unidentifiable fragments and pieces of long bone shaft which could be regarded only as 'probably sheep' or 'probably cattle or deer', and there were problems in several instances in the definite identification of fragmentary cattle and red deer bones, particularly of juvenile animals. These pieces were listed but have not been included in the analysis.

The age of animals was assessed from the state of tooth eruption and wear, and the state of epiphyseal fusion and size and appearance of the bones, using the figures published by Silver (1963, 250–68), the recording system for sheep teeth and jaws developed by Ewbank *et al* (1964, 423–60) and for pigs and red deer the recording system and the notes on ageing from teeth produced by Grant (1975, 437–450) and Mitchell and Youngson (1981, 93–100) respectively. Complete bones or parts of bones from adult animals and complete diaphyses of immature animals were measured. Any evidence of injury or disease was noted, and these bones were submitted to Dr J R Baker for his comments, given below.

Bones of recent or doubtful origin

Small quantities of rabbit bones were found in the uppermost layers of compartments 1, 2 and 3. These are obviously of recent origin. Several bones of rat were found, almost certainly of relatively recent origin. There was a single horse bone, a small second phalanx from layer 1 in trench V. It is worth noting that until recently a few ponies grazed the Holm, in addition to the flock of sheep, and occasional pony bones, undoubtedly of recent origin, were found lying on the surface in several parts of the island. The few horse bones from Knap of Howar, found only in the topsoil, were regarded as probably modern (Noddle 1983, 93), and the only other Neolithic site in the Orkney Islands at which horse bones were found was the chambered cairn at Quanterness, Mainland, where again, the antiquity of the few foetal bones was regarded as dubious. It seems best similarly to regard the Holm pony toe as probably modern until horse bones are found securely stratified well down in the Neolithic deposits in Orkney.

The remains of several sheep were found as partially complete and articulated skeletons in the uppermost levels of the first three compartments: these must have died within the limited shelter of the tomb since Petrie's excavation, as the bones were still articulated despite his disturbance. Sheep are still inclined to take shelter and die there (J Rendall, pers comm). Any bones obviously of such recent origin have been listed but then ignored. It is possible that modern bones have become mixed into Petrie's spoil, for the sheep on the Holm are of a small type and the bones of immature animals particularly would almost certainly be impossible to distinguish from Neolithic bones.

Number of bones

The meticulous sieving has produced a wealth of small bones many of which would otherwise have been missed. This requires particularly careful consideration in counting the bones, and thus loose epiphyses have not been counted, to avoid the possibility of counting a single immature limb bone two or three times, giving a false impression of the relative proportions of mature and immature animals. Cattle and sheep skulls, particularly immature ones, tend to be found in several pieces whereas two adult otter skulls were complete: the figures for the cattle and sheep which include pieces which may be from the same single skull, are not directly comparable with the figures for otter. Similarly, pigs have two main metapodials in each foot (the small lateral metapodials have not been counted though a few were found), whereas cattle, sheep and deer have one; dogs have five metacarpals and four metatarsals, otters five of each, so that the proportions of foot bones for the three main groups: cattle, sheep and deer; pigs; dog and otter: are approximately 1:2:5 respectively, while the proportions of phalanges are approximately 2:2:5 (the small lateral phalanges have been disregarded though several were found). There are other respects in which total numbers are not directly comparable; for instance the presence of fibulae in otter, absent in ruminants, while the scapho cuboid of ruminants was counted though the smaller tarsals of otter were not. In the case of dog and otter adjustments of the total number of bones from the whole tomb to take into consideration the different numbers of foot bones give figures of 18 and 100 respectively, rather than 24 and 147. While these are very different, they do not alter the general picture summarised in Table 9, which shows clearly that in both tomb and forecourt cattle, pig, dog and red deer contributed small numbers of bones, from a small number of individuals; there were rather more from otters, but all these pale into insignificance compared with the enormous number of bones from a large number of sheep, and, considering the small numbers of bones from other animals, precise comparability does not seem very important.

The recovery of very small bones such as unfused epiphyses and otter phalanges is extremely valuable as the analysis can proceed on the assumption that in undisturbed areas all the bones put into the tomb have been retrieved, and this provides a good foundation upon which to construct the interpretation of the bones.

Table 9 shows the number of bone and antler fragments from the larger species represented on the site, in different parts of the tomb and in the three main areas of the site: tomb, forecourt, and outside the back of the cairn. Apart from the overwhelming numbers of sheep bones, this shows that most of the bones were found in the tomb and forecourt, only 7% being from outside the rear of the cairn. The total number of fragments is nearly 4,000, excluding loose teeth, vertebrae, rib fragments, loose epiphyses and some of the minor bones such as deer lateral phalanges as mentioned above. The apparent dearth of bones in compartments 2 and 3 is less striking if those in the 'disturbed' category are distributed between the first three compartments, but it is clear that larger proportions were found in the entrance passage and in compartment 5 than in the other four compartments individually, so that the differences in the bone groups in general seem to reflect the architectural differences in the tomb.

Table 9

Total numbers of animal bone fragments (excluding loose teeth, vertebrae, ribs and loose epiphyses). Note: pigs, dogs and otters have more foot and toe bones than cattle, sheep and red deer

Context	*cattle*	*sheep*	*pig*	*dog*	*red deer antler*	*red deer bone*	*otter*
Chamber and entrance passage							
Disturbed	–	456	2	14	116	14	–
EP	2	520	12	1	8	2	5
Comp 1	6	220	1	1	54	2	–
Comp 2	8	23	–	4	10	–	–
Comp 3	–	30	–	–	1	1	2
Comp 4	3	208	–	–	62	15	27
Comp 5	14	549	1	4	88	5	113
Total	*33*	*2006*	*16*	*24*	*432*	*39*	*147*
Forecourt	12	822	9	10	102	20	4
Outside cairn	34	114	–	80	33	1	–

In view of the small number of bones from outside the back of the cairn, the absence there of pig and dog, both scantily represented in the tomb, may not be significant.

Cattle

There are few cattle bones. Table 14 shows the number of fragments from different parts of the body found in all three main areas. Nearly all of these were from young animals, not having unfused epiphyses, or only the early fusing ones joined, and though some were from very small calves, most were from larger better grown calves, and some probably nearly adult in size. There is an emphasis in the bones found on heads and feet: the 'waste' parts, particularly outside the tomb, but with such small numbers of bones this may not be significant. Most of a calf skull in the forecourt and fragments of two other immature skulls all have small horn cores. Of one rib fragment, probably cattle, from the entrance passage, Dr Baker comments 'it shows a healing fracture, with considerable bone expansion'. Ages at death from epiphyseal fusion are estimated in Table 16.

Sheep

It is possible that goats are represented among the sheep though the cranial fragments and horn cores are all from sheep. As there was a large number of bones, many of them broken and many immature, no attempt was made to find joining fragments or pairs, and in the tables showing numbers of bone fragments some of those more easily broken: skull, scapula and pelvis: appear to be more numerous, but this is a result of their being more fragmented. While bones from skeletally mature animals and immature animals could be fairly readily distinguished, it was deemed useful to attempt a further subdivision of the immature bones into those from very small lambs of newly born size and a little larger, described as immature, and those of larger animals, perhaps a few months old but with the epiphyses still not fused. The distinction between these two groups is arbitrary and may not always be entirely consistent, but dental evidence, the figures for epiphyseal fusion and the evidence of diaphyseal lengths all demonstrate that a large proportion of the bones are from skeletally immature sheep, and that many of these are from very small lambs (Tables in archive). There is no obvious difference in the physical composition of the bone groups in the different parts of the tomb and Table 11 summarises the evidence from the tomb as a whole, while Table 16 shows the numbers of bone fragments from the forecourt. The totals for different parts of the tomb and the forecourt and the midden are shown in Table 13. There is no emphasis on any particular part of the body, and no suggestion that these represent meat bones or waste from slaughtering and butchering. Table 14 shows the age of the animals at death based on mandibles and loose teeth, and Table 15 shows the figures for the state of epiphyseal fusion.

Table 13 shows that in the tomb, nearly half of the bones are mature, nearly a quarter are juvenile, and nearly a third are from very small lambs. These proportions are roughly supported by the figures for mandibles, though the figures for epiphyseal fusion suggest that the proportions of immature and juvenile animals might have been greater, and there is a suggestion in Table 13 that this might have been the case in compartments 4 and 5, and thus that it is possible that the composition of age groups differed slightly between compartments 4 and 5 and the rest of the tomb. The forecourt and the midden contain very similar groups of sheep bones, different from those in the tomb in having a larger proportion of bones from mature animals and considerably less from small lambs: this shows clearly in Tables 13 and 14; in Table 15, though the differences are less distinct, it is clear that in the early and middle fusing groups a greater proportion of the epiphyses are fused.

Most of the skulls or pieces of horn core from the tomb were found in cell 5: two immature frontals and part of a juvenile skull appear to have been polled; six immature frontals have horn buds, three juvenile frontals have small horn cores, and 13 frontals are horned, including four from two skulls which are almost certainly ram's skulls. In the rest of the tomb, in undisturbed contexts, there is another immature frontal which is probably polled, and six that are horned, including one skull possibly from a young ram and one that is sgurred. In the forecourt area, of five frontals one is sgurred and one whole skull is polled, but there are some horn core fragments which may well be from ram's horns.

A few sheep bones show evidence of ill health: a cheek tooth from the entrance passage of which Dr Baker writes 'there are deposits of dental calculus on this tooth which also has very rough irregular roots due to alveolar infection during tooth growth'. A rib fragment from compartment 4 has a healed fracture and a radius from cell 5 has 'an irregular nodule of new bone below the proximal articular surface. The cause is unknown'.

There are several bones with eroded surfaces suggesting that they have been exposed to the elements for some time before burial: these occur in the lowest layer of the entrance passage and in compartment 4 and cell 5, in which there was also an atlas with cuts on the ventral surface, such as might be expected if the throat had been cut. This is the only indication of human action affecting the bones.

In conclusion, bones from a large number of sheep occur within the tomb and from the forecourt area.

Table 10

Cattle: numbers of bone fragments (excluding epiphyses) (⋆totals excluding teeth, vertebrae and ribs)

	tomb			*forecourt*			*outside cairn*		
	L		*R*	*L*		*R*	*L*		*R*
Skull	2	–	2	1	1	2	–	–	–
Maxilla	–	–	–	–	1	–	–	–	–
Mandible	–	2	1	1	–	–	1	1	–
Tooth	–	6	–	–	2	–	–	3	–
Vertebra	–	6	–	–	1	–	–	6	–
Rib	–	13	–	–	9	–	–	12	–
Scapula	–	–	–	–	–	–	–	1	–
Humerus	–	–	–	1	–	–	–	–	–
Radius	1		1	–	–	–	–	–	–
Ulna	–	2	–	–	–	–	–	–	–
Metacarpal	–	–	–	–	–	–	–	2	–
Pelvis	–	–	1	–	–	–	–	–	–
Femur	–	–	–	–	–	–	–	1	–
Tibia	1	1	–	–	–	1	1	–	–
Astralagus	1		1	–	–	–	–	–	–
Calcaneum	1	–	2	–	–	–	1	–	2
Scapho cuboid	1	–	1	1	–	–	1	–	–
Metatarsal	3	–	1	–	–	–	–	12	–
Phalanx 1	1	–	3	1		1	5	–	4
Phalanx 2	–	–	4	–	1		3	–	2
Phalanx 3	–	–	–	–	–	–	2	–	3
Metapodial	–	–	–	–	–	–	–	2	–
Total⋆		33			12			34	
MNI		5			2			3	

Table 11
Sheep: numbers of bone fragments from the tomb as a whole (excluding loose epiphyses)
(*totals excluding teeth, vertebrae and ribs)

	mature			*juvenile*			*immature*		
	L		*R*	*L*		*R*	*L*		*R*
Skull	31	46	33	6	5	10	16	16	10
Maxilla	7	–	5	4	–	6	5	–	3
Mandible	6	–	6	6	3	13	12	1	8
Tooth					All groups 334				
Vertebra	–	194	–	–	361	–	–	70	–
Rib					All groups 879				
Scapula	30	7	22	5	–	5	15	1	12
Humerus	14	2	10	14	3	17	22	–	22
Radius	11	6	16	12	1	16	31	2	25
Ulna	18	–	17	5	1	6	15	–	14
Metacarpal	8	3	6	8	–	10	11	30	18
Pelvis	33	3	25	13	–	21	16	–	17
Femur	8	8	5	17	4	22	18	2	19
Tibia	8	1	7	13	2	22	18	1	23
Astragalus	23	–	19	7	–	7	9	1	9
Calcaneum	21	–	22	3	–	2	14	–	8
Scapho-cuboid	14	–	29	–	–	1	–	4	–
Metatarsal	8	4	11	7	4	13	15	17	21
Phalanx 1	46	1	40	56	–	61	33	10	38
Phalanx 2	55	–	53	17	3	22	12	4	17
Phalanx 3	76	–	80	–	–	–	4	5	5
Total*		904			473			629	

They include all parts of the body with no apparent emphasis on any particular part, and the animals died at all ages from newly born or occasionally foetal to maturity. The proportions vary in different areas, with a higher proportion of bones from very small lambs in compartment 4 and cell 5 than in the rest of the tomb, and a higher proportion from mature animals in the forecourt than in the tomb. The bones are from both rams and ewes, and of 38 frontals seven (18%) are polled or probably polled.

Pig

Only a very small number of pig bones (20) and teeth (11+) was found, and most were in the forecourt area and the entrance passage. They consist almost entirely

Table 12

Sheep: numbers of bone fragments from the forecourt (excluding loose epiphyses)

(*totals excluding teeth, vertebrae and ribs)

	mature			*juvenile*			*immature*		
	L		*R*	*L*		*R*	*L*		*R*
Skull	8	31	6	2	–	–	–	1	2
Maxilla	–	–	–	–	–	–	–	–	–
Mandible	9	–	5	3	–	2	–	–	2
Tooth					All groups 168				
Vertebra		77			84			19	
Rib					All groups 372				
Scapula	15	3	10	–	–	1	3	–	1
Humerus	15	–	5	2	–	5	7	–	8
Radius	16	–	8	28	–	13	12	–	12
Ulna	16	–	9	2	–		1	–	1
Metacarpal	11	7	8	12	5	11	5	12	3
Pelvis	9	–	12	1	–	4	1	–	1
Femur	4	10	3	5	2	4	9	3	7
Tibia	4	–	12	4		9	9	2	13
Astragalus	18	–	19	–	–	–	–	–	–
Calcaneum	17	–	16	–	–	–	1	–	1
Scapho-cuboid	12	–	15	–	–	–	–	–	–
Metatarsal	7	3	8	13	5	6	4	16	6
Phalanx 1	26	–	27	18	–	20	2	–	4
Phalanx 2	25	–	15	1	–	2	–	–	–
Phalance 3	26	–	23		–		–	–	–
Total*		493			180			149	

of parts of head and feet, from quite well-grown animals and from newly born or very young animals. In the NMS collection is a skull, virtually complete, from a pig which was probably between 1.5 and 2 years old, and part of a mandible from another animal of more than 3 years but probably less than 4 years. Incisors found in the entrance passage were from a pig of perhaps about 3 years. Most of the other loose teeth are deciduous, not worn and probably only partially erupted, representing at least two very small piglets, a third being represented in compartment 1 by another tooth (three upper right deciduous second molars in all). There are also some immature pig toe bones from the entrance passage. A bone and two teeth in cell 5 were from a well-grown and a very small piglet. In the forecourt, another mandible came from a pig aged about 3 years, and there were a few bones from both fore and hind feet of a mature pig, besides a single bone from a piglet. Ages at death from epiphyseal fusion are estimated in Table 16.

Red deer

Table 9 shows the number of antler fragments and bones from the three main areas of the site. It is clear that antler fragments form the majority of the deer remains and that in the area at the back of the cairn the proportion of bone to antler is much greater than within the tomb and in the forecourt. Most of the antler fragments are small, less than 100mm long, and although a few joining pieces were noted no systematic attempt was made to establish the number of joins. Petrie records finding parts of twelve pairs of 'deer horns', mostly from compartment 2. In his backfill and in the NMS collection there are three antler bases, and twenty-five tine ends, besides a large number of fragments, but not enough pieces to make up anything approaching twelve pairs of antlers, and it seems probable that only a small proportion of the antler fragments that he found still survive. It is possible that he overestimated in recording ten pairs in compartment 2, though in the undisturbed floor of compartment 1 there were two antler bases and in compartment 4 and cell 5 there were four and six or seven respectively. This is comparable to his note of two pairs in compartment 3 and it may be unjust to doubt his figure for compartment 2. The total number of tine ends from undisturbed deposits in the tomb is as follows: entrance passage: 1, compartment 1: 7, compartment 3: 1, compartment 4: 16, cell 5: 31. If the bases and tines belong together, which is not at all certain, the average number of points per antler would be about four, which would be a little above the average for a modern hill population. There is one thin bent piece of tine from compartment 4 which is probably from an elderly or unhealthy animal.

Petrie's work probably resulted in further fragmentation of the pieces of antler that he found. Those in the undisturbed deposits included more large pieces, among them a piece of crown with two points, five bases with brow tines attached, and in cell 5.3 what is probably the largest piece, a base with brow and tray tines attached. All of the antler bases from the site are cast and therefore did not involve hunting or killing deer. They could have been traded from any distance, though the presence of bones suggests that they were probably collected locally. They are not particularly large: few pieces were usefully measurable, but the

Table 13
Sheep: total numbers of bone fragments (excluding teeth, vertebrae and ribs) from mature, juvenile and immature animals

context	*mature*	*juvenile*	*immature*	*total*
Disturbed	207 (45%)	109 (24%)	140 (31%)	456
EP	270 (52%)	124 (24%)	126 (24%)	520
Comp 1	104 (47%)	50 (23%)	66 (30%)	220
Comp 2	13 (60%)	5 (20%)	5 (20%)	23
Comp 3	17 (60%)	3 (10%)	10 (30%))	30
Comp 4	85 (40%)	37 (20%)	86 (40%)	208
Cell 5	208 (38%)	145 (26%)	196 (36%)	549
Tomb total	904 (45%)	473 (24%)	629 (31%)	2006
Forecourt	493 (60%)	180 (22%)	149 (18%)	822
Rear of cairn	71 (62%)	28 (25%)	15 (13%)	114

Table 14
Sheep: ages at death based on mandibles. a–z = stages of eruption and wear sequence

Context	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*	*o*	*p*	*q*	*r*	*s*	*t*	*u*	*v*	*w*	*x*	*y*	*z*
Disturbed	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1	–	2
EP	1	1	1	–	–	–	–	–	–	–	–	1	–	5	–	1	1	–	–	–	–	–	1	–	–	–
Comp 1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Comp 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Comp 3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Comp 4	–	1	–	–	–	1	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	1
Cell 5	4	–	2	–	1	1	–	–	–	–	–	2	1	2	1	–	–	–	–	1	–	–	–	–	–	1
Tomb total	7	2	3	–	1	2	–	1	–	–	1	3	1	7	3	1	1	–	–	1	–	–	2	1	–	5
Forecourt	–	–	1	2	–	–	–	1	–	–	–	–	–	–	–	2	–	1	2	–	–	1	1	–	1	8
Rear of cairn	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Silver's 'old' ages	0–1½ months					*c.*6 months						*c.*1½ months							3–4 years							

Table 15
Sheep: ages at death according to state of epiphyseal fusion. The age range for each group is given in months (F = fused, N = not fused)

	EP		*Disturbed + comp 1–3*		*Comp 4*		*Cell 5*		*Forecourt*		*Rear of cairn*	
	F	*N*	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*
Early 6–10	9	41	24	50	14	16	42	51	61	19	3	3
Middle 18–30	1	34	7	62	2	33	5	73	23	64	3	10
Late 30–42	8	41	7	106	8	44	13	91	13	77	–	10

maximum length of the cast surface, within the coronet, has an average of 430mm in seven examples, the extremes being 340mm and about 530mm. It is tempting to regard the numerous antlers as being included in the tomb because they had some special significance, but some at least may have been used as picks when the tomb was being dismantled and filled in.

In all three areas of the site, there are only small numbers of bones and bone fragments. These are from all parts of the body, both meat-bearing and waste areas such as feet. Most of the bones are from immature animals, though almost all of them are well-grown. Loose teeth indicate that associated with the tomb there are parts of one small calf, and animals of about two years, more than two years and more than three years. At the back of the cairn there are teeth from at least two animals, of less than two and a half years and more than two and a half years, and the bones represent at least three animals.

Although most of the bones are from young animals of probably less than three years, some at least of the antlers, with comparatively large brow tines, are from stags of four or five years or more. While there must be at least 17 or 18 antlers represented, they could of course have been produced over the years by no more than two or even one stag. Ages at death from epiphyseal fusion are estimated in Table 19.

Red deer bones have been recorded at most of the excavated Neolithic sites in the Southern Isles (Barker 1983, 144), and articulated skeletons at Links of Noltland in Westray (Sharples 2000). Clutton-Brock suggested that red deer were taken to Orkney by Neolithic immigrants and that they remained 'under the direct control of the inhabitants' (1979, 113). There may well have been deer resident in Papa Westray, even if the island were separate from Westray, particularly if the deer were 'farmed' (although the deer bones identified at Knap of Howar by Noddle (1983) have since been discounted as deer, Anne Tresset, pers comm).

Dog

A few dog bones were found, some in the forecourt and some in the tomb, including pieces in the lowest levels of the entrance passage and compartments 1 and 2 (Table 9). All the bones were from mature animals (more than 1–1.5 years) and most of the teeth show some wear. There are bones from at least two animals, one larger than the other, and, although no length measurements were possible, comparison with a reference skeleton of a dog of about 340mm shoulder height shows that these are bones from dogs a little larger and a little smaller. If the bones in the forecourt are from a different dog, the minimum number of animals represented rises to three. Bones from all parts of the body are represented, and they include two vertebrae, one thoracic and one lumbar, with spondylosis of Morgan's grade 2 (identified by Dr Baker). This is the mildest form evident in bones of a condition that is quite common in the rear half of the spine of adult dogs and is associated with ageing (Baker & Brothwell 1980, 129–30).

Otter

Otter bones were found in both the tomb and the forecourt (Table 9), and a single bone in trench VI. Most of the bones were in cell 5. Although some of the bones are broken, many are complete. This may

Table 16
Ages of animals at death according to stages of epiphyseal fusion. Age ranges are given in months, except for red deer which is probably similar to the other species
(F = fused, N = not fused)

	Age groups	*Chamber*		*Forecourt*		*Rear of cairn*	
		F	*N*	*F*	*N*	*F*	*N*
cattle	Early 6–15	3	3	–	2	5	–
	Middle 18–30	1	3	–	–	1	2
	Late 42–48	–	3	–	1	–	–
sheep	Early 6–10	89	158	61	19	3	3
	Middle 18–30	15	202	23	64	3	10
	Late 30–42	36	282	13	77	–	10
pig	Early *c.*12	–	1	–	–	–	–
	Middle 24–27	1	–	3	–	–	–
	Late *c.*42	–	1	–	2	–	–
red deer	Early	3	2	1	2	6	–
	Middle	–	1	–	1	1	–
	Late	3	3	–	3	–	4

be partly because they are small and fairly sturdy: a number of lamb bones, which are also small but less robust, were also complete. There are bones from all parts of the body, with no particular bias for any part, though there are not enough skulls, vertebrae or ribs to go with all the limb bones. There are several pairing bones, mostly in cell 5, although there are also pairs between 5.1 and 4W1, 5.3 and 4W1 and the forecourt V.2 and entrance passage 4. A few bones may be pairs but are too incomplete to be certain, and there are therefore from the tomb and forecourt at least six, possibly seven, adults and three juveniles. The latter are represented by only 11 bones, of which three are from very young cubs, and one at least from an older animal more nearly adult.

Wear on the teeth of the adults is variable. There are jaws with only light wear on the first molar (two animals), jaws in which all the cusps show some wear through to the dentine (three animals), and a skull and mandible which may belong together from one (or more) elderly animal with heavy wear, particularly on the left side, and the canines worn flat, possibly after being broken. This animal may be distinguished as a large individual, and to it belong several vertebrae, a scapula and pairs of all the limb bones except the radius, all showing minor exostoses around the joints. There are a few bones from another animal of similar size, all the other measurable limb bones being shorter by some 15mm or more: possibly these represent two males and four females, though no bacula was found.

There are several bones with abnormalities resulting from fractures or jaw infections. The skull of the elderly otter has an irregular hollow beside the left maxilla. Dr Baker comments: 'the ventral branch of the zygoma on the left hand side contains a cavity which has eroded to the adjacent soft tissue. This is due to a root abcess of the carnassial tooth'. It is odd that wear is more severe on the left side, which must have been painful. A mandible from a young adult, with very light wear, has 'roughening and proliferation of bone adjacent to the inner aspect of the cheek teeth which will have been associated with gingivitis in life. There is also some roughening on the lateral aspect close to the mandibular symphysis possibly associated with infection of the canine tooth alveolus'. Several bones were confirmed as having healed fractures: a rib, four fibulae, two left and two probable right, one possibly belonging to the elderly otter, and a metapodial with a fracture at the distal end.

Vole

A large number of bones of the Orkney vole, *Microtus arvalis*, was found in all areas and levels, but the majority were inside the tomb and there were relatively few from the forecourt and very few from outside the back of the cairn. No attempt has been made to list these comprehensively, particularly since there are many more in the unsorted residue from wet-sieving, but all the hand-excavated mandibles have been counted, distinguishing between left and right, to establish a minimum number of animals and an impression of their distribution for the following areas:

Entrance passage: 72

Compartment 1: 47; compartment 2: 10; compartment 3: 21; compartment 4: 48; cell 5: 75

Forecourt: 19

Rear of cairn: 3

There is no evidence for the presence of voles on the Holm today.

There are also 18 rat bones from compartment 4 and one each from compartment 3, cell 5 and the forecourt.

(Report submitted 1994.)

RADIOCARBON DATES

Patrick J Ashmore

The Holm of Papa Westray North date list comprises four elements. Three are presented in Table 17: dates obtained by Historic Scotland (HS) for A Ritchie from the GU laboratory before 1996, dates obtained by HS from the Groningen laboratory for R Schulting and reported in 2004, and dates obtained in 2006 and 2007 through a co-operation between National Museums Scotland (NMS) and the Oxford Radiocarbon Accelerator Unit (ORAU).

The other element forms Table 18; it is a set of dates obtained by HS from ORAU in 2000 and 2001 and subsequently withdrawn because of measurement problems identified by ORAU.

The dates obtained in 2006 and 2007 were from the same contexts as the 2000 and 2001 dates and superseded them.

Ascough and colleagues have shown that the marine reservoir effect probably varies from time to time and place to place in Scotland (Ascough *et al* 2006). The variation at any given period is potentially sufficiently large to prevent sensible choice of a correction for the marine effect. Therefore I have not included in the diagram (illus 31) the two dates listed in Table 19.

The remaining ages (Table 20) display some peculiarities. It is slightly strange that the three dates for human bone obtained by Schulting in 2004 are significantly earlier than the two dates obtained by HS before 1996, particularly because one of the latter (GU-2068) was described as from a primary context. Indeed that age is significantly younger than the youngest of the Groningen dates (Chi-squared = 5.53 against a highest acceptable value of 3.84). But the sample is so small that no significance can be attached to the difference. Nor for the same reason is it safe to argue that the three Groningen dates represent an early phase separated by a gap from a later phase of disposal of human remains. However it is worth noting that the human bones dated from the chambered cairn at Point of Cott, Westray (Barber 1997), displayed a similar pattern with three ages between 4680 and 4600 BP and five between 4390 and 4250 BP.

Indeed the early dates from the two sites can be combined using OxCal with an agreement of 100.9%, suggesting a 95.4% chance of deposition in the period 3520 BC to 3370 BC. Of course this is a spurious result in real terms because it demands a prior hypothesis that all of the bodies were buried at the same time, which seems unlikely.

Somewhat to my surprise the same trick performed on the late human bone ages from Holm and Cott produces an agreement of 99.8% and a probability of 95.4% that all of the burials were made in the period

Table 17

Usable radiocarbon ages for Holm of Papa Westray North

Datelist	*Reference*	*Description*	*Mat*	*Code*	*Lab Age*	*Lab Error*	*Adj Age*	*Adj Error*	$\delta^{13}C$	$\delta^{15}N$	*C/N Ratio*
DES2004	Schulting 2004	Human sub-adult phalange (HPWN 1) from 3W1.	Bone, human	GrA-25636	4715	40	4715	40	–19.6	11.3	3.2
DES2004	Schulting 2004	Human adult right femur (HPWN 1158) from 5.4.	Bone, human	GrA-25638	4690	40	4690	40	–19.9	10.4	2.9
DES2004	Schulting 2004	Human adult right femur (HPWN 664) from 3E1.	Bone, human	GrA-25637	4640	40	4640	40	–20.8	10	3.0
To96	Davidson & Henshall 1989, 120–2	Human bone from a primary burial in the innermost compartment 4NW4.	bone, human	GU-2068	4430	60	4430	60	–19.4		
To96	Davidson & Henshall 1989, 120–1	Human bone from the deliberate filling of the end-cell 5.3.	bone, human	GU-2067	4395	60	4395	60	–19		
DES2007	Sheridan & Higham 2007, 225	An otter bone from 5.2. Because the $\delta^{13}C$ value suggests a 'marine' effect this age is older than it would have been had the otter eaten material of purely terrestrial origin. This age replaces OxA-9871.	bone, animal	OxA-17780	4331	32			–10.5	16.8	3.2
DES2006	Sheridan & Higham 2006, 202	A young sheep metatarsal from IV.1(2). Because the $\delta^{13}C$ value suggests a 'marine' effect this age is older than it would have been had the sheep eaten material of purely terrestrial origin. This age replaces OxA-9834.	bone, animal	OxA-16472	4252	39	4252	39	–15.3	10.6	3.3
DES2007	Sheridan & Higham 2007, 225	A sheep vertebra from 5.3. This age replaces OxA-9833. The original sample showed a 'marine' effect making that age older than it would have been had the sheep eaten material of purely terrestrial origin. However the $\delta^{13}C$ value for this new age does not show a strong marine effect.	bone, animal	OxA-17779	4167	31	4167	31	–19.8	7.1	3.2
DES2006	Sheridan & Higham 2006, 202	A single piece of red deer antler from V.1. This age replaces OxA-9752.	bone, animal	OxA-16473	4127	39	4127	39	–21.7	5.9	3.2
DES2006	Sheridan & Higham 2006, 202	A single sheep metatarsal from V.2. This age replaces OxA-9753.	bone, animal	OxA-16474	4113	40	4113	40	–20.1	7.0	3.2
DES2007	Sheridan & Higham 2007, 225	A red deer astralagus from IV.1(1). This age along with OxA-17781 from the same sample replaces OxA-9872. The weighted mean of OxA-17781 and OxA-17782 is 4092 ± 22.	bone, animal	OxA-17782	4111	32	4111	32	–21.8	7.1	3.2

Table 17 (continued)
Usable radiocarbon ages for Holm of Papa Westray North

Datelist	*Reference*	*Description*	*Mat*	*Code*	*Lab Age*	*Lab Error*	*Adj Age*	*Adj Error*	$\delta^{13}C$	$\delta^{15}N$	*C/N Ratio*
DES2007	Sheridan & Higham 2007, 225	A red deer astralagus from IV.1(1). This age along with OxA-17782 from the same sample replaces OxA-9872. The weighted mean of OxA17781 and OxA-17782 is 4092 ± 22.	bone, animal	OxA-17781	4075	30	4075	30	–21.6	7.1	3.3
To96	Davidson & Henshall 1989, 120–1	A sheep bone from EP4.	bone, animal	GU-2069	4070	60	4070	60	–19.3	–	–
DES2006	Sheridan & Higham 2006, 202	A red deer bone from 5.1. This age replaces OxA-9832.	bone, animal	OxA-16471	4046	38	4046	38	–21.8	7.4	3.3

between 3030 BC and 2900 BC. Again it must be stressed that using the combination facility like this is invalid without a very good prior archaeological reason for saying that the bones were truly all of the same age as each other.

But this does illustrate how similar the early human bone ages and the late ones at Point of Cott and Holm of Papa Westray North are to each other. Technically, for the sake of argument, were someone to suggest that all the adult human bones in the two tombs were from

Table 18
Unusable radiocarbon ages withdrawn by ORAU (Higham & Sheridan 2006; 2007)

Code	*Originally published*	*Sponsor*	
OxA-9752	Ritchie DES2000	HS	This age of 4250 ± 45 $\delta^{13}C$ –20.4 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-16473
OxA-9753	Ritchie DES2000	HS	This age of 4225 ± 50 $\delta^{13}C$ –18.8 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-16474
OxA-9832	Ritchie DES2001	HS	This age of 4235 ± 45 $\delta^{13}C$ –20.7 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-16471
OxA-9834	Ritchie DES2001	HS	This age of 4440 ± 40 $\delta^{13}C$ –14.6 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-16472
OxA-9872	Ritchie DES2001	HS	This age of 3855 ± 45 $\delta^{13}C$ –21 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-17781 and OxA-17782
OxA-9833	Ritchie DES2001	HS	This age of 4585 ± 40 $\delta^{13}C$ –12.8 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-17779
OxA-9871	Ritchie DES2001	HS	This age of 4680 ± 50 $\delta^{13}C$ –11.3 was measured when the ORAU filtration system was faulty and has been WITHDRAWN. It has been replaced by OxA-17780

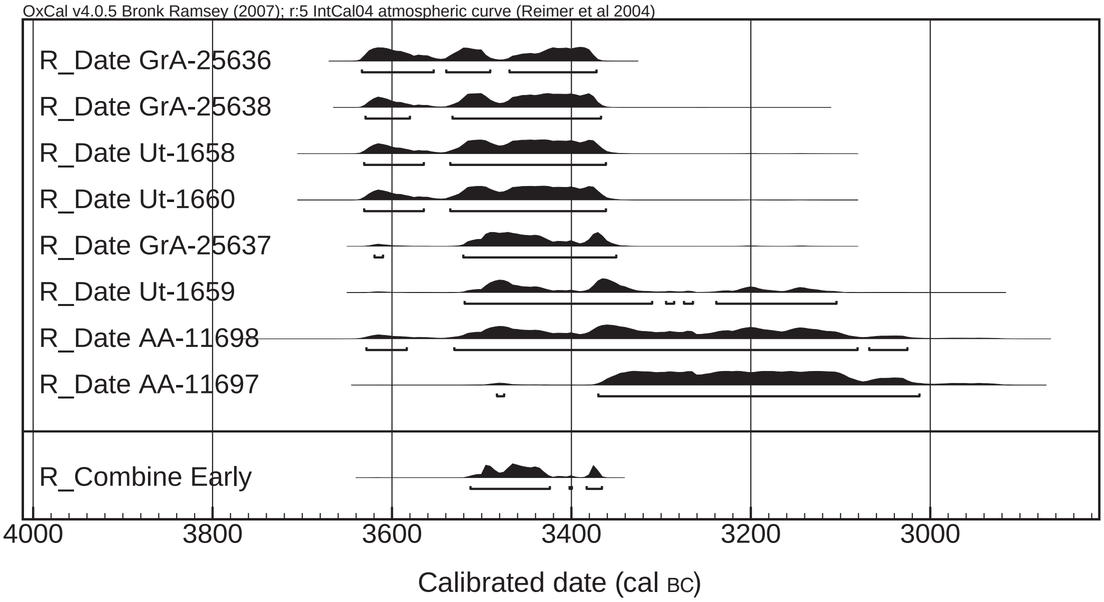
Table 19
Radiocarbon ages not used for the diagram in illus 31 because of uncertainties about the marine effect

DES2007	Sheridan & Higham 2007, 225	An otter bone from 5.2. Because the $\delta^{13}C$ value suggests a 'marine' effect this age is older than it would have been had the otter eaten material of purely terrestrial origin.	bone, animal	cairn	OxA-17780	4331	32	–10.48
DES2006	Sheridan & Higham 2006, 202	A young sheep bone from IV.1(2). Because the $\delta^{13}C$ value suggests a 'marine' effect this age is older than it would have been had the sheep eaten material of purely terrestrial origin. This age replaces OxA-9834.	bone, animal	cairn	OxA-16472	4252	39	–

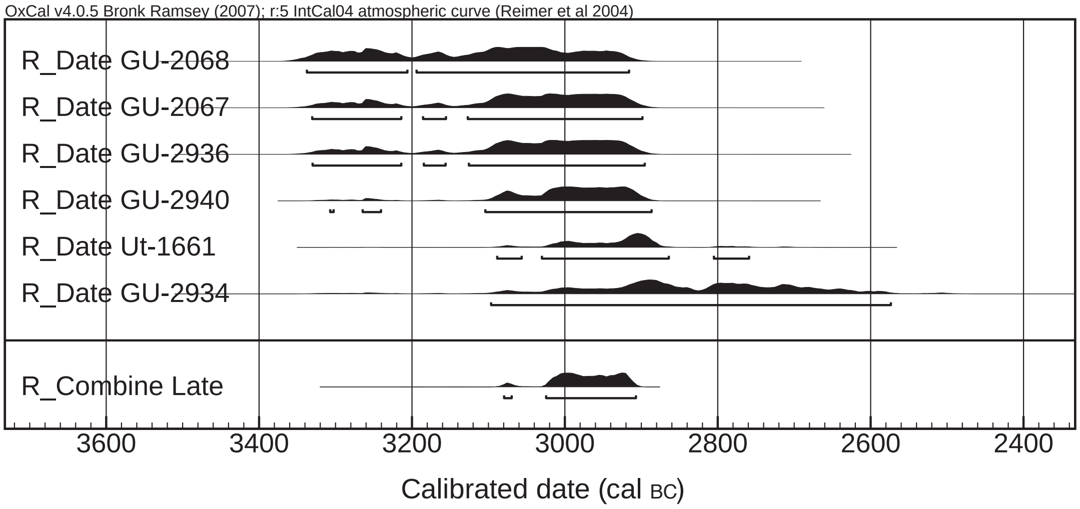
people who died in the first battle (or great plague or mass suicide) of Westray in 3450 BC, and the second one around 3000 BC, the radiocarbon dates could not be used to contradict them.

The oldest age for animal bone (not showing the effects of a partially marine diet) is significantly younger than the youngest human bone age (Chi-squared = 8.23). The same is true at Point of Cott except for one mixed animal bone date from animals including a sheep, vole and bird.

The comparison with Point of Cott suggests a model for Holm of Papa Westray North with an early and a late phase of deposition of human bones, followed by a phase of deposition of animal bones. More data



Illus 29
Early radiocarbon dates for human bones from Holm of Papa Westray North (GrA dates) and Point of Cott



Illus 30
Late radiocarbon dates for human bones from Holm of Papa Westray North (GU-2067, GU-2068) and Point of Cott

Table 20
Radiocarbon ages used for the diagram in illus 31

Mat & Context	*Code*	*Age*	*Error*	*Calibrated date*
bone, human, 3W1	GrA-25636	4715	40	3640 to 3370 cal BC
bone, human, 5.4	GrA-25638	4690	40	3630 to 3360 cal BC
bone, human, 3E1	GrA-25637	4640	40	3620 to 3340 cal BC
bone, human, 4NW4	GU-2068	4430	60	3340 to 2910 cal BC
bone, human, 5.3	GU-2067	4395	60	3330 to 2890 cal BC
bone, animal, 5.3	OxA-17779	4167	31	2880 to 2630 cal BC
bone, animal,V.1	OxA-16473	4127	39	2880 to 2570 cal BC
bone, animal,V.2	OxA-16474	4113	40	2880 to 2570 cal BC
bone, animal, IV.1	OxA-17782	4111	32	2870 to 2570 cal BC
bone, animal, IV.1	OxA-17781	4075	30	2860 to 2490 cal BC
bone, animal, EP4	GU-2069	4070	60	2870 to 2470 cal BC
bone, animal, 5.1	OxA-16471	4046	38	2850 to 2470 cal BC

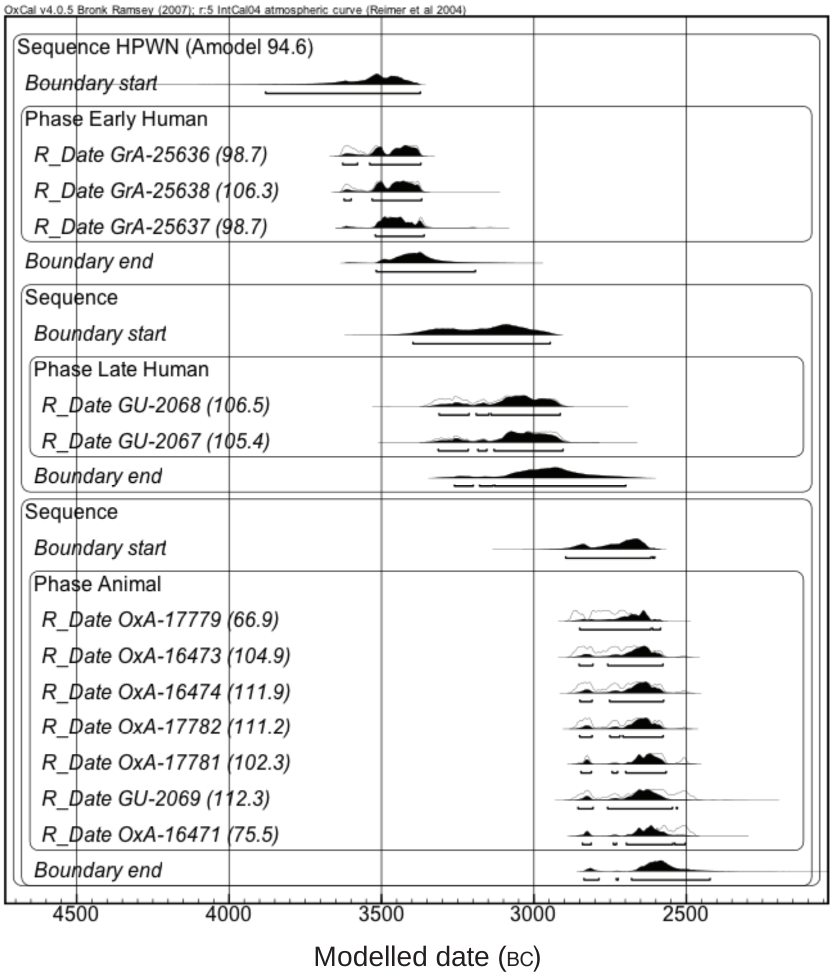
is needed to see whether this pattern recurs at other stalled cairns.

NOTE

Application of the model listed in Appendix 1 produced the output shown in illus 31 and Table 21. Calibrated dates have been added from the latter to Table 20 above.

Model

```
  Plot
  {
   Sequence
{
Boundary;
Phase "Early Human"
{
R_Date "GrA-25636" 4715 40;
R_Date "GrA-25638" 4690 40;
R_Date "GrA-25637" 4640 40;
};
Boundary;
Sequence
{
Boundary;
Phase "Late Human"
{
R_Date "GU-2068" 4430 60;
```



Illus 31
The radiocarbon date sequence for Holm of Papa Westray North

Table 21
Radiocarbon dates: tabbed output

Code	*1 sigma old*	*1 sigma young*	*2 sigma old*	*2 sigma young*
GrA-25636	–3630	–3370	–3640	–3370
GrA-25638	–3520	–3370	–3630	–3360
GrA-25637	–3510	–3360	–3620	–3340
GU–2068	–3320	–2920	–3340	–2910
GU–2067	–3100	–2910	–3330	–2890
OxA-17779	–2880	–2670	–2880	–2630
OxA-16473	–2860	–2620	–2880	–2570
OxA-16474	–2860	–2580	–2880	–2570
OxA-17782	–2860	–2580	–2870	–2570
OxA-17781	–2840	–2500	–2860	–2490
GU–2069	–2850	–2490	–2870	–2470
OxA-16471	–2630	–2490	–2850	–2470
@_Bound	–3640	–3420	–3750	–3380
@GrA-25636	–3530	–3380	–3630	–3370
@GrA-25638	–3520	–3390	–3630	–3360
@GrA-25637	–3510	–3420	–3520	–3360
@_Bound	–3470	–3330	–3520	–3200
@_Bound	–3380	–3060	–3440	–2970
@GU–2068	–3130	–2920	–3320	–2910
@GU–2067	–3100	–2930	–3320	–2900
@_Bound	–3040	–2780	–3250	–2650
@_Bound	–2770	–2630	–2890	–2600
@OxA-17779	–2720	–2620	–2840	–2580
@OxA-16473	–2700	–2590	–2850	–2570
@OxA-16474	–2685	–2585	–2850	–2570
@OxA-17782	–2680	–2585	–2850	–2570
@OxA-17781	–2665	–2580	–2840	–2560
@GU–2069	–2680	–2580	–2850	–2500
@OxA-16471	–2665	–2570	–2840	–2490
@_Bound	–2650	–2530	–2830	–2410

```
R_Date "GU-2067" 4395 60;
};
Boundary;
};
Sequence
{
Boundary;
Phase "Animal"
{
R_Date "OxA-17779" 4167 31;
R_Date "OxA-16473" 4127 39;
R_Date "OxA-16474" 4113 40;
R_Date "OxA-17782" 4111 32;
R_Date "OxA-17781" 4075 30;
R_Date "GU-2069" 4070 60;
R_Date "OxA-16471" 4046 38;
};
Boundary;
};
};
};
```

RADIOCARBON DATES AND STABLE ISOTOPE VALUES ON HUMAN REMAINS

Rick Schulting and Mike Richards

Introduction

The chambered tomb of Holm of Papa Westray North is part of the most northerly manifestation of the Neolithic in Britain. As such, it takes on considerable importance in terms of understanding the processes involved in neolithisation. The two key issues discussed in this paper concern the chronology of the tomb, particularly its primary use-phase, and the diets of the individuals represented. These questions are intimately linked, since the diets of the earliest Neolithic inhabitants of the islands are of some interest, given the distance from putative sources of new domesticated plants and animals, and the ideas that went along with them. This is particularly so in the light of recent debates over the importance and rapidity of dietary shifts in coastal areas in the Neolithic, and the question of regional differences in earlier Neolithic diets (Milner *et al* 2004; Richards *et al* 2003a; Richards & Schulting 2006; Thomas 2003). There is in addition the question of the relationship between the monument and the nearby (relatively speaking) settlement at Knap of Howar in Papa Westray, currently recognised as the earliest Neolithic site on Orkney. Here, then, we present AMS radiocarbon determinations and stable carbon and nitrogen isotope values on humans from the Holm of Papa Westray North chambered tomb, and briefly discuss these results in relation to the other radiocarbon determinations and isotopic measurements on animal bone both from this site, and from Knap of Howar.

Materials and methods

The three human bone samples selected for dating and isotopic analysis comprise an immature phalanx and

Table 22

Results of AMS determinations on human bone collagen from Holm of Papa Westray North. (Calibrated with OxCal-4.0 using Intcal 4.14; Bronk Ramsey 1995; 2001; Reimer *et al* 2004). GU-2067 and 2068 are presented in Table 7; their associated δ^{13}C values are not suitable for palaeodietary analysis

Sample HPWN-	*Element*	*Age*	*Lab. No.*	*^{14}C BP*	±	*2σ cal BC*		*δ^{13}C*
1, 3W.1	phalanx	subadult	GrA-25636	4715	40	3630	3370	–19.6
1158, 5.4	R femur	adult	GrA-25638	4690	40	3630	3370	–19.9
664, 3E.1	R femur	adult	GrA-25637	4640	40	3620	3350	–20.8
‘primary’ burial in 4NW4			GU-2068	4430	60	3340	2910	*–19.4*
Fill of end-cell 5.3			GU-2067	4395	60	3330	2890	*–19.0*

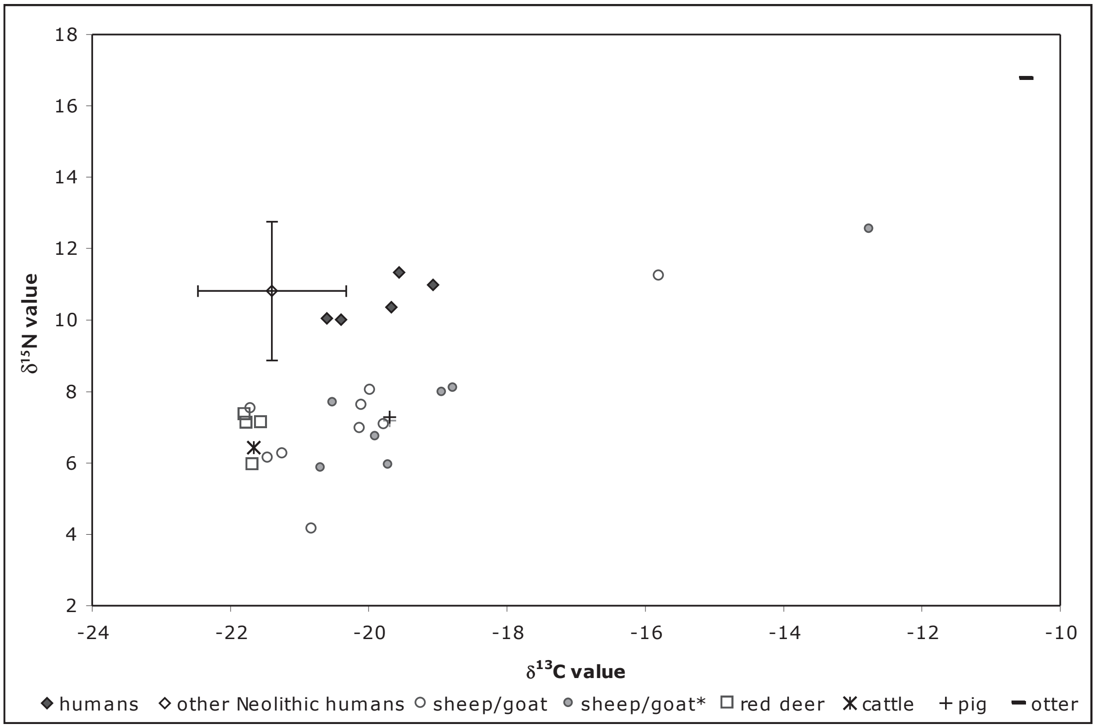
two adult right femora, and so represent three distinct individuals. Two additional human bones, a left ulna and a left metatarsal IV were selected for isotopic analysis only. The samples selected for dating derive from the fills of chambers 3W and 3E, and from the lowest level of the apparently undisturbed end cell 5. The fills of chambers 3W and 3E encountered in Ritchie's 1982–3 excavations are thought to be redeposited material from Petrie's 1854 excavations (Petrie 1857).

AMS and stable isotope measurements on three samples were undertaken at the Centre for Isotope Research, Groningen. Stable isotope measurements on four human bone samples were also run in duplicate at the Max Planck Institute, Leipzig. Two of these four samples derive from two of the same specimens analysed in Groningen, with the remaining two on different specimens, resulting in a total of five measurements on at least three individuals. The samples analysed at the Max Planck Institute were ultrafiltered using 30kDa filters (Brown *et al* 1988).

Results

The ^{14}C AMS determinations form a consistent group of results at 4715 ± 40 BP (GrN-25636), 4690 ± 40 BP (GrN-25638) and 4640 ± 40 BP (GrN-25637) (Table 22). All samples show good collagen preservation, as measured by %C and %N, and C:N ratios, which all fall within the acceptable range of 2.9–3.6 (DeNiro 1985). Though stable isotopes on only two specimens were analysed at both laboratories, it is worth noting that these show a high level of consistency (Table 23).

Treating the samples as purely terrestrial yields two-sigma calibrated date ranges of 3633–3373 cal BC, 3630–3368 cal BC, and 3619–3350 cal BC, respectively (Table 22). However, calibration is complicated somewhat by the possibility of a small input from marine protein, as indicated by the slightly elevated δ^{13}C values for the subadult (HPWN 1) and one of the adult femora (HPWN 1158), with the second femur (HPWN 664) showing more a typical purely terrestrial value (Table 23).



Illus 32

Plot of δ^{13}C and δ^{15}N results for Neolithic human and faunal remains from Holm of Papa Westray North and Knap of Howar. Duplicate measurements on HPWN humans have been averaged. Error bars on 'other Neolithic humans' show two standard deviations. Gray circles are the less precise measurements on sheep associated with the retracted OxA determinations, including the second and more extreme 'marine' lamb. See text for details.

Table 23

Stable carbon and nitrogen isotope analysis on human bone collagen from Holm of Papa Westray North. Note similarity of duplicate measurements on HPWN 1158 and 664.

Sample	*Element*	*Age*	*$\delta^{13}C$*	*$\delta^{15}N$*	*%C*	*%N*	*C:N*
Groningen							
HPWN 1	phalanx	subadult	–19.6	11.3	42.4	15.7	3.2
HPWN 1158	R femur	adult	–19.9	10.4	42.8	16.8	3.0
HPWN 664	R femur	adult	–20.8	10.0	41.5	16.6	2.9
Leipzig							
HPWN 1158	R femur	adult	–19.9	10.3	41.7	15.3	3.2
HPWN 664	R femur	adult	–20.8	10.1	41.9	15.5	3.2
HPWN 1022	L ulna	adult	–19.1	11.0	38.7	13.1	3.5
	L metatarsal IV	adult	–20.4	10.0	42.8	15.7	3.2

As this question assumes some importance in the discussion, the case needs to be presented in some detail, particularly since δ^{13}C values ranging between –19.1 and –20‰ are, on the face of it, marginal in terms of inferring any marine input at all: in many cases such values would be considered as falling within the normal range of variation for humans consuming more or less purely terrestrial diets. And this in fact may well be the case. However, it is possible to make a convincing alternative case that marine protein *did* play a small role in the diets of at least two of the dated individuals, as well as one of the undated samples. Despite their marginality, the main impetus for this argument comes from the δ^{13}C measurements. The δ^{15}N values are not particularly high in the context of a series of 11 values (excluding HPWN) obtained on human bone from coastal chambered tombs in west and north Scotland (averaging 10.8 ± 0.9‰) that are to be presented and discussed in detail elsewhere (Schulting & Sheridan in prep). HPWN 1 is slightly elevated compared to this average, but not significantly so. Moreover, its interpretation is complicated by the fact that the sample in question is from a subadult. While it is not possible to indicate a precise age for a phalanx, it may have derived from a child sufficiently young to retain some element of a nursing signal (Schurr 1998). In any case, as the measurement of 11.3‰ falls within one standard deviation, the difference between it and the adults is trivial.

In contrast, the average δ^{13}C value for 11 individuals from coastal chambered tombs is –21.4 ± 0.5‰ (Schulting and Sheridan in prep), and the difference between this value and the three Groningen measurements (to avoid the possibility of slight interlaboratory differences) from Holm of Papa Westray (ie, including HPWN 664, which is not assumed to show a marine signal) is significant at the .05 level ($t = 3.29$, $p = 0.023$) (illus 32). Including all five available human values for HPWN, averaging the two duplicates, strengthens the result ($t = 4.72$, $p = 0.001$). A terrestrial endpoint of *c*.–21‰ is further supported by previously published human values from the Neolithic sites of Carding Mill Bay and Crarae on the west coast, where a total of 13 measurements on at least five individuals average –21.4 ± 0.2‰ (Schulting & Richards 2002). Importantly, both sets of values demonstrate relatively low variation around the mean of *c*.–21‰ (cf Barrett *et al* 2000, who employ a comparable terrestrial endpoint of –20.6‰ for the Orcadian Viking Age).

Also relevant are faunal isotope values associated with AMS determinations from Holm of Papa Westray North and Knap of Howar (Table 24). These are associated with the AMS dating, but were measured separately and so are suitable for palaeodietary analysis, albeit with slightly wider margins of error than measurements undertaken specifically for palaeodiet, as these are typically run in duplicate. The exception

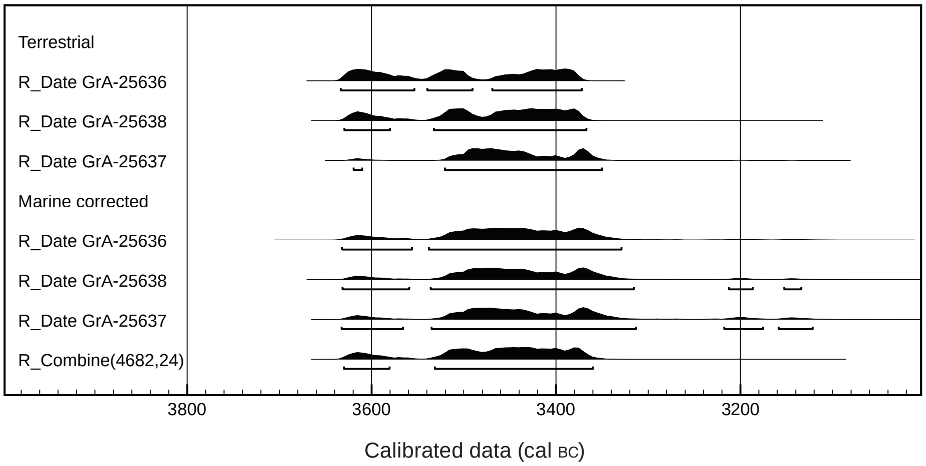
Table 24
Summary of $\delta^{13}C$ and $\delta^{15}N$ results for directly dated Neolithic faunal remains from Holm of Papa Westray North and Knap of Howar, excluding values associated with retracted OxA numbers (see footnote for discussion).

Species	$\delta^{13}C$	±1SD	$\delta^{15}N$	±1SD	*n*
red deer	–21.7	0.11	6.9	0.64	4
sheep (exc. outlier)	–20.7	0.75	6.7	1.22	8
HPWN sheep	–20.0	0.25	7.0	0.08	2
Knap of Howar sheep	–20.9	0.72	6.6	1.43	6
sheep (lamb) outlier	–15.3	–	10.6	–	1
cattle	–21.7	–	6.4	–	1
pig	–19.7	–	7.3	–	1
otter	–10.5	–	16.8	–	1

to this is the neonatal lamb (OxA-16471: 4252 ± 39 BP), which was measured in triplicate because of its unusual results and its importance to the present interpretation: Table 23 reports the average of the three runs. The average $\delta^{13}C$ value for four red deer from HPWN is –21.7‰, while that for eight sheep/goat (almost certainly all sheep) from both sites is –20.7‰. This excludes an extremely elevated value of –15.3‰ for one neonatal lamb from HPWN, matched by a high $\delta^{15}N$ value of 10.6‰. This interesting anomaly is discussed further below. Single cattle and pig measurements from Knap of Howar are –21.7‰ and –19.7‰ respectively. A sea otter unsurprisingly provides an extreme marine value of –10.5‰ for $\delta^{13}C$, and 16.8‰ for $\delta^{15}N$. The difference in $\delta^{13}C$ between the red deer and cattle on the one hand, and the sheep (excluding the outlier) on the other, while slight, is significant ($t = 3.86$; $p = 0.003$) and is discussed further below.

On this basis then, it is possible to argue that at least three samples from a minimum of two individuals from Holm of Papa Westray exhibit evidence for some low-level consumption of marine protein. The marine endpoint can be placed at about –12‰, a value that seems to apply widely to the Holocene waters of Atlantic northwest Europe (cf Barrett *et al* 2000). It is supported by values on a mid-Holocene seal and a sea otter from the west coast of Scotland (Schulting & Richards 2002), and by a value on a Neolithic sea otter from Holm of Papa Westray itself. In addition, measurements on a total of 12 marine fish and seals from the Iron Age to Medieval site of Newark Bay on Mainland, Orkney again average *c.*–12‰ (Richards *et al* 2006). Extrapolating between the terrestrial and marine endpoints of –21‰ and –12‰, respectively, provides estimates of about 15% contribution of marine protein for HPWN 1 and 1158, and, though it does not feature in the dating, possibly a slightly higher contribution of as much as 20% for HPWN 1022. Given the range of natural variation around the terrestrial endpoint, these values should be understood as the maximum likely input of marine protein. If the marine endpoint were more elevated (there is no evidence for it being lower), as suggested by the otter's value of –10.5‰, then the marine contribution in the humans would be correspondingly lower. However, taking the most extreme observed values as endpoints can be misleading, and we prefer to use the averaged value of –12‰.

The above calculation can used to correct for the marine reservoir effect: in the case of such a small contribution of marine protein, the difference in the resulting calibrated range is minimal. The matter does not end here, however, since there is also the issue of uncertainty in the local offset (ΔR) to the northern hemisphere ocean age of 400 years (Reimer and Reimer 2001). The application of a local ΔR is complicated by the possibility that it may have varied over time, even over the limited timescale of the mid- to late-



Illus 33

OxCal-4.0 (Bronk Ramsey 1995; 2001; Reimer *et al* 2004) plot of new dates on human bone from HPWN treated as terrestrial (above) and marine-influenced (below). Because of the inferred slight marine input, the difference is not great, and mainly serves to draw the dates into the period 3520–3360 cal BC. See text and Table 24 for details of marine reservoir correction.

Holocene (Ascough *et al* 2004). Offsets of 143 ± 20, 26 ± 24 (Ascough *et al* 2007, Table 4) and –33 ± 93 years (Reimer *et al* 2002) have been suggested for the period under consideration here, based on paired dating of terrestrial and marine samples. The difference in the values reported by Ascough *et al* (2007, Table 4) relate to temporal variation found at 3650–3520 cal BC and 3370–3110 cal BC, respectively, while Reimer *et al* (2002) present an averaged figure for the mid- to late-Holocene. However, these pairings derive from archaeological sites, and the strength of their association can be called into question. At this stage, therefore, we prefer to apply a ΔR offset of 48 ± 47 years for northern Scottish waters based on the dating of recent but pre-bomb, known-age marine shells (http://intcal.qub.ac.uk/marine/), with the caveat that future refinements will no doubt be forthcoming. This does at least serve to highlight the increased uncertainties that are involved in calibration of dates on humans (or other organisms) consuming marine foods (Table 25). Even for the minimal marine contribution involved, the effects of applying these corrections are noticeable

Table 25

Calibration of AMS determinations on human bone collagen from HPWN, incorporating a marine reservoir correction. Estimated '%marine' is calculated using marine and terrestrial endpoints of –12‰ and –21‰, respectively, and a local ΔR correction of 48 ± 47 years for northern Scottish waters (based on four measurements of recent, known-age marine shells, available at http://intcal.qub.ac.uk/marine/).

Sample	*Lab. No.*	*^{14}C BP*	*±*	*cal BC*		*δ^{13}C*	*δ^{15}N*	*%marine*
HPWN 1	GrA-25636	4715	40	3630	3330	–19.6	11.3	*c*.16%
HPWN 1158	GrA-25638	4690	40	3630	3130	–19.9	10.4	*c*.13%
HPWN 664	GrA-25637	4640	40	3520	3120	–20.8	10.0	*c*.2%

at Holm of Papa Westray North, although much of the expanded range is of low probability (< 10 %), and indeed is negated if the dates are combined (illus 33). An even greater difference would be seen were this offset applied to the sheep and otter showing much more elevated δ^{13}C values (see below).

Discussion

Accepting a small input of marine-derived protein in at least three individuals at Holm of Papa Westray North, the question of the specific source of this contribution arises. The site is immediately adjacent to the sea, so the most obvious suggestion is that a small amount of shellfish, fish and/or marine mammals were utilised and are responsible for the slightly elevated human values. The remains of shellfish and fish were found within the chambered tomb, including a number of large cod and conger eels that were probably caught by hook and line; the origins of the smaller fish also present, on the other hand, is more likely to be the result of otters using the monument as a holt after it ceased being used for burial (Harland and Parks, this volume). The faunal assemblage from Knap of Howar again includes a range of fish and shellfish species, though it is difficult to quantify their importance to the overall diet using traditional zooarchaeological approaches (Evans & Vaughan 1983; Wheeler 1983). The slightly elevated δ^{13}C values seen in the humans from HPWN suggest that fishing played a minor role in overall subsistence practices.

An interesting alternative possibility presents itself in the extremely elevated δ^{13}C values associated with initial AMS determinations on two neonatal lambs from Holm of Papa Westray North[1] (Ashmore 2001, 125; Sheridan & Higham 2006), and confirmed by isotopic analyses run separately on one animal. An additional eight sheep from HPWN and Knap of Howar do not show similarly elevated values, and indeed are not far from the terrestrial baseline (Table 24; illus 32). The suggested explanation for this is that pregnant ewes are feeding on seaweed in the months before giving birth, such that the newborn lambs show a strong marine signal (Schulting *et al* 2004). The contribution of seaweed to the overall adult diet seems to have been far less important, at least as seen in the available δ^{13}C values. Interestingly, the two adult sheep values from HPWN are slightly but significantly elevated ($t = 2.73$; $p = 0.017$) compared to the six sheep from Knap of Howar (using only the new measurements; the difference would be even more marked were the values associated with the retracted OxA measurements to be used). Combined with the elevated values for lambs from HPWN, this pattern concurs with the findings of Balasse and Tresset (this volume; Balasse *et al* 2006), who analysed δ^{13}C and δ^{18}O in tooth enamel of sheep from both sites, and found that evidence for the seasonal consumption of seaweed was only present at HPWN. The practice of grazing sheep on seaweed in recent times is of course well-known from North Ronaldsay (Fenton 1978), where it results in more elevated values for adults than seen here (Ambers 1990; Caumette *et al* 2007).

As noted above, the δ^{15}N values on the humans from HPWN are not particularly high in the context of a series of apparently purely terrestrial human values from other coastal Scottish chambered tombs. The δ^{15}N values for the domestic fauna from HPWN and Knap of Howar average close to 7‰. Applying the standard 3–4‰ trophic level shift (Schoeninger *et al* 1983; Bocherens & Drucker 2003) would result in human values of around 10–11‰, which is close to the observed average of 10.6‰. However, this would imply that nearly all of the protein in the diet of this community came from the meat and/or milk of its animals. While this is possible, it would present a rather extreme scenario, given what is known about more recent mixed farming communities, and the evidence for the cultivation of cereals on Neolithic Orkney, including at Knap of Howar (Dickson 1983). The high δ^{15}N value of 10.6‰ for the 'marine' lamb is relevant here. As the animal is at latest a newborn, this cannot be explained as a nursing signal, and in any case it is probably too high for this. But, unlike most terrestrial plants, seaweeds often exhibit high δ^{15}N values: indeed, Caumette *et al* (2007) report a value of 12.95‰ for seaweed from North Ronaldsay. If such animals made a contribution to the diet of the community using HPWN, they would help account for the high human values here, though leaving the similar values from other sites to be explained. This issue needs further exploration (eg Hedges 2007; Hedges *et al* 2008) and is beyond the scope of this paper, and indeed probably of the presently available information. One possibility that might be noted is the manuring of intensively managed infields, as has been suggested recently by Bogaard *et al* (2007). This would seem particularly germane in Orkney, where good arable land is relatively restricted (though Papa Westray itself is quite fertile), and the sophistication of animal management practices is perhaps already hinted at through the seaweed grazing of sheep. In Orkney, as indeed in many other coastal locations, there would be the option of manuring with high-δ^{15}N seaweed, as well as animal dung, again a practice attested historically (Fenton 1978). The end result of such manuring would be to increase δ^{15}N values in both the cereal grains, and in the remaining animal fodder.

It should be emphasised that we are not suggesting that neonatal lambs would be contributing in any substantial way to human diet. Rather, the economic focus would be on culling immature animals, particularly males, of some months age. The δ^{13}C signatures of these lambs would begin to move towards a more terrestrial signal, as they nursed on milk supplied by sheep grazing on spring and summer grass. Their δ^{15}N values would remain high as a result of the nursing effect.

It is clear that further research on this topic is needed in order both to understand Neolithic animal management practices, and the impact of these practices on human diet in Orkney. The available AMS determinations place the isotopically elevated lamb/s from Holm of Papa Westray North significantly later than the humans. It may well be the case that practices varied over time and that later Neolithic human isotope values would demonstrate a more marked, albeit indirect, marine input. Unfortunately, no suitable stable isotope data are associated with the two later Neolithic dates obtained by Glasgow. Thus, the elevated values noted here for the earlier Neolithic could conceivably still derive primarily or entirely from the more direct consumption of a small amount of marine protein, in the form of shellfish and fish. Nevertheless, the provisional interpretation being forwarded here is that the practice of seasonally grazing at least some pregnant ewes on seaweed, and the resulting 'marine' isotope values for their newborn lambs, is also responsible in part for the slightly elevated human δ^{13}C results. While there is a tendency to see this as reflecting a 'sophisticated' Neolithic economy, the fact that the evidence is thus far limited to Holm of Papa Westray and is not found on adjacent Papa Westray, suggests an alternative explanation: sheep are being left largely to their own devices, and it is the far more limited terrestrial grazing opportunities on the rocky Holm that forced the animals to turn to seaweed for part of the year (Balasse & Tresset, this volume; Balasse *et al* 2006). But this in itself implies a conscious decision on the part of the community, so that this distinction perhaps should not be overdrawn.

Despite the argument for a contribution of marine protein – whether direct or indirect – in the diets of the group using the chambered tomb of Holm of Papa Westray North, it is important to emphasise that the main focus in the subsistence economy was very much based on *terra firma*. The inhabitants of Papa Westray, and indeed all Orkney, maintained a highly successful mixed farming economy. This is seen clearly in the large Early Neolithic faunal assemblage from Knap of Howar, which is overwhelmingly dominated by domestic animals, and in particular sheep and cattle (Noddle 1983; Schulting *et al* 2004; Tresset 2003). While the results from HPWN may provide some evidence for regional variation in Neolithic diets, the length of the discussion required to make a convincing case indicates how minimal was the use of marine subsistence resources. Thus, as has been argued for Britain as a whole, the Neolithic still seems to have seen a rapid and strong shift in diets between the Mesolithic and the Neolithic (Richards *et al* 2003a; Schulting 2004). While this is most clearly observed in coastal contexts, since this is where the stable isotope technique works best, there is no reason to think that the same did not occur in inland areas (*contra* Thomas 2003). In the case of Orkney specifically, Mesolithic human remains have yet to be found, though there is increasing lithic evidence for the presence of people at this time (Saville 1996), as well as new dating evidence (Wickham-Jones 2007). But Late Mesolithic humans from Oronsay have shown just how extremely at least some groups were focused on marine resources (Richards & Mellars 1998; Richards & Sheridan 2000; Schulting & Richards 2002).

Milner *et al* (2004) have criticised the stable isotope data, pointing to zooarchaeological evidence for the continued use of marine resources in the Neolithic of Britain and Denmark (where a comparable, if rather more complex, shift in isotope values is seen – Fischer *et al* 2007; Richards *et al* 2003b; Tauber 1986). But, as we have argued elsewhere (Richards & Schulting 2006), the isotopic and zooarchaeological evidence operates at different scales and resolutions. It is very difficult to quantify the contribution of fish and shellfish protein in the overall diet: a single cow can provide the equivalent protein and calories of a small shellmidden. Sites may reflect only a seasonal or special purpose aspect of the overall subsistence economy, and then there are issues of taphonomy and differential recovery to take into account. Knap of Howar and HPWN are a case in point, in terms of quantifying the contributions of marine and terrestrial protein. Cattle and sheep overwhelmingly dominate the terrestrial fauna.

While there is zooarchaeological evidence for the consumption of marine foods, the stable isotope measurements on human remains indicate that their overall contribution to diet was small, if detectable with some effort (though even this may be indirect in the form of seaweed-eating sheep). The two lines of evidence in this case at least, appear to be more complementary than contradictory.

The AMS results on human bone presented here, centring on 3520–3360 cal BC, are considerably earlier than all previously available dates on human and animal bone from Holm of Papa Westray North, and support the likelihood of a link, originally proposed by Ritchie, between the chambered tomb and the Neolithic settlement at Knap of Howar, less than 3km distant. While Holm of Papa Westray is now a small island off the east coast of Papa Westray, it was probably still a promontory of the larger island in the earlier Neolithic (Ritchie 1983, 59). New dates from Knap of Howar suggest that it was not in use much before about 3500 cal BC (Sheridan & Higham 2006; 2007), which is perfectly consistent with the early human results from the chambered tomb of 3520–3360 cal BC reported here. This is in contrast to the significantly later date of 3340–2910 cal BC (GU-2068: 4430 ± 60 BP) for what was apparently a primary burial in the undisturbed chamber 4. The explanation for this may be that, while this was an undisturbed burial, it was placed into a chamber that was either cleared out, or was empty at the time. There are numerous examples of empty chambers in Neolithic tombs, so that such a situation would not be unusual. One of the early dates reported here (GrA-25638) also derives from the lowest level of an undisturbed chamber, in this case end cell 5. That this is indistinguishable from the other two early dates (GrA-25637 and 25638) from the disturbed fills of 3W and 3E suggests that these latter two individuals also relate to the primary use of the monument, and represent redeposited material from Petrie's 19th-century investigations (Ritchie, this volume).

On the available dates, use of the settlement at Knap of Howar seems to extend until about 3000 BC, and two previously obtained radiocarbon determinations on human bone from HPWN (see above and Table 17) also date to this period. But the small number of human remains, perhaps 10 or so individuals (Davidson & Henshall 1989, 121), can hardly represent all of the dead from Papa Westray over a period of some five centuries. There are one or possibly two other chambered tombs on Holm of Papa Westray, but the limited information available does not suggest that either held very large quantities of human bone. No chambered tombs are known from Papa Westray itself (Ritchie 1983). Nineteenth-century and possibly earlier disturbances may have resulted in the loss of some material from the tombs on Holm of Papa Westray (Davidson & Henshall 1989, 120), though this is unlikely to be the entire explanation. Nor is this situation unusual, as many chambered tombs hold relatively few human remains (Davidson & Henshall 1989). Isbister (Hedges 1983) and Quanterness (Renfrew 1979) stand out as exceptions in this regard, with *c*.340 and *c*.157 individuals represented, respectively (though because of the way these numbers were originally calculated, they may be considerably exaggerated (Lawrence 2006)). A series of 10 determinations on human bone from Point of Cott on neighbouring Westray shows a similar pattern to that seen at HPWN, with the three earliest dates being indistinguishable between the sites, and the others extending down to the late fourth/early third millennia BC (Barber 1997; this volume, illus 29). No specific palaeodietary analyses have been undertaken on the Point of Cott humans, but two values associated with AMS determinations in infants (AA-11697, 4505 ± 60 BP, –20.1‰; AA-11698, 4585 ± 85 BP, –19.6‰) (Barber 1997) hint at the possibility of a slight contribution of marine protein comparable to that seen at HPWN.

Conclusions

The new AMS determinations reported here on three individuals from the Neolithic chambered tomb of Holm of Papa Westray North support the use of the monument *c*.3520–3360 cal BC, significantly earlier than the two previously available dates on human bone from the chambers – modelling of the dates is presented in Table 17. This supports the notion that the monument was built and used from an early stage by the Neolithic settlers of Knap of Howar. Later Neolithic dates from both the monument and the settlement show continued use of both, though the total number of deceased at HPWN is far too small to represent all of the dead of even a small community over a span of centuries. This, however, is not an unusual finding in the context of Neolithic Britain as a whole, though there are exceptions, such as Isbister and Quanterness.

While the diets of the individuals interred in Holm of Papa Westray North are predominantly terrestrial, as inferred by stable carbon and nitrogen isotope measurements, there is the possibility of a slight contribution of marine protein. It is argued here, with due caution, that this may have been introduced in part into the diet indirectly, through the consumption of lambs, and, to a lesser extent, adult sheep, seasonally feeding on seaweed. This seems to have occurred specifically on the small island or promontory of Holm of Papa Westray, where animals may have been left to fend for themselves. The origins and development of this management practice, if that is what it represents, require further investigation, as does its impact on human diet.

Note

1. Due to a filter contamination problem in the Oxford laboratory, the dates reported in Ashmore (2001, 125) have been withdrawn (see Ashmore this volume; Sheridan & Higham 2006; 2007). One of the two elevated lamb samples has been reanalysed both for dating and isotopes and has confirmed a high δ^{13}C value. While the date is rejected, the second animal's δ^{13}C value of –12.8% should be broadly correct, as ^{13}C would be less affected by the contamination problem than ^{14}C.

A KEY TO THE ADAPTATION OF NEOLITHIC HUSBANDRY IN THE ORKNEYS: CONTRIBUTION OF SEAWEED TO THE SHEEP DIET AT THE HOLM OF PAPA WESTRAY, REVEALED THROUGH STABLE ISOTOPE ANALYSIS (δ^{18}C AND δ^{18}O) OF TEETH

Marie Balasse and Anne Tresset

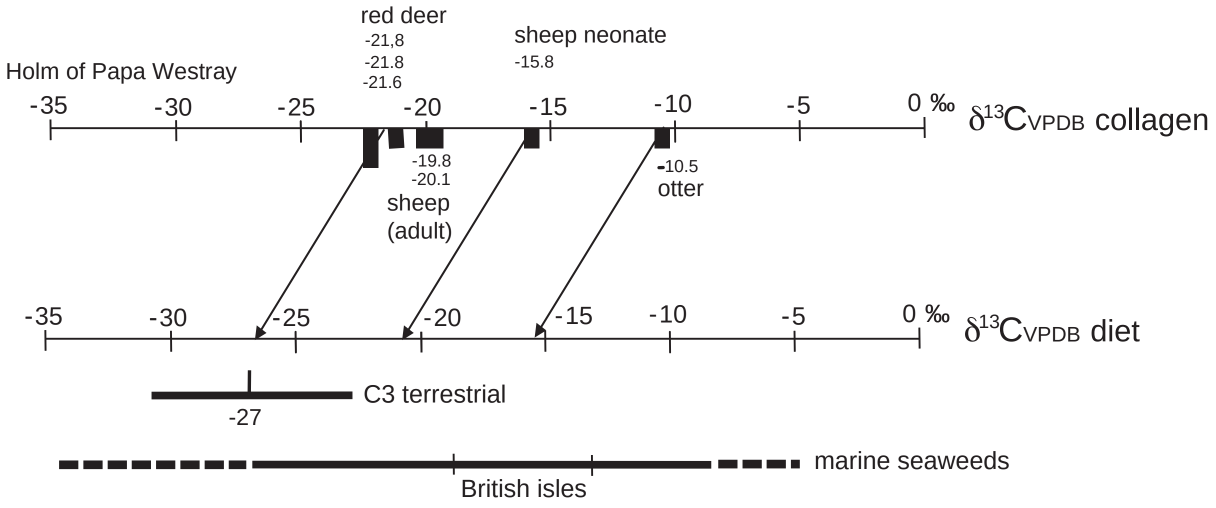
Introduction

Seaweeds have been traditionally used as winter fodder in several regions of the north-western coastline of Europe. An extensive survey of the literature on the subject reveals both the antiquity and the ubiquity of this practice. Virtually all the seaweeds common in our regions (kelps, wracks, dulse and carrageen) have been used. Additionally, in the same area, free range domestic animals feed on seaware, occasionally or on a more regular basis. The most emblematic examples of this are the sheep of North Ronaldsay (Orkney) that feed exclusively on seaweeds all the year round, a behaviour reputed to have begun during the 19th century. In this paper we demonstrate that the adaptation to ingesting important quantities of seaweeds, which implies physiological adjustments, began much earlier. In Orkney at least, it occurred during the Neolithic, a few centuries after the initial introduction of husbandry and domestic stocks to these islands.

Antiquity and ubiquity of the use of seaweeds as fodder

The use of seaweeds to feed domestic animals has been described in Brittany, Scotland, Iceland and Norway. Until recently, dulse (*Palmaria palmata*) was dried and fed to cows at winter time on the Breton isle of Sein and the same species was consumed by cattle directly on the shore on Ushant, Sein and Batz islands (Brittany; Chapman 1970; Arzel 1987). In Brittany, this practice dates back to the 6th century AD at least, as it is mentioned in the old laws collection *Excerpta de libris romanorum and francorum* (Fleuriot 1986). During recent times in Iceland, dulse was also dried, or cooked, to be used as winter fodder for cattle, sheep and horses, together with dabberlocks (*Alaria esculenta*; Hallson 1964). This last species was also fed, dry, to cattle in Norway. In the same region, serrated wrack (*Fucus serratus*) was used together with sea lace (*Chorda filum*) and horsetail kelp (*Laminaria digitata*) as occasional winter fodder (Chapman 1970).

In Scotland, Martin Martin reports in his *Description of the Western Islands of Scotland* (1703) that at the end of the 17th century AD cattle fed on seaware on the island of Lingay (Outer Hebrides) at winter and springtime. More recently, dabberlocks were also boiled and used as shortage fodder at the end of harsh winters in the Shetlands (Fenton 1978). Nowadays, on the island of North Ronaldsay (Orkney), sheep (pregnant ewes excepted) feed exclusively on seaweeds all the year round, as they are kept from grazing inland by a wall built in 1832, and only have access to the shore. There, they find kelp washed ashore by storms at wintertime and different red seaweeds such carrageen, sea beech (*Delesseria sanguinea*) and the species *Odonthalia dentata* during spring and summer. In order to be able to digest the components of red and brown algae, the microbiological flora of sheep rumen had to adapt. In North Ronaldsay, this adaptation was believed to be very recent, dating back to the building of the wall around the island. We discovered, by accident, that this was not the case and that it had, quite on the opposite, a very long history.



Illus 34

Stable carbon isotope composition (δ^{13}C) of bone collagen from mammals from Holm of Papa Westray (data Schulting & Richards, this volume) and estimated corresponding values for their diet.

Radiocarbon dating and δ^{13}C values of sheep bones, or how we discovered that Neolithic sheep ate seaweeds at Holm of Papa Westray

Bone samples from Holm of Papa Westray North selected by one of us (AT) in 2000 for radiocarbon dating and sent to Oxford Radiocarbon Accelerator Unit yielded unexpected δ^{13}C values associated to dates produced on two sheep neonates (Bronk Ramsey *et al* 2002). These δ^{13}C were extremely high for a terrestrial herbivorous species in a C$_3$ environment (–14.6‰ and –12.8‰) and suggested that these animals had a marine component in their diet. Since then the dates in question have been withdrawn (Sheridan & Higham 2007) as being faulty due to filter contamination problems and measurements have been redone for a number of remains including one of the two bones (which yielded a δ^{13}C very similar to the initial one). Despite these changes, the reasoning that led us to demonstrate that sheep had indeed ingested seaweeds still stands.

Marine seaweeds and terrestrial plants rely on different carbon sources (dissolved inorganic carbon *versus* atmospheric CO$_2$) and use different carbon acquisition mechanisms for photosynthesis (Raven *et al* 2002). Consequently, they have different δ^{13}C values. Modern terrestrial C$_3$ plants have δ^{13}C with a modal value of –27‰ (O'Leary 1988; Tieszen & Boutton 1988; Tieszen 1991). Once corrected for the fossil fuel effect (+1.4‰: Freyer & Belacy 1983; Stuiver *et al* 1984; Friedli *et al* 1986; Cerling & Harris 1999), they suggest a modal δ^{13}C value close to –25.6‰ for pre-industrial C$_3$ plants. Specimens of modern seaweed species collected in Scotland and England have δ^{13}C values ranging from –18.5‰ to –13.1‰ (Raven *et al* 2002). The magnitude of the fossil fuel effect in oceanic ecosystems is lower than in the atmosphere due to the time lag for equilibration of the water reservoir with atmospheric CO$_2$ (Takahashi, Matsumoto & Watanabe 2000; Bauch *et al* 2000). However, if pre-industrial marine plants supposedly had slightly higher δ^{13}C than modern marine plants, the effect differs regionally and has not been measured in the study area. The difference in the δ^{13}C of terrestrial and marine plants is passed to the herbivore bone collagen with a ^{13}C-enrichment of 5‰ (Vogel 1978; Sullivan & Krueger 1981; Lee-Thorp *et al* 1989).

At Holm of Papa Westray, the remeasured δ^{13}C values clearly reflects feeding on terrestrial plants for the red deer (mean= –21.7‰, N=3), while the bone of one adult sheep delivered a slightly higher δ^{13}C value (mean= –20.0‰, N=2), and the bone of one sheep foetus even higher δ^{13}C values (–15.3‰), closer to the δ^{13}C values measured on the fish-eating otter bones (–10.5‰) reflecting hunting in the marine ecosystem (illus 34: data Schulting & Richards, this volume).

As reviewed above, there are many cases in different locations of the north-western coastline of Europe

Table 26

Minimum and maximum carbon (δ^{13}C) and oxygen (δ^{18}O) stable isotope compositions measured in enamel bioapatite from sheep and red deer third molars (M3) from Holm of Papa Westray (HPWN) and Knap of Howar (KH) and corresponding position in the crown (mm from the neck).

Specimen ID	*Isotope analysis ID*	δ^{13}C *VPDB (‰)*					δ^{18}O *VPDB (‰)*				
		min	*mm*	*max*	*mm*	Δ	*min*	*mm*	*max*	*mm*	Δ
HPWN 2 W 1	HPWNovis7 M3	–10.1	6.3	–4.1	20.5	6	–3.7	19.5	–1.7	7.3	2
HPWN 5 2	HPWNovis8 M3	–11.1	5.1	–7.1	14.1	4	–4.2	11.9	–1.7	3.1	2.5
HPWN 3E1	HPWNovis9 M3	–11.4	5.72	–8.2	13.7	3.2	–4.3	15.0	–2.5	5.7	1.8
HPWN 3E1	HPWNovis 10 M3	–9.8	8.6	–6.3	22.8	3.5	–3.5	18.0	–1.6	8.6	1.9
HPWN V 2	HPWNovis 11 M3	–10.8	6.8	–8.6	15.8	2.2	–4.6	17.1	–2.2	7.8	2.4
HPWN 2 E 4	HPWNovis 12 M3	–11.4	4.9	–5.6	15.0	5.8	–4.0	16.4	–2.3	22.0	1.7
HPWN V 2	HPWNcervus1 M3	–13.4	18.3	–12.7	5.1	0.7	–4.6	18.3	–4.0	5.1	0.6
KH II 1	KHovis 5 M3	–12.2	13.4	–11.3	4.0	0.9	–5.3	20.7	–1.8	8.6	3.5
KH II 1	KHovis 6 M3	–11.9	15.1	–10.6	21.1	1.3	–4.7	21.1	–2.4	11.5	2.3
KH House I 9	KHovis 7 M3	–11.2	29.4	–10.2	17.1	1	–5.3	18.3	–2.7	8.4	2.6
KH73 III 3	KHovis 8 M3	–11.4	16.4	–10.8	8.3	0.6	–6.4	22.4	–1.2	10.8	5.2
KH73 III 3	KHovis 9 M3	–13.2	8.8	–12.2	15.5	1	–5.8	7.7	–1.9	20.0	3.9
KH II 1	KHovis 10 M3	–13.0	18.2	–11.8	2.8	1.2	–4.7	4.9	–2.4	12.6	2.3
KH House I 11	KHovis 11 M3	–12.6	17.4	–11.2	27.6	1.4	–4.8	23.3	–1.8	12.2	3

where seaweeds are either an all year round diet basis or a common winter fodder and we had to consider these possibilities to explain the high $\delta^{13}C$ observed on some sheep remains. However, the fact that only very young subjects had clearly marine signatures was puzzling. As these animals were neonates or at least still suckling, the explanation had to include the mother's diet, the nature of which directly reflects on the isotopic signature of the young's tissues *in utero* or though the milk. But, at the same time, an all year round feeding on seaweeds seemed excluded, as it should have shown more clearly in the $\delta^{13}C$ values obtained on adults (these values are only slightly, though significantly, higher than the ones obtained on the red deer from the same site and on the sheep from the earlier site of Knap of Howar, also located in Orkney, see Schulting & Richards, this volume). A possibility was that marine signatures of neonates, incorporated during their intrauterine life, reflected a seasonal diet of their mothers, based on seaweeds. This implied that the isotopic signature had been recorded during winter and early spring, as this is the time of ewes' gestation in this part of the world (birth season is set in April and May and gestation is approximately 5 months long). Thus, all these elements strongly suggested that sheep had relied on seaweeds during the cold season, that this had been voluntarily managed by humans (foddering) or not (free ranging animals having access to the shore and relying on a resource abundant at this time of the year). This hypothesis was investigated through the isotopic analysis of tooth enamel micro-samples.

Principles of the sequential analysis ($\delta^{13}C$, $\delta^{18}O$) of tooth enamel

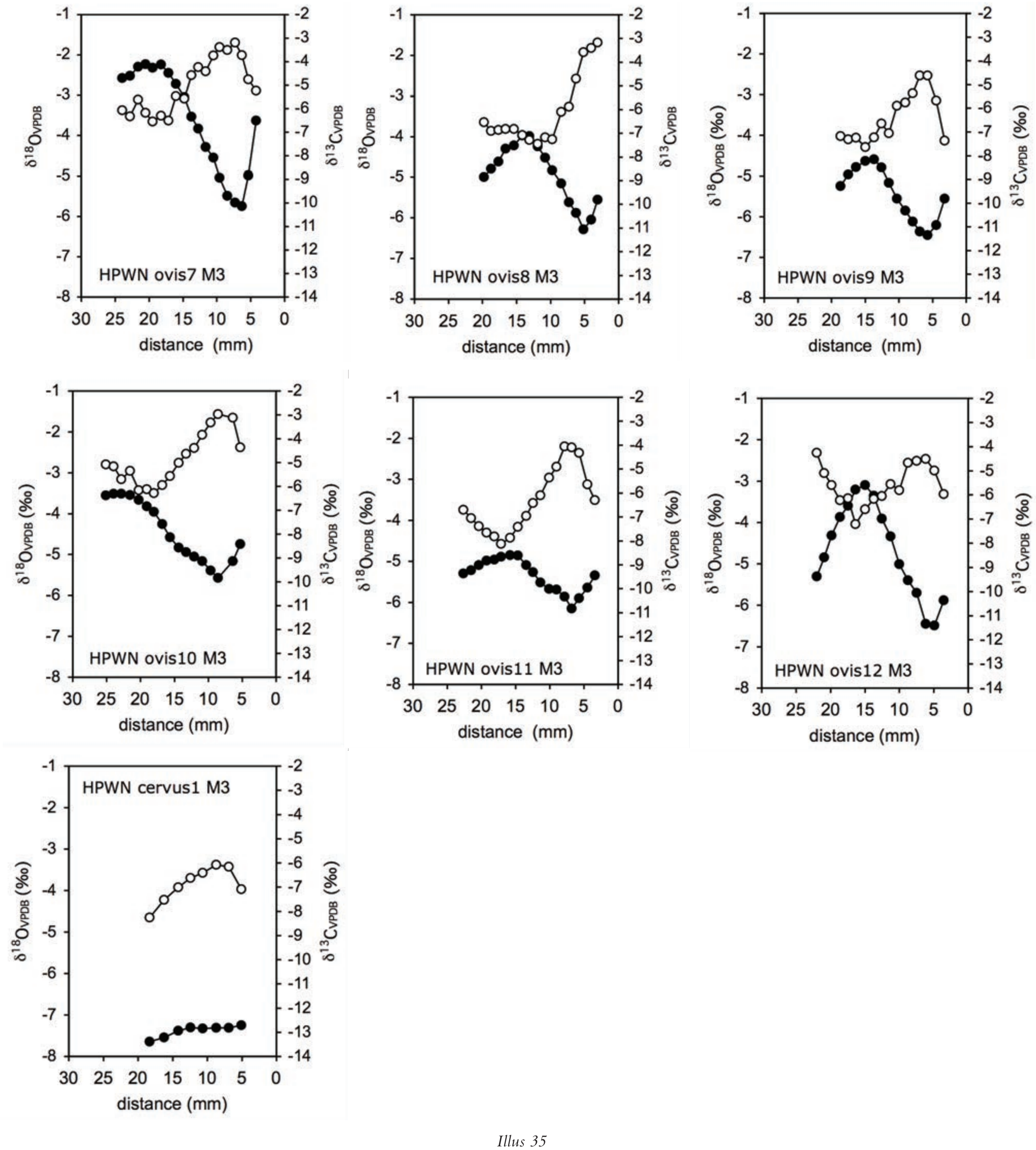
Seasonal contribution of marine resources to the sheep diet can be investigated by conducting a sequential analysis of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope compositions of tooth enamel mineral fraction (bioapatite). The carbon stable isotope composition of bioapatite is controlled by that of diet (Krueger & Sullivan 1984; Lee-Thorp & van der Merwe 1987; Ambrose & Norr 1993; Tieszen & Fagre 1993), with a ^{13}C-enrichment of 14.1‰ (Cerling & Harris 1999).

The oxygen isotope composition ($\delta^{18}O$) of enamel bioapatite is linked to that of ingested water, indirectly meteoric water for terrestrial animals (Land *et al* 1980; Longinelli 1984; Luz *et al* 1984). At high and middle latitudes, the $\delta^{18}O$ of precipitation varies seasonally with ambient temperature (Gat 1980). These seasonal changes are recorded in enamel bioapatite during tooth growth. A sequential sampling following the tooth growth axis permits to access the temporal changes in enamel bioapatite $\delta^{18}O$ and to reconstruct the seasonal cycle. A coupled analysis of enamel $\delta^{13}C$ and $\delta^{18}O$ permits to detect the consumption of marine resources and to track any seasonal changes in their contribution, as demonstrated on the molars from modern seaweed-eating sheep from the North Ronaldsay island in the Orkney archipelago (Balasse *et al* 2005).

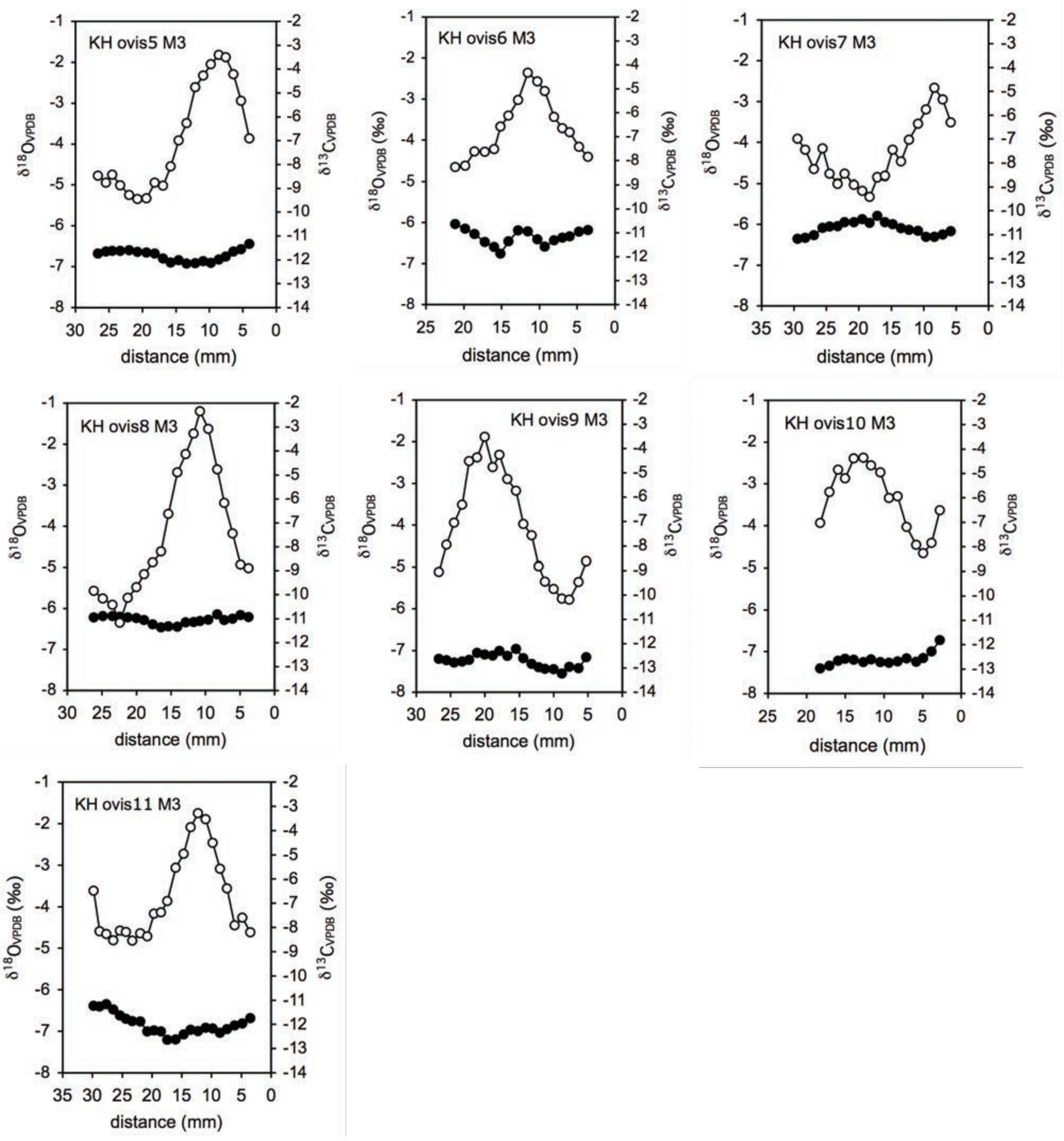
Previous studies investigating sheep diet at the Holm of Papa Westray also included for comparison the analysis of sheep and cattle teeth from the Middle Neolithic assemblage of Knap of Howar, a small farmstead on Papa Westray, dated to about 3600 BC (Ritchie 1983). Its occupation corresponds to the very first colonisation of the archipelago by farming communities. Several thousand bone fragments were recovered, including predominantly cattle and sheep. Sheep husbandry seems to have been mostly oriented toward meat production, as documented by the kill off pattern obtained on the basis of tooth wear analysis (Tresset, unpublished). Comparing the diet of domestic stock at Holm of Papa Westray and Knap of Howar permits a diachronic approach of the history of adaptation of husbandry to the archipelago. Earlier isotope studies conducted on both assemblages concluded to a winter contribution of marine resources to the sheep diet at Holm of Papa Westray and exclusive reliance on terrestrial resources for both sheep and cattle at Knap of Howar (Balasse *et al* 2006). These studies included a limited number of teeth: six sheep teeth from Holm of Papa Westray and four sheep teeth and five cattle teeth at Knap of Howar. In order to confirm earlier conclusions, the present study enlarges the data set, including new material from both sites.

Material and methods

Six sheep third molars (HPWNovis7-12 M3) and a red deer upper third molar (HPWNcervus M3) from Holm of Papa Westray and seven sheep third molars from Knap of Howar (KHovis 7-12 M3) were selected for the analysis. From tooth development and wear, these teeth belong to different individuals, and cannot be paired with individuals sampled earlier. Sampling of sheep teeth was performed on the buccal side of the middle lobe on the lower third molars, on the lingual side of the anterior lobe of the upper third molars. The red deer upper third molar was sampled on the lingual side of the anterior lobe.



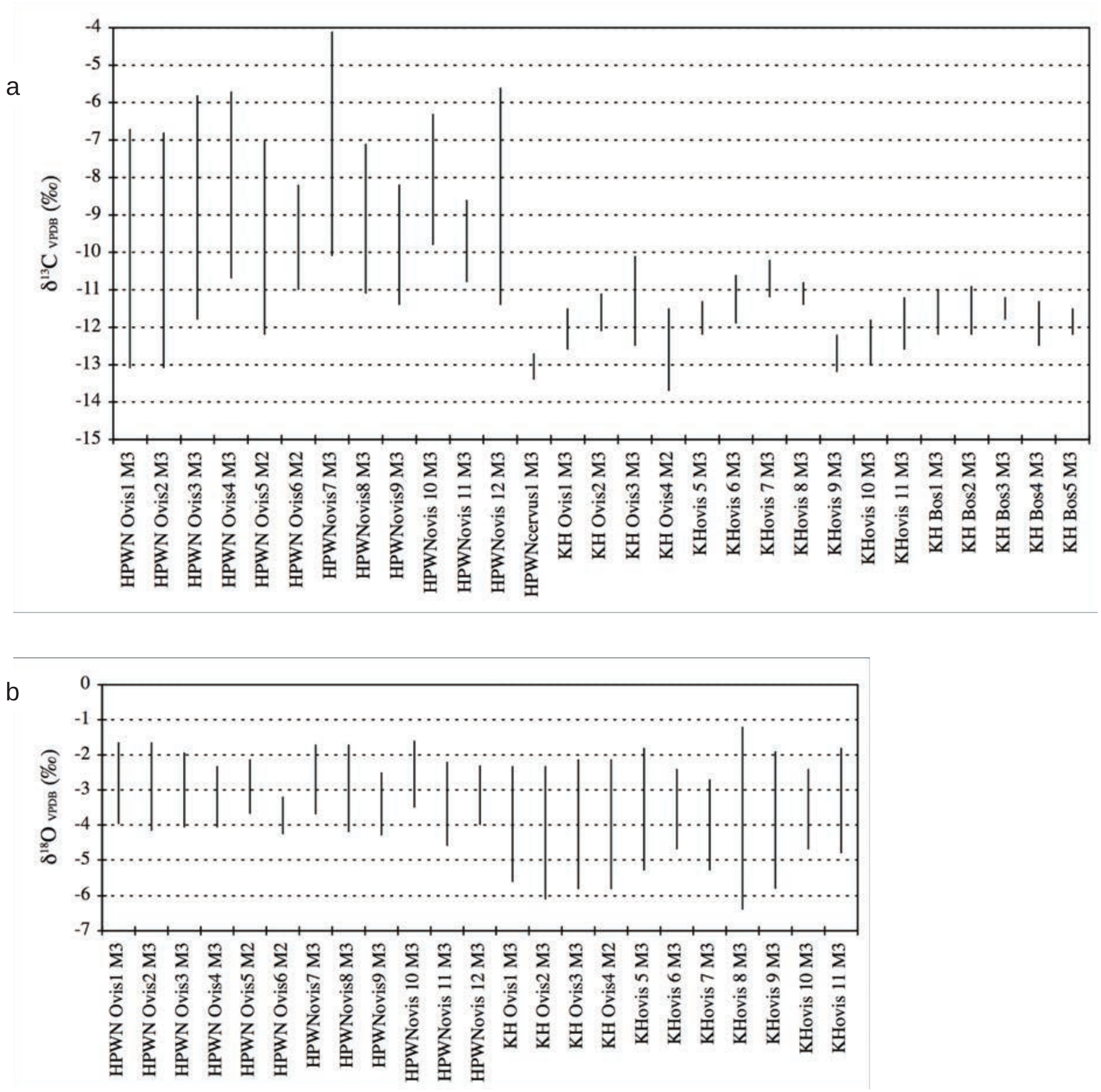
Illus 35
Intra-tooth variation of the carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope compositions of enamel bioapatite from sheep (HPWNovis7-12) and red deer (HPWNcervus1) third molars (M3) from Holm of Papa Westray. Distance: distance from the enamel-root junction.



Illus 36
Intra-tooth variation of the carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope compositions of enamel bioapatite of sheep third molars (M3) from Knap of Howar. Distance: distance from the enamel-root junction.

Tooth enamel surfaces were cleaned by abrasion with a tungsten drill bit. Enamel was sequentially sampled from the apex to the cervix of the crown with a diamond burr bit. Each sample is a 1mm-wide groove perpendicular to the tooth growth axis, drilled through the whole thickness of the enamel layer. Fourteen to 23 samples were drilled out of the sheep third molars and eight sampled was drilled on the red deer third molar.

Enamel powder was treated for bioapatite extraction as described in Balasse *et al* (2002). Purified bioapatite samples weighing 500 to 650µg were then reacted with 100% phosphoric acid at 70°C for 240 seconds in individual vessels in an automated cryogenic



Illus 37

Range of variation of the carbon (a) and oxygen (b) stable isotope ratios measured in tooth enamel of sheep (ovis), cattle (bos) and red deer (cervus) from Holm of Papa Westray (HPWN) and the Knap of Howar (KH). Data: Balasse *et al* (2006) and this study.

distillation system (Kiel IV device) interfaced with a Delta V Advantage isotope ratio mass spectrometer. Over the period of analysis of the bioapatite samples, the analytical precision estimated from analysis of 129 samples of the laboratory internal carbonate standard (Marbre LM) produced an analytical precision of 0.02‰ for δ^{13}C and 0.06‰ for δ^{18}O.

Results

Results from the stable isotope analysis are presented in illus 35 and 36 and in Table 26. A total number of 243 samples were analysed, all of which delivered both a δ^{13}C and δ^{18}O value. Because of the size of the dataset, only minimal and maximal values measured in each tooth are presented in Table 26. Illus 37 includes previously published stable isotope values and the new data from this study.

Oxygen stable isotope values

Oxygen stable isotope values measured in sheep tooth enamel bioapatite vary from −4.6‰ to −1.6‰ at Holm of Papa Westray and from −5.8‰ to −1.2‰ at Knap of Howar. Oxygen stable isotope values measured in the red deer tooth enamel vary from −4.6‰ to −4.0‰ (Table 26). All teeth recorded sinusoidal variations, reflecting most probably the seasonal cycle. The time sequence recorded in the sheep teeth is always close to a year, whereas the red deer third molar delivered a signal covering slightly less than half a year (illus 35), corresponding to the warm season as suggested by the peak towards the highest δ^{18}O values (Gat 1980). The amplitude of variation of the δ^{18}O values recorded in the sheep from Holm of Papa Westray is lower than those measured in the sheep from Knap of Howar and this is due to higher minimum values whereas the maximum values are comparable. This confirms previous observations at both sites (Balasse *et al* 2006).

Carbon stable isotope values

Carbon stable isotope values measured in the red deer tooth from Holm of Papa Westray are stable and range from −13.4‰ to −12.7‰ (illus 35 and Table 26). A 14.1‰ ^{13}C-enrichment between diet and enamel bioapatite (Cerling & Harris 1999) would lead to δ^{13}C values of −27.5‰ to −26.8‰ for diet, reflecting feeding on terrestrial plants for the all duration of the warm season. The range of variation of the carbon stable isotope values measured in sheep from Knap of Howar (−13.2‰ to −10.2‰, reflecting δ^{13}C values of −27.4‰ to −24.3‰ for diet) and the low amplitude of intra-tooth variation (0.6‰ to 1.4‰; Table 26) suggest feeding on terrestrial plants all year round (illus 36). Higher values were measured in the sheep teeth from Holm of Papa Westray, varying from −11.4‰ to −4.1‰. In these individuals, the amplitude of intra-tooth variation for δ^{13}C values varies from 2.2‰ to 6.0‰ (Table 26), and δ^{13}C and δ^{18}O values covary conversely: the highest δ^{13}C are measured when the δ^{18}O values are the lowest (illus 35), suggesting contribution of a ^{13}C-enriched diet over winter time, most probably marine seaweed.

Discussion

Difference between Holm of Papa Westray and Knap of Howar: a consequence of the environmental setting?

The whole dataset available for discussion, including previously published data (Balasse *et al* 2006, Balasse & Tresset 2007) and data from the present study, is composed of 12 sheep molars (MNI=11) and one red deer molar from Holm of Papa Westray, and 11 sheep teeth (MNI=11) and five cattle molars (MNI = 5) from Knap of Howar. It is striking to note that at Knap of Howar seaweed consumption could be not detected in any of the five cattle and 11 sheep analysed, while at the Holm of Papa Westray seaweed contributed to the winter diet of all of 11 sheep analysed. This suggests that the contribution of marine resources was not a common practice (if not totally absent) at the earlier site of Knap of Howar, whereas it seems to have been a recurrent (if not systematic) practice at Holm of Papa Westray, several centuries later.

The location of the Holm of Papa Westray could partly explain the difference between both sites, for the Holm of Papa Westray is a small islet peripheral to Papa Westray. Both this particular setting and the presence of thousands of bones of very young lambs and foetuses in the tomb (Tresset 2003) suggest that the monument provided a shelter against strong winds and precipitations to a herd most probably wandering freely. The islet might have served as penning area, as part of an extensive herding strategy, as is commonly practiced in Brittany, Scotland and Ireland (Schulting *et al* 2004). Even though at the time of occupation of the site it might have been possible to link the islet to Papa Westray at low tide, the rarefaction of the vegetal cover during winter might have been particularly constraining.

A strictly terrestrial red deer

In this regard, it is interesting to note that the δ^{13}C values measured in the red deer tooth enamel do not suggest the consumption of marine resources, although this species was observed to include a significant amount of seaweeds to its winter diet when living in similar environmental contexts (Clutton-Brock *et al* 1982; Conradt 2000). Despite that the time sequence recorded in the third molar only spans the warm season, the incursion towards lower δ^{18}O values in bioapatite sampled between 20 and 10mm from the neck is not correlated with a change towards higher δ^{13}C values, making contribution of seaweed at winter time unlikely (illus 35). Moreover, the δ^{13}C values measured on collagen for the same species (–21.7‰, illus 34) do not suggest any contribution of marine resources to the red deer diet. This raises important questions. First, the absence of reliance on seaweeds in Neolithic red deer might have to do with the history of their behavioural adaptation to the British islands. Red deer was introduced to Orkney, the Outer Hebrides and in Ireland at the beginning of the third millennium BC (Serjeantson 1990; Woodman *et al* 1997; Tresset 2002; 2003). If the individuals present at Holm of Papa Westray were among the first populations introduced, a diversification of their dietary behaviour might have occurred later. Nevertheless, the presence of red deer bones at the site does not necessarily induce that red deer were living on the islet. These individuals might have been hunted on Westray or Papa Westray (Tresset 2003), where a larger availability of terrestrial resources would not have required reliance on marine seaweeds for survival in winter.

The role of the herders

Alternatively, if red deer came alive to the islet and eventually spent some time between this location and Papa Westray, their non-reliance on seaweeds suggests that sheep, in the same way, could have survived on terrestrial plants during winter. The fact that they did not raises the question of the role of the herder in the introduction of seaweeds to the sheep diet. The provision of dried seaweeds as fodder to domestic stock has been reported in recent history in Iceland and Norway, in the British Isles and in Brittany (Hallson 1964; Chapman 1970; Arzel 1987; see above). However, the δ^{18}O values measured in the sheep teeth suggest that it was not the case at Holm of Papa Westray. Reduced amplitudes of intra-tooth variation in δ^{18}O values were observed in modern seaweed-eating sheep from North Ronaldsay, explained by the ingestion of oceanic water through consumption of fresh seaweeds (Balasse *et al* 2005). A similar observation could be made on the sheep teeth from Holm of Papa Westray, where the amplitude of variation of δ^{18}O values is lower than that observed at Knap of Howar (*c. supra*, illus 37b and Balasse *et al* 2006). This would lead to the conclusion that seaweed was consumed fresh at the Holm of Papa Westray, which might result from the gathering by the sheep themselves of a fully accessible resource washed ashore by storms.

The history of a physiological adaptation

The modern sheep population of the North Ronaldsay islands, the northernmost island of the Orkney archipelago, is famous for relying almost exclusively on marine seaweeds all year round. This dietary behaviour has necessitated physiological adaptations, including a specific rumen microbiology (Orpin *et al* 1985; MacLaghlan 1988; Indergaard & Minsaas 1991), the metabolism of high salt contents (Hall 1975; Morris 1999), high levels of arsenic (Feldmann *et al* 2000; Hansen *et al* 2003) and low levels of bioavailable copper (Maclaghlan & Johnston 1982; Haywood *et al* 2001). These adaptations surely became most advantageous during the past two centuries, since the building of a dyke around the island, preventing animals from grazing freely on inland pastures. Although the sheep from Holm of Papa Westray relied only partly on seaweeds and essentially during winter, this might represent the first step towards adaptation to significant reliance on seaweeds.

A key to the adaptation of husbandry in Orkney?

The challenge of introducing husbandry to the northern British small isles lies notably in the difficulty of feeding domestic stock during winter, when the availability of terrestrial pasture was severely reduced and the practice of storing hay arguably uncommon or absent because of moist climatic conditions (Amorosi *et al* 1998; McCormick 1998; Tresset 2002). Exploitation of marine resources might have been a key to this adaptation, which most probably reflects a zootechnical innovation by Neolithic herders but might also involve a revolution in minds, in exploiting the littoral margin to sustain terrestrial domestic stock.

Moreover, adaptability to reliance on seaweeds over winter at the Holm of Papa Westray might have had consequences on the onset of the sheep breeding season. In an earlier study investigating sheep and cattle birth seasonality from tooth enamel $\delta^{18}O$ values (Balasse & Tresset 2007), both cattle and sheep were shown to have had a very restricted birth season at Knap of Howar, and sheep births were shown to occur slightly later at Knap of Howar than at Holm of Papa Westray. A restricted and late breeding season for sheep at Knap of Howar most probably directly results from the harsh climatic conditions of winter, which might have naturally shifted the animal's reproduction cycle. It could also result from a human management aiming at avoiding high mortality due to fodder shortage problems during the milking period for the mothers (if animals were born too early). In this regard, an earlier onset of the lambing season at Holm of Papa Westray could have been facilitated by the reliance on seaweeds over winter.

Conclusion

The adaptation of sheep to seasonal reliance on seaweeds and its possible consequences on stock management is emblematic of the series of adaptations that both domestic herds and husbandry techniques underwent in the course of their diffusion across Europe during the Neolithic. The necessity of these adaptations probably became critical when the process of dissemination reached high latitudes where harsher climatic conditions and modifications in day length had dramatic effects on animal reproduction (especially the restriction of the fertility period) and seasonal mortality in young animals in particular. Today's flourishing sheep husbandry in the Northern Isles of Scotland evidences that these early adaptations were successful in the long term.

BIOARCHAEOLOGICAL ANALYSIS OF IODINE IN DENTAL ENAMEL: INITIAL ANALYSIS OF SHEEP DENTAL ENAMEL FOR ELEMENTAL IODINE, FOR THE PURPOSE OF FUTURE DETECTION OF *IN VIVO* IODINE DEFICIENCY IN RUMINANTS AND HUMANS

C C Wright, M Collins, D Brothwell
and M Shafer

Introduction

This ongoing research is focused on taking the first steps toward being able to detect iodine deficiency in ruminant and human skeletal material from archaeological contexts. Iodine deficiency, especially in cases of low to moderate deficiency, tends to be confined to the soft tissue of the body, in particular the thyroid gland (Jones 2005, 524). Analysis of iodine in skeletal material is complicated and has been skipped over in favour of more biologically abundant and/or easily detectable elementals for analysis.

The importance of iodine as a necessary element for human and ruminant growth and development is well-established (Jones 2005, 524; Nordberg & Cherian 2005, 190; Ureles 1990, 4–5). It is a trace dietary element, and is key to the production of the hormones thyroxine and triiodothyronine (Lindh 2005, 149–51; Singer 1990, 27–9). When these metabolic hormones are severely deficient, humans and ruminants may experience delayed maturation, mental retardation, and endemic cretinism (Nordberg & Cherian 2005, 189–90). More commonly individuals will, over time, develop goitre (Jones 2005, 524). The availability of iodised salts, oils, bread and water have reduced iodine deficiency greatly throughout the world, but even as recently as the 1990s the World Health Organisation and the United Nations estimated that one billion people were at risk of iodine deficiency (Nordberg & Cherian 2005, 189, 191). Combining the issue of current risk and the short history, only the last two centuries, of iodine deficiency bring addressed (Ureles 1990, 1–2), it is abundantly clear that there is a need to study iodine deficiency in the archaeological record.

This research project is taking up the challenge by analysing dental tissues, specifically dental enamel. The process of assessing iodine in dental enamel for bioarchaeological interpretation has required the careful development of a research plan that eliminates as many extraneous variables as possible, and focuses on diet. The Orkney islands have been very important to this research due to the use of iodine rich seaweed playing a role in the traditional Orkney sheep diets, as evidenced by the research of Balasse *et al* (2005; 2006), and has provided modern and Neolithic dental samples of these island sheep. The importance of seaweed to the diets of Neolithic Orkney sheep is well-documented by Balasse *et al* (2005; 2006). Their winter diet demonstrates a change over time of C3 and C4 plant consumption that is indicative of seaweed consumption in a seasonal cycle. Combined with the oxygen isotope data, this indicates when warmer and colder months were occurring and that links to the carbon isotope data, showing seaweed consumption was occurring in the coldest months, ie during winter when terrestrial plants tend to be in short supply.

Table 27
Third molar (M3) Iodine data for one of the Holm of Papa Westray North Neolithic sheep teeth (HPWN ovis10 M3) and one of the modern North Ronaldsay sheep teeth (IS017511)

Just below crown (Sample 1) to just above Root (Sample 8)	*Iodine: IS017511 μg/g*	±	*Iodine: HPWN ovis10 M3 μg/g*	±
Sample 1	4.1	0.1	167.7	5.7
Sample 2	5.0	0.2	124.0	5.0
Sample 3	4.2	0.1	143.5	6.9
Sample 4	4.9	0.1	95.4	1.9
Sample 5	5.2	0.2	100.5	2.8
Sample 6	4.4	0.1	98.5	3.4
Sample 7	5.5	0.2	65.3	1.5
Sample 8	4.8	0.1	113.6	2.1

Without the isotopic information this research project would not be possible.

Materials and methods

Dental tissue, especially dental enamel, was selected as the main tissue under study due to its survivability in archaeological contexts, and the fact that it is more resistant to diagenetic change than bone. The research uses dental enamel and dentin from sheep with differing *in vivo* iodine exposure. The samples discussed in this paper fall into three groups:

Low or no iodine diets (modern sheep, Canberra, Australia – samples pending)

Fluctuating access to iodine from a seasonal diet of seaweed, as demonstrated by $\delta^{13}C$ and $\delta^{18}O$ data provided by M Balasse (Neolithic sheep, Holm of Papa Westray North, Orkney, Scotland – HPWN ovis10 M3 from layer 3E1)

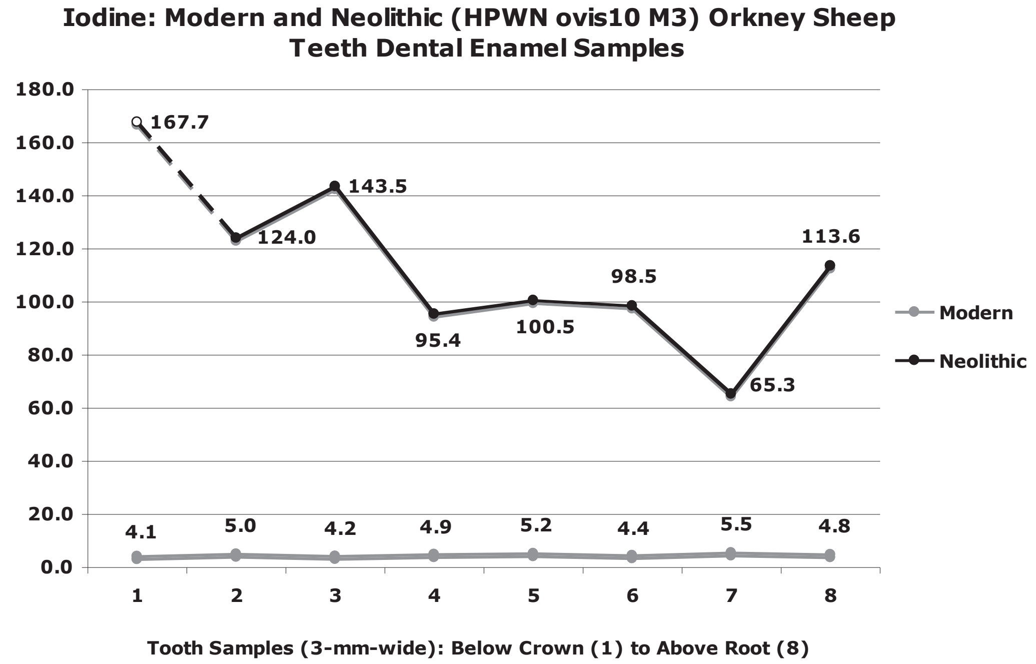
Very high iodine diets through a near continuous consumption of seaweed (modern sheep, North Ronaldsay, Orkney, Scotland – IS017511)

The initial sample preparation involved first cleaning the dental enamel surface of the sheep teeth by careful abrasion with a diamond tipped sander drill bit. Sampling of the dental enamel involved using a diamond tipped drill bit to incrementally remove powdered enamel samples in 3mm-wide segments perpendicular to the tooth growth axis in the same manner as discussed in Balasse *et al* (2006).

The instrumental method for analysing these samples is High Resolution Inductively Coupled Plasma Mass Spectroscopy (HR-ICP-MS). HR-ICP-MS provides a very high mass resolution capable of detecting and quantifying trace elements in dental enamel and dentin samples. This is especially important for detecting ultra low levels of iodine in dental samples from *in vivo* iodine deficient sources as well as the fluctuations in iodine levels for sheep that consume seaweed seasonally. M Shafer and his colleagues have, on behalf of this research project, developed iodine specific methodologies for sample digestion, as iodine can be volatile and vulnerable to loss during traditional acidic digestions. The methods, extremely simplified, are (1) a base digestion for vegetation samples and (2) an acid/base digestion for dental and soil samples.

Results

The results of the analysis for elemental iodine are shown in Table 27 and in illus 38 and 39. The modern North Ronaldsay sheep tooth (IS017511) dental enamel samples demonstrated very little variation of iodine



Illus 38

The Neolithic tooth (HPWN ovis10 M3), sample 1 (white outlined in black) had some dentin contamination and Sample 8 may have also had a very small amount of dentin contamination, the effect of which will not be known until the dentin associated with the dental enamel samples for this tooth are analysed, but it means that Samples 1 and 8 may not be accurate

levels over time (amplitudes tooth variation from 4.1 to 5.5µg/g). On the other hand, the Neolithic Holm of Papa Westray North tooth (HPWN ovis10 M3) demonstrated a fair amount of variation over time (amplitudes of tooth variation from 65.3 to 167.7 µg/g).

Discussion

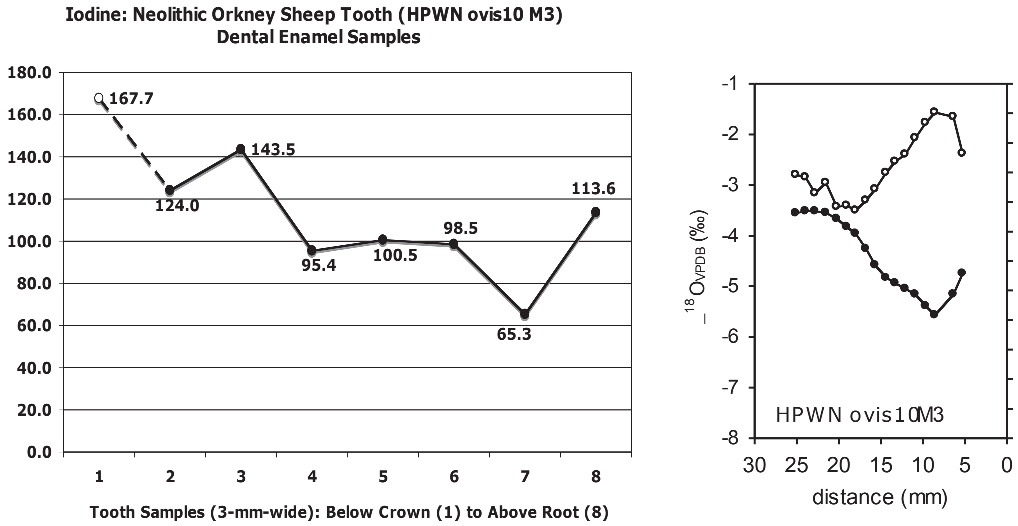
There are two main areas of discussion for the data. The first involves comparing iodine data for IS017511 and HPWN ovis10 M3 to each other. The second is to compare the iodine and isotopic data of HPWN ovis10 M3.

Iodine: IS017511 and HPWN ovis10 M3

Illus 38 summarises the comparison between IS017511 and HPWN ovis10 M3. The data for IS017511 was anticipated to be unvaried over time, because the diet of modern North Ronaldsay sheep is very well-known. These sheep spend their lives confined by a sheep dyke to the beaches of the small island of North Ronaldsay, the northernmost Orkney Island (Balasse *et al* 2006, 170, 175). The overwhelming majority of their diet is seaweed rich in iodine and arsenic, predominantly *Laminaria digitata* and *Laminaria hyperborea* (Hansen *et al* 2003, 845). The exception is when the ewes are brought onto pasture during the lambing season (Balasse *et al* 2006; 175; Caumette *et al* 2007, 2673). The data for IS017511 illustrates this pattern of little to no variation of iodine over time, as was anticipated.

The Neolithic tooth HPWN ovis10 M3 was selected for this research project because the tooth was tested for carbon and oxygen isotopes by M Balasse and provides data regarding dietary pattern. The isotope data, however, at the time of my analysis of the tooth for iodine had not been published, though the tooth is discussed in M Balasse's contribution to this site report. The iodine data found for this tooth demonstrated a change over time that seemed to resemble some of the data contained in papers by Balasse *et al* (2005; 2006).

It became apparent, when the modern and Neolithic Orkney sheep teeth were looked at together, that something unexpected was occurring. As previously



Illus 39

A (Iodine) and B (Isotopes) graphs of data for intra-tooth variation of dental enamel for iodine and the isotopes δ18OVPDB (white) and δ13CVPDB (black) from the Neolithic sheep tooth HPWN ovis10 M3 (in B the 'distance (mm)' is mm from neck). The modern tooth is North Ronaldsay ISO17511

stated, there was little or no change over time for the modern tooth IS017511. The data fell between 4.1 to 5.5µg/g. It was when this information was compared against the range, 65.3 to 167.7µg/g, for HPWN ovis10 M3 that questions arose. The Neolithic tooth contained a tremendous amount of iodine compared to the modern. This begged the question as to why a tooth from an animal that was consuming vast quantities of iodine rich seaweed would have such low values when compared to its ancient brethren. Especially as diagenesis did not seem to be an issue based on the isotopic data for the Neolithic tooth and the fact that the modern tooth had been collected shortly after the animal had died.

Without more samples being tested this question can not be properly addressed, but it is worth mentioning that modern North Ronaldsay sheep are remarkable animals that have developed both tolerances and extreme sensitivity to elements that would normally be toxic (arsenic) (Hansen *et al* 2003; Caumette *et al* 2007) or required for good health (copper) (Haywood *et al* 2001). Therefore, this example of low iodine for modern North Ronaldsay sheep may be an indication of a metabolic process and/or physiological adaptation to extreme levels of iodine. Going forward, all sample analyses, will also include testing for arsenic. Adding arsenic to the analysis will provide greater insight into traditional Orkney sheep metabolism, as well as having another element that is abundant in seaweed to compare against iodine.

HPWN ovis10 M3: Iodine and Isotopes

In this portion of the discussion illus 39A and B are being compared to show the change over time in the pattern of oxygen, carbon isotopes and iodine. The iodine data contained in illus 39A is the same as the Neolithic HPWN ovis10 M3 portion of illus 38. M Balasse kindly supplied the isotope graph for HPWN ovis10 M3, prior to publication, for comparison with the iodine data. Looking at illus 39B, it shows that the $\delta^{13}C_{VPDB}$ and $\delta^{18}O_{VPDB}$ values demonstrate a seasonal consumption of fresh seaweed, possibly also with some oceanic water, during winter. Even with the possibility of some contamination, the results of the iodine analysis demonstrate a pattern of 'seasonal' iodine consumption, likely from seaweed, that very closely matches the $\delta^{13}C_{VPDB}$ isotope data. This favorable comparison indicates, at least in the case of HPWN ovis10 M3, that the methodology employed to test dental enamel for elemental iodine works and that diagenesis may not be a problem to future analysis. Certainly much more work needs to be done, however, before this assertion can be given great weight.

Conclusion

At this time, and with the small number of samples analysed, it is not possible to state any strong conclusions. What can be stated is that some evidence of possible metabolic adaptation to the high levels of toxins in seaweed, at least regarding iodine, has been detected. If later analyses of modern North Ronaldsay and Neolithic Holm of Papa Westray North sheep dental enamel also demonstrate this trend, then it would indicate a remarkable adaptation to a seaweed diet over a very short time. Even as short a period as that since the sheep dyke was constructed on North Ronaldsay two centuries ago (Balasse *et al* 2006, 175). Additionally, preliminary evidence has been found for the Neolithic tooth, HPWN ovis10 M3, that demonstrates not only through isotopic analysis, but iodine as well, that sheep at that time consumed seaweed seasonally. Most importantly, there is strong evidence to show that the methodology employed to analyse dental enamel works in testing for elemental iodine.

The next stage of this research has already begun with more Neolithic HPWN and modern NR sheep dental samples and the addition of modern sheep teeth from Canberra, Australia (which is an extremely low iodine environment). Soil and terrestrial vegetation have also been added from North Ronaldsay and Canberra. It is also hoped that Neolithic Orkney ruminants from Knap of Howar, Papa Westray, which demonstrate little or no signature for seaweed consumption through isotopic analysis (Balasse *et al* 2006), may also be added to the project. Coastal Scottish human dental samples have been added to the next stage of the research along with assessing dental enamel against dentine, which should help determine, especially in the case of HPWN ovis10 M3, the effect of dentine contamination. These new samples and continued analysis should be the next step toward meeting the ultimate goal of assessing humans and ruminants for iodine deficiency.

ANALYSES OF THE VOLE REMAINS

T Cucchi, R Barnett, J Searle and K Dobney

Introduction

The study of vole remains from Holm of Papa Westray is part of the research project, 'Prehistoric origins of Orcadian cultural exchange networks: biomolecular and morphometric studies of Orkney voles', funded by the Arts and Humanities Research Council and involving both Departments of Archaeology and Biological and Biomedical Sciences at Durham University and the Biology Department of York University.

Much debate surrounds the origins of the Orkney vole *Microtus arvalis orcadensis* (Yalden 1999; Corbet 1961). It is the only vole on Orkney and is found on eight islands, while in mainland Britain the field vole *(M. agrestis)* is the only *Microtus* species. *M. arvalis* and *M. agrestis* occur widely across continental Europe with overlapping distributions (Mitchell-Jones *et al* 2003). It is therefore clear that *M. arvalis* did not colonise Orkney naturally (Haynes *et al* 2003; Haynes *et al* 2004), and although modern consensus supports a human introduction during the Neolithic (Hedges *et al* 1987), their geographic origin and mechanisms of introduction still remain uncertain.

The objective of this research project is to address the introduction and *in situ* evolution processes of the Orkney vole using genetic and morphometric approaches on both modern and archaeological populations. The results will be integrated in an attempt to further highlight the human dispersal and maritime trade and exchange routes between Orkney and mainland Europe since the Neolithic.

Sampling

The *Microtus arvalis orcadensis* remains analysed from the Holm of Papa Westray site were hand-excavated from the interior of the chambered tomb (others have since been retrieved from sieved samples). Our samples were selected from compartments which did not contain remains of brown rat (*Rattus norvegicus*, introduced not before the 13th century), thereby alleviating modern pollution and stratigraphic disturbances.

From these compartments, samples were selected from undisturbed floor deposits in compartment 1, layer 3: NMI = 23 (left mandibles) and compartment 2, layer 3: NMI = 9 (left mandibles). The first lower molar (M_1) of each of the mandibles was photographed for morphometric analyses. Four mandibles were used for aDNA sequencing and C^{14} AMS dating, each hemi-mandible being divided in two halves: one for aDNA and one for C^{14}. aDNA sequences were successfully extracted from all samples in the aDNA facility of the Department of Biological and Biomedical Sciences at Durham University.

Table 28

Radiocarbon dates for vole hemi-mandibles

Lab	*Description*	*^{14}C Age*	*^{14}C Age SD*	*68% (1σ)*	*95.4% (2σ)*	*Calibration data*
OxA-18665	*M. arvalis* mandible	4054	28	cal BC 2622–2496	cal BC 2835–2486	Reimer *et al* 2004
OxA-18666	*M. arvalis* mandible	4089	29	cal BC 2835–2577	cal BC 2859–2499	Reimer *et al* 2004

The two half hemi-mandibles have been dated by colleagues in the Oxford Radiocarbon Accelerator Unit (ORAU). The results (Table 27) show that the voles we have sampled are clearly associated with the archaeological floor deposit inside the chambered tomb.

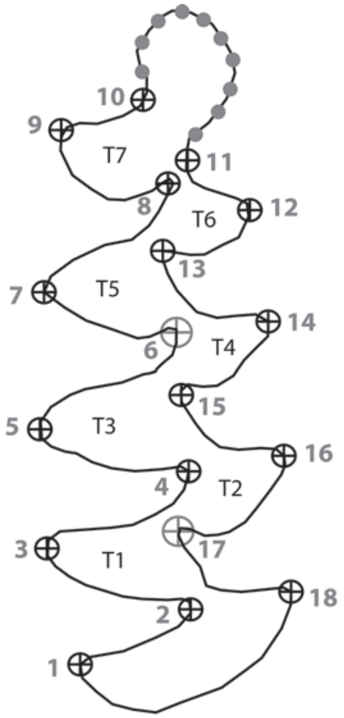
Nature of the bone assemblage

The material is clearly the result of an accumulation of regurgitated pellets from a raptor (bird of prey) species. Although macroscopic observation indicates the breakage of the teeth most likely to have occurred due to trampling, sediment compression and the excavation process itself, the tell-tale signs of strong corrosive digestion, normally associated with diurnal raptors like the hen harrier (*Circus cyaneus*), are not present in this material. Therefore, the principal raptors most likely responsible for this vole accumulation are probably one of the owls (*Asio flammeus, Asio otus* or possibly *Tyto alba* (Andrews 1990). The barn owl though currently rare in Orkney may have been more widespread and common in the past (Williams 2006).

Ancient DNA

Ancient DNA (aDNA) work was carried out on vole hemi-mandibles using a procedure modified from Nichols *et al* (2007). DNA extractions were performed within a sterile glovebox, inside a dedicated lab, separated from any modern molecular biology work and utilising sterile reagents and equipment. The ascending ramus was removed using a disposable scalpel blade, wrapped in aluminium foil, and then manually crushed using a blunt instrument. The resulting powder and suitable extraction blanks were then digested overnight in extraction buffer and DNA was collected using Qiaquik purification kits.

Ten samples from HPW were attempted and four were found to contain endogenous aDNA (Table 28). Polymerase chain reaction (PCR) primers were designed based on existing sequences in the literature (Fink *et al* 2004; Haynes *et al* 2003; Heckel *et al* 2005) and 1158bp of mitochondrial cytochrome b (cyt b) was amplified for comparison. The cyt b region was amplified in 8/9 overlapping PCRs to circumvent the generally fragmented nature of aDNA.



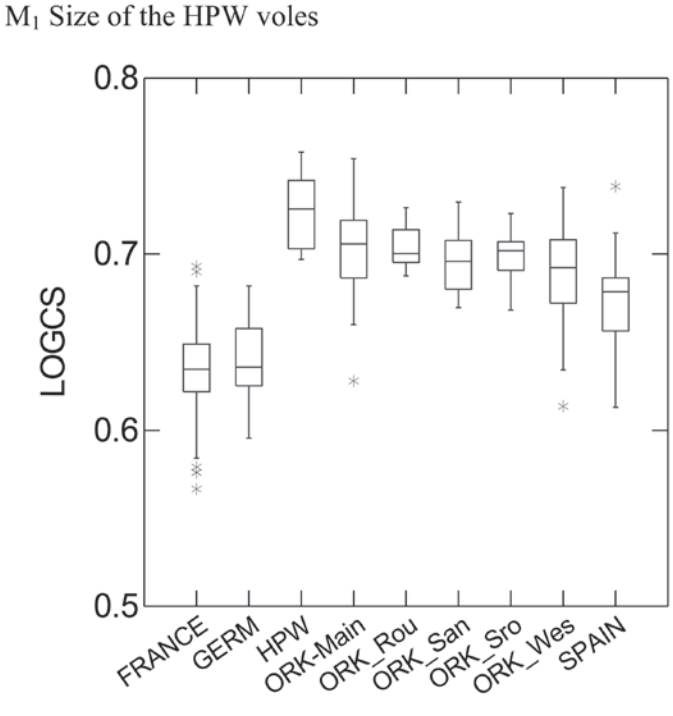
Illus 40

Geometric morphometric analyses of the mandibular first molar of the voles

All four of the ancient HPW sequences were identical to the majority haplotype (D) currently found in Westray (Haynes *et al* 2003). This sequence is only found in modern Westray and Burray but had a wider distribution during the Neolithic, also being found in mainland. The genetics and radiocarbon data suggest that voles have been in Westray for a considerable period of time. Median-joining analysis using Network (Bandelt *et al* 1999) shows that the D haplotype is central to the diversity found in all extant and ancient Orkney voles, potentially indicating the haplotype of the original colonisers.

Geometric morphometric analyses of the mandibular first molar

The complex morphology of the mandibular first molar (M_1) has been quantified using Cartesian coordinates of landmarks (Bookstein 1991) positioned on the base and tips of the lingual and buccal cusps with semi-landmarks along the anterior loop (illus 38).



Illus 41

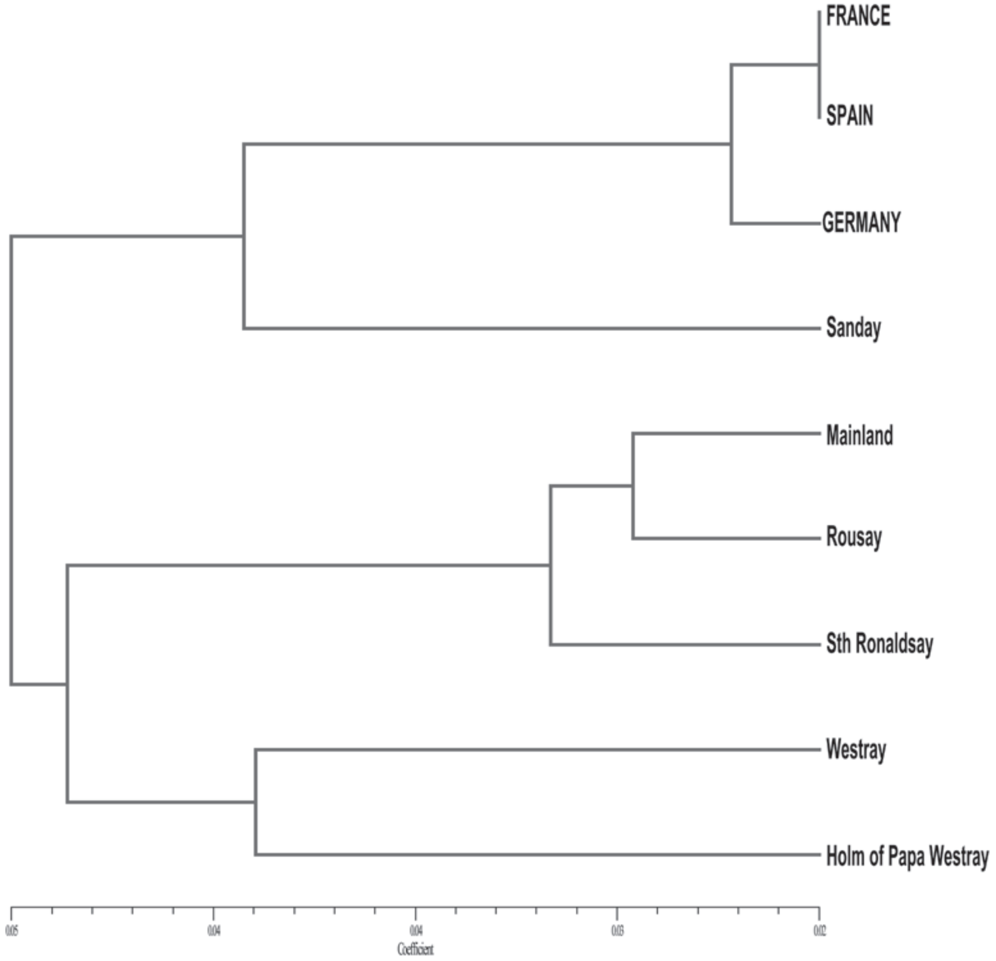
Box plot comparing Logarithm centroid size of M_1 from Orkney (Neolithic Holm of Papa Westray [HPW] and modern) with modern Mainland Europe. (France, N=40; Germany, N=40, Spain, N=15, ORK Mainland, N=46; ORK Rousay, N=10; ORK Sanday, N=20; ORK South Ronaldsay, N=17; ORK Westray, N=33)

The Generalised Least Square Superimposition of the landmarks configuration allows filtering out the location, scale and rotation effects and retaining only the geometric information used to describe the Shape of the M_1 (Bookstein 1991).

The size of the M_1 is separately computed and mathematically independent of Shape. It is called the Centroid Size and its computation is based on the distances between each landmarks and the centroid of the molar points' configuration.

The range of M_1 centroid size from Holm of Papa Westray voles has been compared with modern populations from mainland Europe and Orkney provided by several institutions (National Museum of Scotland, Natural History Museum of London, Natural History Museum of Paris, Natural History Museum of Washington D.C., Biogeoscience Department, Earth Science University, Dijon, France). Results show that modern and archaeological samples from Orkney are larger than mainland Europe samples. Among the Orkney samples, HPW voles display a significantly (ANOVA/Bonferroni post hoc test) larger M_1 than most of the extant populations suggesting the occurrence of a strong 'insular syndrome' (Lomolino 2005). Noticeably the Spanish sample is the largest among mainland Europe, displaying non-significant difference with extant voles of Sanday, South Ronaldsay and Westray.

The phenetic relationship (illus 42) shows that molar shape of extant and HPW voles is extremely divergent from their mainland relatives. Sanday voles are the most similar to continental European common voles but nevertheless highly different. This strong insular divergence precludes any reconstitution of a potential geographic source of the HPW voles. A strong inter-island divergence is also observable among modern Orkney population whereas continental voles display far more morphological resilience. This crucial difference between the Orkney voles and the continental Europe molar shape is mainly observed on the anterior loop, with Orkney voles being characterised by a much broader mesial cusp (illus 40), a characteristic trait observable within the HPW voles. This suggests that the morphological uniqueness of these Orkney voles was acquired from the earliest Neolithic colonisers, resulting in a fast and strong morphological evolution.



Illus 42
Phenogram (UPGMA) displaying phenetic relationships between the mean shapes of each sample

Conclusion

The accumulation of vole remains from Holm of Papa Westray probably resulted from the natural deposition of owl pellets within the chambered tomb. These voles display the genetic and phenotypic uniqueness of extant Orkney voles. This provisional study therefore clearly shows that the divergence of Orkney voles resulted in an evolutionary acceleration rather than in a progressive process of divergence. The founder event and a consecutive bottleneck have triggered an adaptation to the unique insular environment of Orkney. The most likely factor to promote this insular syndrome would be the release of predation and inter and intra competition pressures that newcomers would have encountered, allowing the founding populations to expand their ecological niche (Adler & Levins 1994). This could explain the increase in size and the broadening of the anterior loop of the M_1 of the Orkney voles.

Further genetic and morphometric analyses are currently being pursued within the framework of the project ‘Prehistoric origins of Orcadian cultural exchange networks’. They include the study of archaeological and modern samples from all over Orkney and mainland Europe, which should unveil the mystery of the origin of the Orkney voles and provide new indirect evidence of prehistoric interaction between Orkney and mainland Europe.

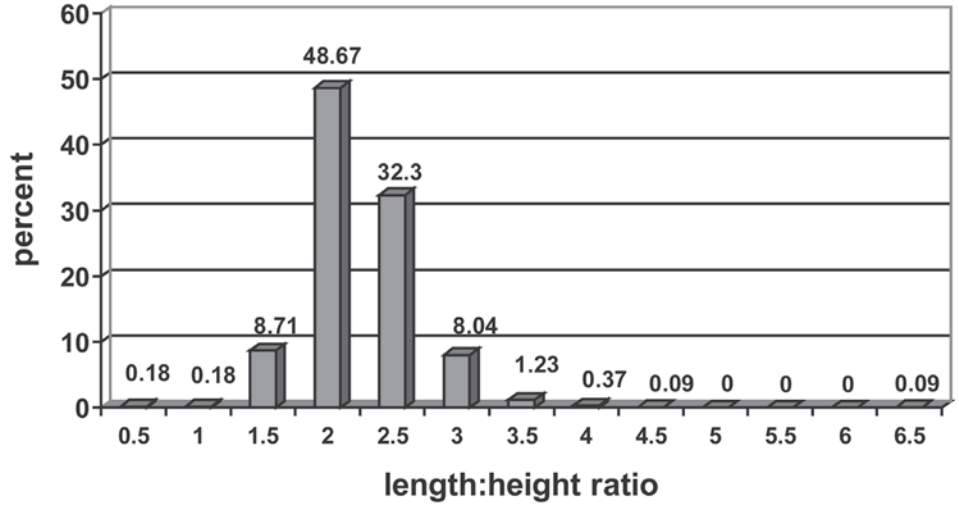
Table 29
DNA extractions from vole hemi-mandibles

Extract	*Provenance*	*aDNA?*	*Haplotype*	*Radiocarbon*
R16	5(2)	Yes	D	
R17	5(2)	No		
R18	5(2)	No		
R19	2E (2)	No		
R20	(1)	Yes	D	OxA-18665
R21	Trench 1 4W (1)	No		
R22	2E (2)	No		
R23	EP (2)	Yes	D	OxA-18666
R24	EP (2)	No		
R25	EP (2)	Yes	D	

MARINE MOLLUSCA

Monika Maleszka-Ritchie

Excavation at the cairn of Holm of Papa Westray North, Orkney, recovered an extraordinary deposit of more than ten thousand limpet shells, often stacked one within the other. This feature, layer EP2, had been dumped as a filling into the central section of the entrance passage of the chambered tomb. Within the assemblage as a whole, seven species of shellfish were recorded, mostly being marine gastropod molluscs (Table 30). The limpet *Patella vulgata* was dominant in this collection (96.25%), which was completed with fragments of razor *Ensis siliqua* (2.42%), periwinkle



Illus 43
Length:height ratios of the measured *Patella vulgata* from the entrance passage deposit EP2. The measured shells amounted to 1056 individuals. Each column represents the total number of shells that fall within the range between the ratio displayed and its larger neighbour

Littorina obtusata (0.92%), winkle *Littorina littorea* (0.27%), cockle *Cerastoderma edule* (0.11%), whelk *Buccinum undatum* (0.01%) and dog whelk *Nucella lapillus* (0.005%). It is clear that gastropods of *Patella vulgata* were the main species collected by the people who closed the tomb, whether for human consumption or for the baiting of fishing lines. The lack of soil and other domestic debris indicates that the deposit derived from a shell dump rather than a general domestic midden. Ten out of every hundred limpet shells were measured from layer EP2, their length along the major axis and the maximum height at the apex being recorded. A ratio was calculated using these two measurements to indicate the rough size of the individual shell.

The majority of the limpets from layer EP2 had a length:height ratio of between 2.2 and 2.6 (illus 43 & 44). This shape indicates that they were gathered predominantly from the lower parts of the tidal range. Given that the normal length for *Patella vulgata* today is 30mm (Graham 1971), the average limpet from layer EP2 is larger than the modern norm, as were the limpets from Knap of Howar (Evans & Vaughan 1983, 112).

To establish the nutritional value of the limpets, a calculation has been used following Evans & Vaughan (1983, 114). Their basic calculation, that 100 shells = 0.15kg of cooked meat weight (boiled for 20 minutes) = 97.5 Kcal, gives the following results when considering the EP2 deposit:

c.10560 limpets = *c*.15.84kg = *c*.10296 Kcal

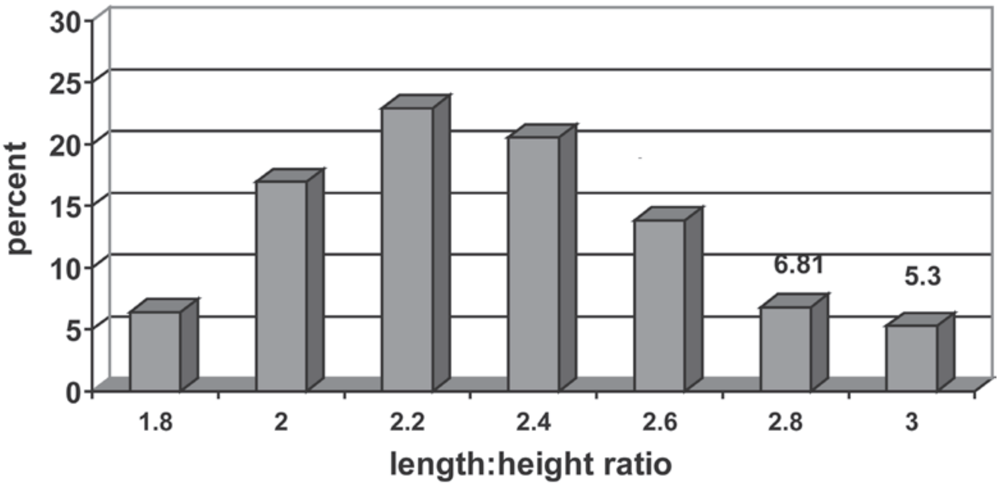
If we presume an average requirement of 2700 calories per person per day, this would mean that the limpets from this deposit could support one person for approximately 4 days. If the limpets were eaten raw, the weight and the calories contained can be approximately doubled.

However, Tolan-Smith (2001, 112) estimated that the human calorific requirement could be met by 400 raw limpets per day, yielding a value of approximately 300 Kcal per 100g of fish. Thus:

c.10560 limpets = *c*.7920 Kcal

Again, if we presume an average requirement of 2700 calories per person per day, this would mean that the limpets from this deposit could support one person for approximately three days.

Mellars recorded the preference in modern Colonsay in the west of Scotland for limpets gathered from low-tide situations, which were considered to be more tender and palatable than those gathered from higher parts of the shore (Mellars 1977, 57). The higher up the shore a limpet grows, the longer it will be exposed to the air. In Papa Westray, there has been a tradition of eating razorfish (known as 'spoots' from the spouts of sand that rise as they burrow). Despite the fact that they are labour-intensive to collect (one has to dig fast to catch them), cooked briefly and



Illus 44
Length:height ratios of the measured *Patella vulgata* collected from the entrance passage deposit EP2. Detail from illus 43

Table 30
Marine mollusca

Context	*limpets*	*cockles*	*winkles*	*periwinkles*	*razor frags*	*dog whelks*	*whelks*
1W1	460	1	3	–	28	–	–
1E1	378	–	3	–	59	–	–
2W1	107	–	1	–	3	–	2
2E1	239	1	4	–	2	–	–
2W2	95		1	1	12	1	–
2E2	50	1	5	–	4	–	–
3W1	144	–	–	–	2	–	–
3E1	2	–	–	–	–	–	–
4W1	86	1	–	2	12	–	–
4E1	50	–	1	–	6	–	–
4NE1	49	–	1	–	3	–	–
4SE1	69	–	2	–	6	–	–
1W3	46	2	2	–	6	–	–
1E3	5	1	–	–	–	–	–
2W3	1	–	–	–	–	–	–
2E3	–	–	1	–	–	–	–
3E3	32	6	–	–	–	–	–
2E4	2	–	1	–	–	–	–
4NE8	–	–	–	162	–	–	–
5.2	94	–	5	–	15 + 1 whole half	–	–
5.4	9	–	3	–	1	–	–
EP2	10,871	–	1	–	208 (small frags)	–	–
EP3	34	–	4	–	–	–	–
II.1	3586	5	7	–	9	–	–
II.2	20	–	–	–	–	–	–
III.1	182	–	1	–	9	–	–
VI.1	170	1	3	–	9	–	–
Total	17,253	20	50	165	429 + 1 whole half	1	2

gently they are considered to be much superior to limpets. They appear not to have played more than an incidental role in the diet suggested by the shells from Holm of Papa Westray, however, for even the 208 fragments from EP2 need represent no more than six to eight animals. The one intact valve from layer 5.2 measured 183mm in length, which is very large compared to modern specimens and again mirrors the size of animal recorded from Knap of Howar (Evans & Vaughan 1983, 112).

The other gastropods and bivalves in this assemblage are small in number and insignificant in the collecting habits of the community. One deposit of 162 periwinkles from 4NE8 appears to have had a special significance, for it was associated with a burial. The shells were found in a small heap and none was perforated.

The east side of the island is rocky and exposed, whereas the west side is low-lying, pebbly and sheltered. The limpets are thus likely to have been collected mainly along the east coast of the Holm, or along the adjacent east coast of Papa Westray, where they are common today at low tide on the flat rocks from Neil's Helly southwards to Burland. Limpets were used as the main bait for line fishing in recent times in Papa Westray (John Rendall, pers comm), and they are still used today for catching cod and ling by handline throughout Orkney, for which 30–60 limpets are required for a 5-hour fishing trip (Jeannine Hazlehurst, pers comm). The shell dump represented by the limpets from the entrance passage could thus have accumulated as a result of some 220 fishing trips in Neolithic times.

THE FISH REMAINS

Jennifer Harland and Rachel Parks

Introduction

This report details the analysis of 4738 identified fish bones from hand collected, coarse sieved and sieved features excavated at the Holm of Papa Westray North, a Neolithic chambered cairn located in Orkney.

Table 31
Fish: summary of trench and cell/compartment bone quantities analysed

Trench	*Cell/ Compartment*	*Hand collection*			*Coarse sieving*			*>2mm*			*Grand total*
		Id'd	*Unid'd*	*Total*	*Id'd*	*Unid'd*	*Total*	*Id'd*	*Unid'd*	*Total*	
EP	–	207	251	458	120	291	411	94	62	156	1025
I	1	195	349	544	43	58	101	61	181	242	887
	2	96	148	244	39	124	163	304	818	1122	1529
	3	35	60	95	1	2	3	106	124	230	328
	4	108	254	362	128	1007	1135	1367	2671	4038	5535
	5	384	317	701	7	8	15	1263	671	1934	2650
II	–	3	10	13	–	–	–	–	–	–	13
III	–	39	49	88	–	–	–	–	–	–	88
IV	–	5	3	8							8
V	–	127	304	431	–	–	–	–	–	–	431
VI	–	3	4	7	–	–	–	–	–	–	7
VI/central cairn		3	1	4	–	–	–	–	–	–	4
Grand total		1205	1750	2955	338	1490	1828	3195	4527	7722	12505

Table 32
Fish: surface texture of QC1 elements

			Hand collected					*Coarse*				*>2mm*					
Trench	*Cell/comp.*	*Context*	*Excellent*	*Good*	*Fair*	*Poor*	*Total*	*Excellent*	*Good*	*Fair*	*Total*	*Excellent*	*Good*	*Fair*	*Poor*	*Total*	*Grand Total*
EP	–	–	10	28	9	2	49	16	26	10	52	–	4	2	–	6	107
I	1	–	21	30	11	4	66	3	7	2	12	1	5	–	–	6	84
	2	–	7	26	10	2	45	1	8	4	13	1	22	5	–	28	86
	3	–	–	15	5	1	21	–	–	1	1	–	7	2	–	9	31
	4	–	2	21	20	–	43	2	24	8	34	5	143	63	4	215	292
	4	1	1	18	17	–	36	–	12	5	17	–	–	–	–	–	53
	–	2	1	1	3	–	5	2	8	–	10	–	–	–	–	–	15
	–	3	–	1	–	–	1	–	–	–	–	–	38	26	2	66	67
	–	4	–	–	–	–	–	–	2	√	2	–	21	12	–	33	35
	–	5	–	–	–	–	–	–	2	3	5	–	10	4	–	14	19
	–	6	–	1	–	–	1	–	–	–	–	5	53	13	1	72	73
	–	7	–	–	–	–	–	–	–	–	–	–	12	5	1	18	18
	–	8	–	–	–	–	–	–	–	–	–	–	9	3	–	12	12
	5	–	8	87	39	1	135	2	1	1	4	–	73	24	–	97	236
II	–	–	1	1	–	–	2	–	–	–	–	–	–	–	–	–	2
III	–	–	2	7	2	1	12	–	–	–	–	–	–	–	–	–	12
IV	–	–	–	1	–	1	2	–	–	–	–	–	–	–	–	–	2
V	–	–	2	29	9	1	41	–	–	–	–	–	–	–	–	–	41
VI	–	–	–	1	–	1	2	–	–	–	–	–	–	–	–	–	2
VI/central cairn			–	1	–	–	1	–	–	–	–	–	–	–	–	–	1
Grand Total			53	247	105	14	419	24	66	26	116	7	254	96	4	361	896

Although disturbed by antiquarian digging, the 1980s excavations revealed extensive undisturbed deposits in and around the tomb; even the disturbed areas appeared to contain remains of appropriate Neolithic date.

The fish remains fall into three categories. Firstly, there are those remains that are most likely the result of deliberate, anthropogenic fishing for marine species, including some that could only have been caught using deep-water fishing methods. Secondly, there are very numerous remains of very small fish, many of which were crushed and, given the species ranges found, it is most likely these represent otter spraint. Finally, a number of 'pierced' vertebrae were discovered, and parallels are discussed from other sites in Neolithic Orkney.

Methods

Analysis was conducted using the extensive reference collection available in the *fishlab*, Centre for Human Palaeoecology, University of York. Specimens recovered by hand collection and coarse sieving were fully recorded using the York system recording methods, as detailed in Harland *et al* (2003). Briefly, this entails the detailed recording of 18 commonly occurring and easily identified elements, termed quantification code (QC) 1. For each of these, the element, species, approximate size, side, fragmentation, texture, weight, applicable measurements and any modifications are recorded in detail. Fish vertebrae (QC2) are recorded in more limited fashion, with counts, element and species recorded. Some elements are unusual and particularly diagnostic, like otoliths, and are fully recorded (QC4). The final category of material (QC0), includes elements not routinely identified as well as unidentifiable material. Elements that are from very unusual species, or that are butchered or otherwise modified, are recorded in detail even if not from the QC1 category.

Due to time constraints full recording of the very extensive wet sieved material was not possible. Upon initial examination it was noted that this material contained numerous very small specimens, including many from species that are notoriously difficult to identify beyond family level. Prior to analysis, the wet sieved material was randomly subsampled using a sample splitter, and one quarter of each sample was then sieved to 2mm and analysed. For very small samples of fewer than 50 bones the whole bag was recorded. The remaining three quarters of these samples was quickly scanned to ensure that no unusual remains were neglected. A similar method was successfully applied to a discrete, dense deposit of very tiny fish bones at Bu Broch (Colley 1987), where it was possible to successfully ascertain the nature of the deposit without spending undue amounts of time identifying myriad tiny remains. A bulk sample from compartment 4 NE, context 3, was dry sieved by the authors to 2mm, sorted and analysed as per the wet sieved material.

To maximise the information collected from this sieved material from the Holm, a summarised version of the York system was applied. The routinely identified cranial and appendicular elements (QC1) were identified as usual. The vertebrae (QC2 elements) were recorded to family level but were not split into anterior or posterior vertebral groups. Two additional taxonomic categories were applied to this material: 'tiny perciformes' and 'rocklings'. The former includes a variety of species that are very difficult to distinguish when small, including blennies, gobies, eelpouts, dragonet and butterfish, while the latter includes a number of morphologically very similar species. In both cases, our reference collection did not include all possible fish species that could have been found in the Orcadian Neolithic, making it necessary to generalise. That said, in the few cases where secure identification could be made, particularly for QC1 elements, species level recording was applied.

The complete archive has been submitted to the excavator as both an Access file and as simple text files containing the same data. These are also kept on file in the *fishlab* at the University of York.

Recovery

A total of 12,505 bones were recovered from all areas of the site, 4738 of which were identified to either species or family. Three methods of recovery were used, as summarised in Table 31, showing the quantities of bone analysed by area, recovery method and quantification code. Coarse and detailed 2mm sieving focused on samples taken from the chamber (trench I) and the entrance passage (EP), while hand collection was undertaken throughout the site. The 2mm sieving produced the largest quantity of material, particularly from compartment 4 and cell 5 within the tomb. Hand-collected recovery of fish bone has a known bias towards large, distinctive elements from larger fish, while material from sieved bulk samples is generally considered to provide a more representative sample of fish bones (Wheeler & Jones 1989; Colley 1990, 208–9). However, smaller bones were present in

Table 33
Fish: completeness of QC1 elements

Trench	Cell/comp.	Context	Hand collected						Coarse					>2mm						Grand Total
			0–20%	21–40%	41–60%	61–80%	81–100%	Total	21–40%	41–60%	61–80%	81–100%	Total	0–20%	21–40%	41–60%	61–80%	81–100%	Total	
EP	–	–	1	6	8	5	29	49	12	8	18	14	52	1	–	2	2	1	6	107
I	1	–	3	8	9	17	29	66	–	3	3	6	12	–	1	2	1	2	6	84
	2	–	1	10	4	9	21	45	–	5	4	4	13	–	5	8	12	3	28	86
	3	–	1	2	4	4	9	20	–	–	–	1	1	–	1	4	2	2	9	30
	4	–	–	5	10	8	20	43	6	5	8	15	34	2	27	46	75	65	215	292
	–	1	–	5	9	7	15	36	1	3	4	9	17	–	–	–	–	–	–	53
	–	2	–	–	–	1	4	5	3	1	2	4	10	–	–	–	–	–	–	15
	–	3	–	–	–		1	1	–	–	–	–	–	–	11	10	18	27	66	67
	–	4	–	–	–	–	–	–	1	–	1	–	2	1	2	5	18	7	33	35
	–	5	–	–	–	–	–	–	1	1	1	2	5	1	1	2	4	6	14	19
	–	6	–	–	1	–	–	1	–	–	–	–	–	–	12	20	22	18	72	73
	–	7	–	–	–	–	–	–	–	–	–	–	–	–	1	5	6	6	18	18
	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	4	7	1	12	12
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	5	–	8	31	21	31	44	135	–	–	–	4	4	1	17	25	29	25	97	236
II	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	2
III	–	–	–	–	2	4	6	12	–	–	–	–	–	–	–	–	–	–	–	12
IV	–	–	–	–	2			2	–	–	–	–	–	–	–	–	–	–	–	2
V	–	–	–	6	8	6	21	41	–	–	–	–	–	–	–	–	–	–	–	41
VI	–	–	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–	–	–	2
VI/central cairn			–	–	–	1		1	–	–	–	–	–	–	–	–	–	–	–	1
Grand Total			14	68	68	86	182	418	18	21	33	44	116	4	51	87	121	98	361	895

the hand-collected material suggesting that collection during excavation was very thorough. Samples taken and coarsely sieved to 4mm (referred to throughout as 'coarse sieved') present similar problems as the hand-collected material, with much of the smaller bones and smaller fish likely not recovered from this fraction. Samples for wet sieving were taken from inside the tomb and were sieved to 1mm during processing, and later sieved to 2mm for analysis. It became apparent during analysis that the sampled material contained very few of the larger elements and species. As the entirety of the tomb's interior had been sampled, it is likely that hand-collected bone was first removed during excavation, and then the remaining sediment was either coarse or wet sieved.

Preservation

Preservation was assessed on two criteria: surface texture and percent element completeness of QC1 elements, as defined in Harland *et al* (2003). Tables 32 and Table 33 detail preservation by context and recovery method. Across all contexts and recovery methods surface texture was typically good to fair with few elements of poor texture recorded. Element completeness was variable but most were greater than 20% complete. No particular patterns were noted, aside from those caused by differing recovery methods.

Modifications

Very little burning was found. Three specimens were noted: context 4 of the entrance passage, context 3 of compartment 3, and from context 2 of compartment 4. Specimens with evidence of carnivore gnawing were restricted to cell 5, contexts 2 and 3 and trench V, context 2 (Tables 34 and 35). A typical example of carnivore gnawing is illustrated in illus 48, showing a wrasse articular with a typical 'puncture'. Bones with signs of acid etching, typically an indication of digestion, were recovered from cell 4, cell 5 and trench V.

Crushing was the predominant form of modification, with 153 crushed specimens from the hand collected and coarse material (Table 34) and 1377 from the >2mm material (Table 35). A high proportion of the crushed bones were vertebrae, and this pattern is

Table 34
Fish: bone modifications (hand collected and coarse sieved)

	Recovery	*Coarse*				*Hand collected*											*Total*
	Trench	EP		I		EP	I								V		
	Cell/ compartment			2	4		1	2	3	4	5						
QC	Context	2	4	2	2	2	3	2	1	1	1	2	3	4	1	2	
0	Carnivore gnawing	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	Crushed	–	–	–	–	9	2	1	–	–	–	–	–	–	–	9	22
1	Acid etched	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
	Carnivore gnawing	–	–	–	–	–	–	–	–	–	–	5	2	–	–	2	9
	Crushed	–	–	–	–	–	–	–	–	1	–	–	1	1	–	–	4
	Root etching	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10
2	Carnivore gnawing	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	
	Crushed	1	1	–	–	26	8	2	1	1	1	22	59	1	1	2	127
Total		1	1	1	1	35	10	3	1	3	8	29	64	2	2	16	177

indicative of otter spraint and is returned to in more detail below.

Results

Taxonomic abundance and element representation

With the exception of material recorded as >2mm, as outlined above, specimens were identified to species wherever possible, or family level when morphology or preservation did not allow a more detailed identification.

To summarise the overall assemblage, species from the wrasse family and cod family were most abundant in the hand collected and coarse sieved material (Tables 36 and 37). Cod family fish (Gadidae) included cod, ling, saithe, haddock, pollack and specimens identified to either saithe or pollack (see Table 46 for Latin nomenclature). Within the wrasse family (Labridae), both ballan and cuckoo wrasse were recorded. While the vertebrae are very difficult to identify to species, most are likely to have been ballan wrasse, on the basis of QC1 identifications. A small number of corkwing wrasse was also recorded. From the hand collected and coarse sieved material some specimens of eel, megrim, horse mackerel, herring, conger eel, sea scorpion family fish, butterfish and species belonging to the ray family and dogfish family were also recorded.

In stark contrast to the hand collected and coarse sieved material, rocklings account for most of the gadids in the >2mm sieved fraction (Table 38). Ling and haddock disappear and cod, saithe and pollack are only present in small numbers. Wrasse become less common, eels increase in significance and there is a dramatic increase in the number of 'tiny perciformes' and sea-scorpion family fish. Although it is possible these small fish were stomach contents of the larger ones, this is unlikely given the overwhelming quantities of the small fish compared to the larger.

Tables 36, 37 and 38 give a summary of the numbers of QC1 and QC2 elements by method of recovery. Detailed element representation is given for the wrasse and cod family fish in Tables 39, 40 and 41, and a full breakdown of elements from all species is provided in the site archive. There is no obvious skeletal element patterning in any area of the site, suggesting that all parts of the fish were found and none was removed from the site. There is no evidence that might be indicative of a particular processing method, but a single cut mark on a cod caudal vertebra may represent an attempt to divide the tail into sections (discussed in more detail below). The higher number of vertebrae (QC2 elements) from all species is to be expected given the high frequency of these elements in the

Table 35
Fish: bone modifications (>2mm sieved fraction)

	Trench	*EP*	*I*													*Total*
	Cell/compartment		1	2			3	4						5		
QC	Context	4	4	3	4	5	3	3	4	5	6	7	8	2	3	
0	Acid etched	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
	Crushed	–	2	–	–	2	–	41	–	–	1	–	–	–	–	46
1	Acid etched	–	–	–	–	–	–	–	–	–	–	3	–	–	1	6
	Crushed	–	–	–	–	–	–	2	–	1	3	–	–	1	2	9
2	Acid etched	1	–	–	–	–	–	–	3	–	1	–	–	–	1	6
	Carnivore gnawing	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
	Crushed	57	7	101	7	7	49	107	117	39	80	66	29	165	491	1322
Total		58	9	101	7	9	49	153	120	40	85	69	29	166	496	1391

Table 36

Fish: number of identified specimens (hand collected)

Trench		*EP*					*I*																			*II*		*III*			*IV*		*V*			*VI*		*Total*
Cell/compartment		–	–	–	–	–	1	–	2	–	–	–	3	–	–	4	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Context		1	2	3	4	5	1	3	1	2	3	4	1	2	3	1	2	3	4	6	7	1	2	3	4	1	2	1	2	3	1	2	1	2	3	1	2	
Taxa	QC																																					
Dogfish families	2	–	2	–	–	–	1	1	–	–	1	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	13
Flatfish order	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Scorpaeniformes	2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	5	–	–	–	–	1	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14
Eel	1	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	2	–	4	–	–	–	–	7	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	5	–	–	–	19
Blenny family	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Turbot family	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	2	–	1	–	–	–	2	3	–	2	–	–	–	1	–	2	–	–	–	–	–	2	4	2	–	–	–	–	–	–	–	–	–	2	–	–	–	21
Megrim	1	–	3	–	1	–	1	1	–	–	2	–	–	–	2	–	1	–	–	–	–	–	1	2	–	–	–	2	–	–	–	–	–	1	–	–	–	17
	2	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Megrim?	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	2
Atlantic horse-mackerel/ scad	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	2
Atlantic herring	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	–	3	–	–	–	3	2	3	3	–	–	–	–	–	14	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	30
	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Conger eel	1	–	3	–	3	3	2	–	2	1	–	–	–	–	1	1	1	–	–	–	–	1	1	5	–	1	–	–	–	1	–	–	2	–	–	–	–	28
	2	–	2	–	–	–	3	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	5	1	1	–	2	–	–	–	2	2	8	–	1	–	29
Bull-rout	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	2	–	–	–	–	6
	2	–	6	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11
Sea scorpion	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Sea scorpion family	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	6
Cod	1	–	1	–	–	–	6	1	–	3	2	–	5	–	1	3	–	–	–	–	–	9	1	13	–	–	–	2	–	–	2	–	5	10	1		1	66
	2	1	1	–	–	–	1	7	1	2	–	–	–	–	1	2	1	–	1	–	–	–	1	5	–	–	–	5	–	–	1	–	6	6	–	–	1	43
Cod family	1	–	–	–	–	–	2	1	2	2	–	–	2	–	–	5	–	–	–	–	–	1	1	1	–	1	–	1	–	–	–	–	–	3	–	–	–	22
	2	–	19	–	–	–	1	5	1	3	1	–	–	–	–	9	–	–	–	–	–	–	13	11	–	–	–	1	–	–	–	–	–	10	1	1	–	76
Cod/saithe/pollack	1	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2

Table 36 (continued)

Fish: number of identified specimens (hand collected)

Cod/saithe/pollack		2	–	–	–	1	– –	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	3
Five-bearded/ northern rockling	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Haddock	1	1	–	–	1	–	–	3	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	11
	2	–	–	–	–	–	2	2	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	9
Ling	1	1	1	–	–	–	4	1	1	1	–	–	2	–	1	8	–	1	–	–	–	5	–	2	–	–	–	2	–	–	–	–	4	5	–	1	1	41
	2	–	3	–	–	–	2	3	1	2	–	–	5	–	1	4	1	–	1	–	–	7	2	3	–	–	–	5	–	–	–	–	6	4	2	–	–	52
Pollack	1	–	–	–	–	–	1	2	1	–	1	–	–	–	–	–	1	–	–	–	–	2	–	1	1	–	–	1	–	–	–	–	–	1	1	–	–	13
	2	–	–	–	1	–	2	–	–	1	2	1	–	–	–	–	–	–	–	–	–	3	1	–	–	–	–	1	–	–	–	–	1	3	1	–	–	17
Rockling	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	5
	2	–	14	–	–	–	1	23	–	–	–	–	–	–	1	7	–	–	–	–	–	–	11	25	–	–	–	–	–	–	–	–	–	4	–	–	–	86
Saithe	1	–	–	–	–	–	8	2	6	3	3	–	1	–	–	7	–	–	–	–	–	2	–	1	–	–	–	1	–	–	–	–	–	2	–	–	–	36
	2	–	1	–	–	–	4	11	1	5	–	–	–	–	1	2	1	–	–	–	–	1	4	3	–	–	–	3	–	–	–	–	1	8	–	–	–	46
Saithe/pollack	1	–	–	–	1	–	3	–	4	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	11
	2	–	–	–	–	–	1	2	1	–	–	–	–	–	–	1	–	–	–	–	–	1	1	1	–	–	–	1	–	–	–	–	–	3	–	–	–	12
Ballan wrasse	1	–	17	–	1	–	3	10	4	–	–	–	2	–	–	2	2	–	–	1	–	–	38	16	–	–	–	–	–	–	–	–	–	1	–	–	–	97
	2	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	5
Ballan/cuckoo wrasse	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	2	–	74	–	–	–	3	20	2	10	–	–	–	–	–	10	–	–	–	–	–	–	75	20	1	–	–	2	–	–	–	–	–	1	–	–	–	218
Corkwing	1	–	4	–	–	–	–	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16
	2	–	1	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Corkwing wrasse/ goldsinny	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Cuckoo wrasse	1	–	2	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Wrasse family	1	–	3	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	5	1	–	–	–	–	–	–	–	–	–	–	–	–	16
	2	–	14	–	–	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	1	–	–	–	20
Butterfish	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Halibut family	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	–	4	–	–	–	–	8	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	6	–	–	–	–	1	–	–	–	–	–	–	–	–	22
	4	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Ray family	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	9	–	–	–	–	–	1	–	–	–	1	–	–	–	15
	4	–	–	–	–	–	–	4	–	–	–	–	1	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
Gurnard family	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Total identified		3	192		9	3	58	137	34	45	15	2	24	1	10	95	8	1	2	1	1	42	184	153	4	3		36	1	2	3	2	30	91	6	3	3	1204
Total fish		6	230	2	6	3	98	249	51	73	23	1	41	6	11	211	24	3	7	1	7	48	54	175	7	1	9	41	6	2	3		30	259	15	1	4	1708

Table 37

Fish: number of identified specimens (coarse sieved)

Trench		EP				I											Total
Cell/compartment						1	2			3	4				5		
Context		2	3	4	5	3	2	3	5	3	1	2	4	5	3	4	
Taxa	QC																
Dogfish families	2	–	–	1	–	1	–	–	–	–	–	–	1	–	–	–	3
Eel	1	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	3
	2	–	–	4	–	1	2	–	–	–	1	2	2	–	–	–	12
Turbot family	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	2	–	–	1	–	4	1	–	–	–	–	–	–	–	–	–	6
Megrim	1	–	–	4	–	2	1	–	–	–	–	–	–	–	–	2	9
Turbot family	2	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Atlantic horse-mackerel/scad	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Atlantic herring	2	–	–	–	–	2	1	–	–	–	–	1	–	–	–	–	4
Conger eel	1	–	–	2	3	1	–	–	–	–	1	–	–	–	–	–	7
	2	–	2	2	1	–	–	–	–	–	–	–	–	–	1	–	6
Bull-rout	1	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
Sea scorpion family	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	–	–	1	–	–	–	–	–	–	2	–	–	–	–	–	3
Cod	1	–	–	1	–	–	2	–	–	–	1	–	–	–	–	–	4
	2	–	–	2	3	–	–	–	–	–	–	–	–	–	–	–	5
Cod family	1	–	–	–	–	2	2	–	–	–	–	–	1	2	–	–	7
	2	–	–	2	1	5	–	–	5	1	–	9	4	4	–	1	41
Cod/saithe/pollack	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–		1
Five-bearded/northern rockling	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Four-bearded rockling	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2
Haddock	1	–	–	–	–	–	1	–		–	–	–	–	–	–	–	1
	2	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	2
Ling	1	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	3
	2	1	–	–	–	1	1	–	–	–	–	–	1	–	–	–	4
Pollack	1	–	–	2	–	–	–	1	–	–	1	–	–	–	–	–	4
	2	–	1	1	–	–	1	–	–	–	–	–	–	–	–	–	3
Rockling	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	1	–	–	–	–	–	–	–	–	–	10	5	–	–	–	16
Saithe	1	–	1	–	1	–	1	–	–	–	2	2	–	–	1	–	8
	2	–	–	1	–	3	7	–	–	–	2	4	7	–	–	–	24
Saithe/pollack	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
	2		–	–	–	1	–	–	–	–	–	1	–	–	–	–	2
Ballan wrasse	1	1	3	7	14	3	2	–	–	1	9	1	1	1	–	–	43
	2	–	–	2	–	5	–	–	–	–	13	1	–	–	1	–	22
Ballan/cuckoo wrasse	1	–	–	–	2	1	1	–	–	–	1	–	–	1		–	6
	2	9	–	10	–	–	–	–	–	5	2	–	–	–	–	–	26
Corkwing	1		2	1	–	–	–	–	–	1	–	–	–	–	–	1	5
Wrasse family	1	1	2	–	3	1	1	–	–	–	1	1	–	1	–	–	11
	2	–	5	3	7	1	4	–	–	–	–	–	–	1	–	–	21
Butterfish	2	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
Halibut family	2	–	–	1	–	–	1	–	–	–	3	2	2	–	–	–	9
Ray family	4	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Scorpion-fish family	2	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Dogfish family	2	–	–	–	–	1	–	–	–	–	–	–	–	1	–		2
Identified fish		13	18	51	38	36	32	1	6	8	48	44	25	11	3	4	338
Total fish		3	58	95	114	57	111	1	13	2	217	474	242	74	3	5	1489

Table 38

Fish: number of identified specimens (>2mm sieved fraction)

Trench		EP		I												*Total*
Cell/compartment			1	2			3	4						5		
Context		4	4	3	4	5	3	3	4	5	6	7	8	2	3	
Taxa	QC															
Dogfish families	2	–	–	1	–	–	1	–	2	–	1	–	2	–	2	9
Flatfish order	1	–	–	–	–	–	–	1	–	–	–	–	–	–	2	3
	2	3	–	6	–	–	4	11	10	1	4	6	1	6	21	73
Perciformes order	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Scorpaeniformes	1	–	–	1	–	–	–	2	–	–	1	–	–	–	–	4
	2	–	–	–	–	3	–	2	–	–	–	–	–	–	–	5
Tiny perciformes	1	–	–	2	–	–	2	7	5	2	1	1		3	4	27
	2	7	12	19	3	6	9	138	19	8	52	14	1	58	159	505
Eel	1	–	–	2	–	–	2	–	2	–	–	1	1	–	5	13
	2	23	14	31	8	10	20	15	7	2	21	10	12	42	72	287
Blenny family	1	–	–	–	–	–	–	–	–	–	1	1	–	–	–	2
Scaldfish	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Turbot family	1	–	–	1	–	–	–	–	1	–	–	–	–	–	–	2
	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Megrim	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
Dragonet	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Atlantic herring	2	–	–	2	–	–	–	–	–	1	–	–	–	–	1	4
Conger eel	1	1	–	–	–	–	–	1	–	–	–	–	–	–	–	2
Bull-rout	1	–	–	–	1	–	–	4	–	–	1	–	–	–	–	6
Sea scorpion family	1	–	1	4	1	–	2	20	6	3	11	2	3	8	12	73
	2	13	3	19	7	–	8	71	35	14	26	17	8	40	87	348
Cod	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Cod family	1	–	1	4	1	1	–	12	1	4	16	4	2	6	14	66
	2	25	12	89	9	10	34	44	57	36	40	46	25	136	222	785
Cod/saithe/pollack	2	–	–	–	–	–	–	2	–	–	–	–	–	–	–	2
Five-bearded/northern rockling	1	–	–	–	–	–	–	1	2	–	2	–	–	–	–	5
Rockling	1	3	–	5	–	–	3	12	11	3	15	7	5	4	28	96
	2	17	1	30	5	7	16	158	54	9	66	18	7	67	223	678
Saithe	1	1	–	2	–	–	–	3	–	–	7	–	–	–	2	15
	2	–	9	2	–	3	–	9	2	–	18	–	1	2	8	54
Saithe/pollack	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
	2	–	–	–	–	–	–	4	–	–	–	–	–	–	–	4
	4	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Stickleback family	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Three-spined stickleback	2	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Ballan wrasse	1	–	1	–	–	–	–	2	2	–	1	–	–	–	–	6

Table 38 (continued)

Fish: number of identified specimens (>2mm sieved fraction)

Trench		EP	I													*Total*
Cell/compartment			1	2			3	4						5		
Context		4	4	3	4	5	3	3	4	5	6	7	8	2	3	
Taxa	QC															
Ballan/cuckoo wrasse	1	–	1	–	–	–	–	–	–	–	–	–	–	2	–	3
	2	–	–	–		–	–	2	1	1	–	–	–	–	–	4
Corkwing	2	–	1	–	1	–	–	5	–	–	2	–	–	–	–	9
Corkwing wrasse/ goldsinny	1	–	–	–	–	–	–	–	2	1	–	–	–	1	4	8
	2	–	1	–	–	–	–	–	–	–	5	–	–	–	–	6
Goldsinny	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Wrasse family	1	1	2	–	1	1	–	–	–	–	4	–	–	–	–	9
	2	–	2	–	–	–	3	3	13	–	1	–	–	6	13	41
Perch family	1	–	–	–	1	–	–	–	–	–	1	–	–	–	–	2
Butterfish	1	–	–	–	–	–	–	–	–	–	6	–	–	–	–	6
Halibut family	1	–	–	–	–	–	–	–	1	1	–	–	–	–	2	4
	2	–	–	–	–	1	–	5	–	–	1	–	–	–	–	7
Salmon and trout family	2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Eelpout family	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Viviparus eelpout	1	–	–	–	–	–	–			–	1	–	–	–	–	1
Identified fish		94	61	220	38	45	106	536	233	86	311	130	69	381	881	3191
Total fish		39	177	531	125	137	106	732	369	149	835	290	129	120	395	4134

skeleton. For example, saithe typically have 53–56 vertebrae, ling 63–65, ballan wrasse 35–40 and conger eel 148–153 vertebrae (Hureau 1996). Turning to the two most common families from the site, wrasse appendicular and cranial elements (QC1) do appear to be more abundant than those from the cod family, but it is likely that the number of wrasse elements has been inflated as they are more robust and distinct than the cod family and thus survive very well in the archaeological record.

The element representation of the >2mm material does differ from that of the hand collected and coarse sieved material. Even when the high frequency of vertebrae in the skeleton is taken into account there seem to be fewer QC1 elements. This could be the result of taphonomic patterning, and could likely result from much of this small material being otter spraint, rather than the remains of anthropogenic fishing. Otter spraints typically include high numbers of vertebrae and jaw bones, while other elements tend to be much less easily identifiable (Nicholson 2000).

Detailed intra-site comparison is difficult given the different recovery methods and disturbed fillings found in much of the tomb. This was compounded by the fact larger bones were probably removed during hand collection from sediments that were later sampled, leading to a discrepancy between recovery methods that is difficult to reconcile. However, it is possible to discuss the variation found within the entrance passage, as well as within compartment 4. In the upper layer of the entrance passage (context 2) the fish bone is in a fill rich in limpet shells while

Table 39

Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*															*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
Cod	1	Articular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	3
		Basioccipital	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	–	4
		Ceratohyal	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	1	–	–	–	4
		Cleithrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Dentary	–	–	–	1	–	–	1	–	–	1	–	1	–	–	–	–	1	–	1	–	–	1	–	1	2	–	–	–	10
		Hyomandibular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	2
		Infrapharyngeal	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2
		Maxilla	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2	–	2	–	–	–	5
		Opercular	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	2
		Palatine	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	2
		Parasphenoid	–	–	–	1	1	–	–	–	–	1	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	6
		Posttemporal	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	5
		Premaxilla	–	–	–	–	–	–	1	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	1	6
		Quadrate	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
		Supracleithrum	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–	1	2	–	–	–	6
		Vomer	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	3	–	1	–	–	–	–	–	–	–	–	–	6
	2	Abdominal vertebra 1	1	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	3	–	–	–	–	10
		Abdominal vertebra 2	–	–	–	–	1	1	2	–	–	–	–	1	1	–	–	–	–	–	1	–	–	3	–	–	2	–	–	1	13
		Abdominal vertebra 3	–	1	–	–	4	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	1	4	–	–	–	12
		Caudal vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra 1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	1	–	–	–	1	1	–	–	–	–	5
		First vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	2
Cod family	1	Articular	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Basioccipital	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1

Table 39 (continued)

Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*															*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
		Ceratohyal	–	–	–	1	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
		Dentary	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Maxilla	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Parasphenoid	–	–	–	1	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
		Preopercular	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2
		Premaxilla	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	3
		Quadrate	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3
		Supracleithrum	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	3
	2	Abdominal vertebra	–	4	–	1	1	1	3	–	–	–	–	4	–	–	–	–	–	–	–	–	–	1	–	–	1	–	1	–	17
		Abdominal vertebra 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	2
		Abdominal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Abdominal vertebra 3	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra	–	14	–	–	2	–	–	–	–	–	–	5	–	–	–	–	–	6	–	–	–	–	–	–	3	–	–	–	30
		Caudal vertebra 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	5	–	–	–	–	–	6	–	–	–	16
		Caudal vertebra 2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	4
		Ultimate vertebra	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	–	–	–	–	–	–	–	4
		Vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
Cod/ saithe/pollack	1	Basioccipital	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Five-bearded/northern rockling	1	Parasphenoid	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1

Table 39 (continued)

Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*														*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						1		2				3		4				5												
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
Haddock	1	Cleithrum	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Hyomandibular	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
		Palatine	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Preopercular	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
		Posttemporal	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Quadrate	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	3
		Supracleithrum	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 1	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
		Abdominal vertebra 2	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2
		Abdominal vertebra 3	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3
		Caudal vertebra	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra 2	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Ling	1	Articular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	1	–	1	–	–	–	–	4
		Basioccipital	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Cleithrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
		Dentary	1	–	–	1	–	–	–	–	–	–	–	2	–	1	–	–	1	–	1	–	–	–	–	–	3	–	–	–	10
		Hyomandibular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
		Maxilla	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Parasphenoid	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	4
		Preopercular	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
		Premaxilla	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	4
		Quadrate	–	1	–	–	–	1	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
		Supracleithrum	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	3

Table 39 (continued)

Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*															*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
		Vomer	–	–	–	1	–	–	–	–	–	1	1	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	5
	2	Abdominal vertebra 1	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	1	–	–	1	–	–	–	5
		Abdominal vertebra 2	–	–	–	–	–	–	2	–	–	–	1	1	1	–		–	4	1	–	–	–	1	–	2	–	–	–	–	13
		Abdominal vertebra 3	–	1	–	2	1	–	–	–	–	2	–	3	–	–	1	–	3	–	2	–	–	1	–	3	–	–	–	–	19
		Caudal vertebra	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3
		Caudal vertebra 1	–	1	–	–	1	–	–	–	–	2	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3	2	–	–	10
		First vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
		Vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Pollack	1	Articular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
		Basioccipital	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Cleithrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Dentary	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2
		Parasphenoid	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
		Preopercular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	1	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
		Quadrate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Supracleithrum	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	2
		Abdominal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Abdominal vertebra 3	–	–	1	1	–	–	1	1	1	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	1	1	–	–	9
		Caudal vertebra 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	1	–	–	–	3
		Caudal vertebra 2	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		First vertebra	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1

Table 39 (continued)
Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*															*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
Rockling	1	Articular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Basioccipital	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Cleithrum	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	3
	2	Abdominal vertebra	–	4	–	1	3	–	–	–	–	–	–	3	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	13
		Abdominal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	5
		Abdominal vertebra 3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	5
		Caudal vertebra	–	10	–	–	19	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	34
		Caudal vertebra 1	–	–	–	–	1	–	–	–	–	–	–	3	–	–	–	–	–	7	6	–	–	–	–	–	–	–	–	–	17
		Caudal vertebra 2	–	–	–	–	–	–		–	–	–	–	1	–	–	–	–	–	2	9	–	–	–	–	–	–	–	–	–	12
Saithe	1	Articular	–	–	–	1	–	–	2	1	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	6
		Basioccipital	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Ceratohyal	–	–	–	1	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
		Cleithrum	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Dentary	–	–	–	1	–	2	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	6
		Maxilla	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
		Opercular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Palatine	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
		Parasphenoid	–	–	–	1	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
		Preopercular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	2	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	5
		Supracleithrum	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Vomer	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 1	–	–	–	4	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
		Abdominal vertebra 3	–	–	–	–	3	–	2	–	–	–	–	1	–	–	–	–	1	–	–	–	–	1	–	–	1	–	–	–	9

Table 39 (continued)

Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*															*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
		Caudal vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra 1	–	–		–	6	–	3	–		–	–	–	1	–	–	–	–	3	3	–	–	1	–	1	5	–	–	–	23
		Caudal vertebra 2	–	–	–	–	1	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	2	–	–	–	6
		First vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
Saithe/pollack	1	Basioccipital	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Dentary	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2
		Hyomandibular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Parasphenoid	–	–	1	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
		Preopercular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Vomer	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	2
		Abdominal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
		Abdominal vertebra 3	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	4
		Caudal vertebra	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	3
		Caudal vertebra 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Cod family total			3	40	4	39	63	23	23	11	1	18	6	49	4	1	2		31	35	72	1	1	27	3	23	61	6	2	3	552
Ballan wrasse	1	Articular	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	4
		Ceratohyal	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	2
		Dentary	–	3	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	15	2	–	–	–	–	–	–	–	–	–	23
		Hyomandibular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Infrapharyngeal	–	5	1	–	–	1	–	–	–	–	–	–	1	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	14
		Maxilla	–	1	–	–	1	–	–	–	–	1		1	–	–	–	–	–	2	3	–	–	–	–	–	–	–	–	–	9

Table 39 (continued)

Cod family and wrasse family element representation (hand collected)

Trench			*EP*			*I*																	*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
		Opercular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	1	–	–	–	3
		Palatine	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	4
		Parasphenoid	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	2
		Preopercular	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2	3	–	–	–	–	–	–	–	–	–	7
		Premaxilla	–	2	–	–	–	2	–	–	–	–	–	–	1	–	–	1	–	3	3	–	–	–	–	–	–	–	–	–	12
		Quadrate	–	4	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	9
		Supracleithrum	–	1	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
		Scapula	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	3
	2	Abdominal vertebra	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
		Caudal vertebra	–	1		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		First vertebra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Ballan/cuckoo wrasse	1	Infrapharyngeal	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra	–	28	–	1	7	1	4	–	–	–	–	3	–	–	–	–	–	31	–	–	–	–	–	–	1	–	–	–	84
		Caudal vertebra	–	42		2	11	1	5	–	–	–	–	5	–	–	–	–	–	36	11	1	–	–	–	–	–	–	–	–	114
		First vertebra	–	4	–	–	2	–	1	–	–	–	–	2	–	–	–	–	–	8	1	–	–	1	–	–	–	–	–	–	19
		Penultimate vertebra	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Corkwing	1	Dentary	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	2
		Infrapharyngeal	–	3	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	7	–	–	–	–	–	–	–	–	–	–	12
		Opercular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	1
	2	Caudal vertebra	–	1	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	5
Corkwing wrasse/ goldsinny	2	Caudal vertebra	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2

Table 39 (continued)
Cod family and wrasse family element representation (hand collected)

Trench			*EP*					*I*															*II*	*III*	*IV*	*V*			*VI*		*Total*
Cell/compartment						*1*		*2*				*3*		*4*				*5*													
Context			1	2	4	1	3	1	2	3	4	1	3	1	2	3	4	6	1	2	3	4	1	1	1	1	2	3	1	2	
Taxa	QC	Element																													
Cuckoo wrasse	1	Infrapharyngeal	–	2	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Wrasse family	1	Articular	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Dentary	–	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	4
		Infrapharyngeal	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	6
		Opercular	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	2
		Supracleithrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Scapula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
		Caudal vertebra	–	6	–	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	11
		First vertebra	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	2
Wrasse family total			–	123	1	6	40	6	10	–	–	3	1	13	2	–	–	1	–	129	41	2	–	3		1	4	–	–	–	386

Table 40

Cod family and wrasse family element representation (coarse sieved)

Trench			*EP*				*I*											*Total*
Cell/compartment							1	2			3	4				5		
Context			2	3	4	5	3	2	3	5	3	1	2	4	5	3	4	
Taxa	QC	Element																
Cod	1	Basioccipital	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Ceratohyal	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Opercular	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
	2	Abdominal vertebra 1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Abdominal vertebra 2	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	2
		Abdominal vertebra 3	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	2
Cod family	1	Ceratohyal	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
		Dentary	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
		Maxilla	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	2
		Vomer	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	2
	2	Abdominal vertebra	–	–	1	–	2	–	–	1	–	3	1	2	–	–	1	11
		Caudal vertebra	–	–	1	1	3	–	–	4	1	5	8	2	4	–	–	29
		First vertebra	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Cod/saithe/pollack	2	Caudal vertebra	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Five-bearded/ northern rockling	1	Premaxilla	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Four-bearded rockling	2	Abdominal vertebra	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Haddock	1	Quadrate	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 3	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1

Table 40 (continued)
Cod family and wrasse family element representation (coarse sieved)

Trench			*EP*				*I*											*Total*
Cell/compartment							1	2			3	4				5		
Context			2	3	4	5	3	2	3	5	3	1	2	4	5	3	4	
Taxa	QC	Element																
		First vertebra	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Ling	1	Dentary	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Posttemporal	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Quadrate	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
		Caudal vertebra 1	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	2
Pollack	1	Articular	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
		Basioccipital	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Hyomandibular	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Opercular	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra 2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Abdominal vertebra 3	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	2
Rockling	1	Premaxilla	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra	1	–	–	–	–	–	–	–	–	–	3	2	–	–	–	6
		Caudal vertebra	–	–	–	–	–	–	–	–	–	–	7	–	–	–	–	7
		Caudal vertebra 1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2
		Caudal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Saithe	1	Basioccipital	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Ceratohyal	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
		Maxilla	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
		Parasphenoid	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1

Table 40 (continued)

Cod family and wrasse family element representation (coarse sieved)

Trench			*EP*				*I*											*Total*
Cell/compartment							1	2			3	4				5		
Context			2	3	4	5	3	2	3	5	3	1	2	4	5	3	4	
Taxa	QC	Element																
		Premaxilla	–	1	–	–	–	–	–	–	–	–	1	–	–	1	–	3
		Vomer	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	Abdominal vertebra 1	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	2
		Abdominal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
		Abdominal vertebra 3	–	–	–	–	1	3	–	–	–	–	–	–	–	–	–	4
		Caudal vertebra 1	–	–	1	–	1	3	–	–	–	–	4	4	–	–	–	13
		Caudal vertebra 2	–	–	–	–	–	–	–	–	–	2	–	1	–	–	–	3
		First vertebra	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Saithe/pollack	1	Supracleithrum	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
	2	Caudal vertebra 1	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	2
Cod family total			2	4	12	6	13	17	1	6	1	15	27	18	6	1	1	130
Ballan wrasse	1	Articular	1	–	–	1	–	1	–	–	–	1	–	1	–	–	–	5
		Dentary	–	–	1	1	–	1	–	–	–	–	–	–	–	–	–	3
		Hyomandibular	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	2
		Infrapharyngeal	–	–	4	5	1	–	–	–	1	–	–	–	–	–	–	11
		Maxilla	–	–	–	1	1	–	–	–	–	2	–	–	–	–	–	4
		Posttemporal	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	2
		Premaxilla	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	2
		Quadrate	–	1	–	–	–	–	–	–	–	2	–	–	1	–	–	4
		Supracleithrum	–	2	1	–	–	–	–	–	–	1	–	–	–	–	–	4
		Scapula	–	–	–	2	–	–	–	–	–	2	1	–	–	–	–	5
		Vomer	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1

Table 40 (continued)

Cod family and wrasse family element representation (coarse sieved)

Trench			*EP*				*I*											*Total*
Cell/compartment							1	2			3	4				5		
Context			2	3	4	5	3	2	3	5	3	1	2	4	5	3	4	
Taxa	QC	Element																
	2	Abdominal vertebra	–	–	–	–	4	–	–	–	–	9	–	–	–	–	–	13
		Caudal vertebra	–	–	1	–	1	–	–	–	–	4	1	–	–	–	–	7
		First vertebra	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	2
Ballan/cuckoo wrasse	1	Infrapharyngeal	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	2
		Maxilla	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	2
		Posttemporal	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Supracleithrum	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra	3	–	5	–	–	–	–	–	4	1	–	–	–	–	–	13
		Caudal vertebra	5	–	5	–	–	–	–	–	1	–	–	–	–	–	–	11
		First vertebra	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
Corkwing	1	Infrapharyngeal	–	2	1	–	–	–	–	–	1	–	–	–	–	–	1	5
Wrasse family	1	Infrapharyngeal	1	2	–	2	1	–	–	–	–	1	–	–	1	–	–	8
		Maxilla	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Supracleithrum	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	2	Abdominal vertebra	–	4	1	2	–	1	–	–	–	–	–	–	–	–	–	8
		Abdominal vertebra 1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Caudal vertebra	–	1	2	4	–	2	–	–	–	–	–	–	1	–	–	10
		Caudal vertebra 1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		First vertebra	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Wrasse family total			11	12	23	26	11	8	–	–	7	26	3	1	4	1	1	134

the lower fill (contexts 3 and 4) has a near lack of shells. While more fish bone was noted in the upper layer, there is no discernable difference between fish species present between the lower and upper fill of the entrance passage. Given that these layers represent the infilling of the entrance passage, it is conceivable that both represent redeposition of midden material from the same source.

Compartment 4 is of special interest due to context 4NE3, which was described during excavation as a large deposit of fish within a stone setting. The material, which also included small stones, was recovered in bulk and weighed a total of 9kg. In addition, it was noted during analysis that many small mammals and amphibians were also present. The majority of identified specimens are from the >2mm fraction and species present include those from the flatfish order, the tiny perciformes group, sea scorpion family and rocklings. However, fish bones from 4NE3 show no real difference from the other sieved deposits from the NE corner of compartment 4. Fish bone evidence, therefore, suggests that the fish in 4NE3 is consistent with otter spraint, as discussed below. Repeated use over time may have led to stony material becoming incorporated into the build up of spraint material.

Otter spraint

Otter spraints are the excreted remains of food, mixed with glandular secretions, and they are deliberately placed in prominent locations for reasons of territoriality and communication, including near or at the entrances to 'holts' – the tunnel-like systems that are created or reused by otters for shelter and for raising their young (Kruuk *et al* 1998, 124). Otters will also spraint within their holts, particularly where young are being fed (Nicholson 2000, 56), and over time these can develop into large accumulations of food remains (Kruuk 2006, 78–82). Otters will often re-use man-made structures for their holts – like tombs – and they will readily live near to human activities (Kruuk *et al* 1998, 124).

The diet of otters varies with location and no detailed study of spraints from Orkney is available. Studies from similar island coastal environments, however, do give some insight into the types of fish targeted by otters. Analysis by Kingston *et al* (1999) of modern spraints from the Aran Islands off the west coast of Ireland revealed rocklings and wrasse were the main species groups eaten, with each representing about one third of the diet (by weight). Other species groups each represented less than 10%, including eel, cottids and blennies, while sticklebacks, butterfish and conger eel were also noted (Kingston *et al* 1999). The faster-moving fish like saithe, pollack and whiting were less frequently caught by otters, even if they inhabited the same coastal environments as their preferred prey; however, in Shetland, otters were observed eating saithe and pollack in winter, when they could be found among dense seaweed and therefore were easier for otters to catch (Kingston *et al* 1999, 178). Other modern studies of otters have included eelpout, salmonids and small perciformes (blennies, gobies, butterfish etc.) in the diet, and at one study in mainland Scotland, eelpout was the most commonly eaten species (Kruuk *et al* 1998, 121; McMahon & McCafferty 2006, 32). Flatfishes were occasionally observed as prey, but it appeared otters inhabit the rocky shorelines that flatfishes naturally avoid (Kingston *et al* 1999, 179). Although it was difficult to positively identify the rocklings and wrasses to species in the modern samples, the five-bearded rockling, ballan and corkwing wrasses were likely the most commonly eaten species in both the Irish and Shetlandic studies (Kruuk *et al* 1998, 121; Kingston *et al* 1999, 180).

The marine fish eaten by otters all tend to be very small, at less than 50g per specimen, often represented by fish of less than 30cm total length, and these fish are found in inshore, shallow coastal waters usually within 100m of the shore at depths of no greater than 10m (Kruuk *et al* 1998, 122; Nicholson 2000, 56). However, otters will sometimes scavenge larger species, including those caught by humans (O'Sullivan *et al* 1992).

Some of the contexts from the Holm were identified as otter spraint during excavation (including EP2, EP5 and compartment 4SE6), and otter remains were themselves found in most contexts, making it likely that otter spraint would be found. The two entrance passage contexts were only recovered by hand collection or coarse sieving, which would have discarded most of the small bones associated with otter spraint – as confirmed by the overall large size of these fish (see Table 32). However, the deposit in 4SE6 *was* sieved to 2mm, and can therefore be examined for evidence of sprainting activity. The fish sizes in this context were all small, at less than 30cm total length – but so were most of the fish from the >2mm sieved contexts in the chamber. This therefore opens the suggestion that other sieved material was in fact otter spraint, but not identified as such during excavation. The most common species observed in 4SE6 were, in order, cod family, rocklings, tiny perciformes, saithe, eel and sea scorpion family. However, these were

Table 41

Cod family and wrasse family element representation (>2mm sieved fraction)

Trench			*EP*	*I*													*Total*
Cell/compartment				1	2			3	4						5		
Context			4	4	3	4	5	3	3	4	5	6	7	8	2	3	
Taxa	QC	Element															
Cod	1	Articular	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	Vertebra	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Cod family	1	Articular	–	1	1	–	–	–	4	–	–	9	–	–	2	–	17
		Basioccipital	–	–	–	–	–	–	1	–	1	–	1	–	–	2	5
		Ceratohyal	–	–	–	–	–	–	1	–	–	1	1	–	–	1	4
		Cleithrum	–	–	–	–	–	–	1	–	–	1	–	–	–	2	4
		Dentary	–	–	1	–	–	–	2	–	–	2	–	–	1	–	6
		Hyomandibular	–	–	–	–	–	–	1	–	2	2	–	1	1	1	8
		Infrapharyngeal	–	–	1	–	–	–	–	1	–	–	1	–	–	–	3
		Maxilla	–	–	–	–	–	–	–	–	1	–	–	–	–	3	4
		Opercular	–	–	–	–	–	–	–	–	–	–	–	1	–	2	3
		Palatine	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
		Parasphenoid	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
		Preopercular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	–	–	1	1	–	2	2	6
		Quadrate	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Supracleithrum	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Vomer	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
	2	Abdominal vertebra	–	2	–	–	–	–	1	–	–	2	–	–	–	–	5
		Caudal vertebra	–	6	–	–	–	–	1	–	–	11	–	–	–	–	18
		First vertebra	–	–	1	–	–	2	–	–	–	–	–	–	–	–	3
		Ultimate vertebra	–	–	–	–	–	–	1	1	–	–	–	–	–	–	2
		Vertebra	25	4	88	9	10	32	41	56	36	27	46	25	136	222	757
Cod/saithe/pollack	2	Vertebra	–	–	–	–	–	–	2	–	–	–	–	–	–	–	2
Five-bearded/ northern rockling	1	Dentary	–	–	–	–	–	–	1	–	–	2	–	–	–	–	3

Table 41 (continued)
Cod family and wrasse family element representation (>2mm sieved fraction)

Trench			*EP*	*I*													*Total*
Cell/compartment				1	2			3	4						5		
Context			4	4	3	4	5	3	3	4	5	6	7	8	2	3	
Taxa	QC	Element															
		Hyomandibular	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
		Vomer	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Rockling	1	Articular	–	–	–	–	–	–	3	4	2	2	1	1	1	1	15
		Basioccipital	–	–	–	–	–	1	1	1	–	–	–	–	2	–	5
		Ceratohyal	–	–	–	–	–	–	–	–	–	–	2	1	1	5	9
		Cleithrum	1	–	1	–	–	1	1	–	–	1	–	–	–	3	8
		Dentary	–	–	1	–	–	–	–	1	–	3	2	–	–	6	13
		Hyomandibular	1	–	2	–	–	–	1	1	1	6	1	1	–	1	15
		Maxilla	1	–	1	–	–	–	2	–	–	–	1	–	–	5	10
		Opercular	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	1	4	2	–	2	–	2	–	6	17
		Quadrate	–	–	–	–	–	–	–	1	–	1	–	–	–	1	3
	2	Abdominal vertebra	–	1	–	–	1	–	2	–	–	8	–	–	–	–	12
		Caudal vertebra	–	–	–	–	–	–	–	–	–	5	–	–	–	–	5
		Vertebra	17	–	30	5	6	16	156	54	9	53	18	7	67	223	661
Saithe	1	Articular	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
		Dentary	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Hyomandibular	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
		Palatine	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Parasphenoid	–	–	–	–	–	–	–	–	–	1	–	–	–	1	2
		Preopercular	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Posttemporal	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	2	–	–	1	–	–	–	–	3
		Quadrate	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Vomer	–	–	1	–	–	–	–	–	–	–	–	–	–	1	2

Table 41 (continued0

Cod family and wrasse family element representation (>2mm sieved fraction)

Trench			*EP*	*I*													*Total*
Cell/compartment				1	2			3	4						5		
Context			4	4	3	4	5	3	3	4	5	6	7	8	2	3	
Taxa	QC	Element															
	2	Abdominal vertebra	–	–	–	–	3	–	–	–	–	2	–	–	–	–	5
		Abdominal vertebra 2	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
		Abdominal vertebra 3	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Caudal vertebra	–	7	–	–	–	–	3	–	–	6	–	–	–	–	16
		Caudal vertebra 1	–	2	–	–	–	–	1	–	–	–	–	–	–	–	3
		Vertebra	–	–	2	–	–	–	4	2	–	10	–	1	1	8	28
Saithe/pollack	1	Cleithrum	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
	2	Caudal vertebra	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Caudal vertebra 1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Caudal vertebra 2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Vertebra	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
	4	Otolith	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Cod family total			46	23	132	15	21	54	246	127	52	165	76	40	215	497	1709
Ballan wrasse	1	Dentary	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Hyomandibular	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	1	1	–	–	–	–	–	–	2
		Quadrate	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
		Supracleithrum	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Ballan/cuckoo wrasse	1	Maxilla	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2
	2	Abdominal vertebra	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Caudal vertebra	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
		Vertebra	–	–	–	–	–	–	–	1	1	–	–	–	–	–	2
Corkwing	2	Abdominal vertebra	–	1	–	–	–	–	–	–	–	1	–	–	–	–	2
		Caudal vertebra	–	–	–	–	–	–	2	–	–	1	–	–	–	–	3

Table 41 (continued)

Cod family and wrasse family element representation (>2mm sieved fraction)

Trench			*EP*	*I*													*Total*
Cell/compartment				1	2			3	4						5		
Context			4	4	3	4	5	3	3	4	5	6	7	8	2	3	
Taxa	QC	Element															
		First vertebra	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Vertebra	–	–	–	–	–	–	3	–	–	–	–	–	–	–	3
Corkwing wrasse/ goldsinny	1	Dentary	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
		Infrapharyngeal	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
		Opercular	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
		Preopercular	–	–	–	–	–	–	–	–	1	–	–	–	1	–	2
		Premaxilla	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
		Quadrate	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
	2	Vertebra	–	1	–	–	–	–	–	–	–	5	–	–	–	–	6
Goldsinny	1	Preopercular	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	2	Caudal vertebra	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Wrasse family	1	Articular	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
		Infrapharyngeal	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Opercular	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Palatine	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
		Posttemporal	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
		Premaxilla	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Quadrate	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Scapula	–	–	–	–	1	–	–	–	–	1	–	–	–	–	2
	2	Caudal vertebra	–	1	–	–	–	–	–	–	–	1	–	–	–	–	2
		First vertebra	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
		Vertebra	–	–	–	–	–	3	3	13	–	–	–	–	6	13	38
Wrasse family total			1	8	–	2	2	3	12	18	2	14	–	–	9	17	88

among the most common species recovered from all of the >2mm sieved material, including the one sample from EP4, the only sample taken from outside of the chamber (Trench I). In fact, there is very little variation between the order of commonly occurring species throughout all the >2mm sieved samples – even those with very small sample sizes. All species commonly found are those that are favoured by otters and almost all are within the small size ranges that otters prefer.

This hypothesis can be further examined by considering the taphonomic evidence for otter spraint. Much of the >2mm material contained bones that had been crushed when fresh, with vertebrae in particular showing a high degree of crushing (Table 35). In Nicholson's (2000) study of modern and archaeological otter spraint, in addition to species presence and fish size, spraint was identified using three criteria. The first was element representation, with most of the elements tending to be vertebrae and jaw bones, which are naturally more robust. The second was distinctive gnaw marks: 'chewed or crushed bones were more often vertebrae than head bones, and the vertebrae tended to be crushed in the medio-lateral plane' (Nicholson 2000, 59–60). The large numbers of crushed vertebrae, summarised in Table 35, were almost entirely crushed in a manner consistent with otter spraint. These crushed vertebrae and other elements also showed a lack of acid etching, which is again a distinctive trait of otter spraint (Nicholson 2000, 61). Finally, concretions of fish bones were sometimes noted in modern spraints, but were not common (Nicholson 2000, 61). Few concretions were noted from the Holm material but it was present on material from 4NE3. It therefore seems likely that all of the sieved material was in fact otter spraint. The disturbed nature of the fills caused by otters and sheep in Neolithic times, and more recently following the antiquarian explorations, means that the fish remains are likely to represent both deliberately caught fish as well as otter spraint, combined together.

Fish sizes

Fish sizes were estimated for the suite of routinely identified cranial elements (QC1 and QC4), based on comparisons with modern reference material of known size. Some measurements were recorded, but they were insufficient in quantity to use for comparative purposes and are included in the site archive. Sizes are summarised in Table 42, grouping together the individual contexts within each cell or compartment, while details for the most commonly occurring species from the chamber are provided in Table 43, allowing greater exploration of the context-level variations within each cell and compartment.

A wide variety of fish sizes was recorded, from fish of less than 15cm total length, to those of over a metre – indicating varied fisheries exploiting a wide range of habitats, a conclusion supported by the wide species diversity observed throughout the site (see above). The hand-collected material is biased towards the larger fish species and individuals, while the sieved material is predominantly very small fish, as is to be expected given the recovery methods. However, the presence of smaller individuals in the hand-collected material is further proof that this was undertaken with a high degree of thoroughness.

Considerable size variation was noted in the gadids, the cod family fish. Those that could only be identified to broad family level (because of high fragmentation or poor preservation) were generally less than 30cm total length in the sieved material, as expected given the small nature of the remains in this fraction. These were likely small, inshore cod family fish like rocklings or saithe. A wider range of sizes was observed for the other fractions, from 15cm to over 100cm in length. Fish identified as cod were found throughout much of the site, and again they ranged in size from 15cm to over 100cm in total length. Some spatial differences can be seen in the hand-collected assemblage. Some of the cod family fish from cell 5 tend to be slightly bigger than those from the other cells in the tomb interior. The cod tended to be between 50 and 100cm in cell 5, with one individual of over 100cm in length. In the other compartments, the cod tended to be slightly smaller, with no emphasis on any particular size range; this cannot be explained by taphonomic patterning as preservation and texture was broadly similar between all cells and compartments within the tomb. The ling found in cell 5 also tended to be larger, from at least 80cm total length to well over 1m, while in the other cells and compartments, a greater size range was found. Within cell 5, this pattern is particularly notable in context 1, and, to a lesser degree, context 3.

A range of saithe sizes were noted in the hand-collected material, while they tended to be less than 30cm total length in the sieved material, and 15 to 50cm total length in the coarse sieved material – again a reflection of sieving methods. There was no particular focus on the smaller sized, young saithe

Table 42
Fish sizes, summary

Recovery		Hand collected													Coarse sieved							>2mm							*Grand Total*
Trench		EP	I					II	III	IV	V	VI	VI/	Total	EP	I					Total	EP	I					*Total*	
Cell/compartment			1	2	3	4	5						central cairn			1	2	3	4	5			1	2	3	4	5		
Common name	Total length																												
Eel	15–30cm	–	2	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	3	1	4	1	9	11
	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	3	–	–	2	1	1	4	8	11
Conger rel	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	1
	50–80cm	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	1
	80–100cm	–	–	1	–	–	–	1	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	>100cm	9	2	2	1	2	7	–	1	–	2	–	–	26	4	1	–	–	1	–	6	–	–	–	–	1	–	1	33
Atlantic herring	15–30cm	–	–	–	–	3	1	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Salmon and trout family	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
Cod family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	5	–	16	5	27	27
	15–30cm	–	–	1	–	–	3	–	–	–	1	–	–	5	–	1	–	–	1	–	2	–	2	1	–	26	15	44	51
	30–50cm	–	1	2	1	1	–	1	–	–	1	–	–	7	–	1	1	–	–	–	2	–	–	–	–	–	–	–	9
	50–80cm	–	1	–	–	2	–	–	1	–	–	–	–	4	–	–	1	–	1	–	2	–	–	–	–	–	–	–	6
	80–100cm	–	–	–	–	2	1	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	>100cm	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Cod/saithe/pollack	15–30cm	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	50–80cm	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Cod	15–30cm	–	–	1	2	–	1	–	–	–	1	–	–	5	–	–	–	–	–	–	–	–	–	–	–	1	–	1	6
	30–50cm	–	1	2	–	–	4	–	–	–	3	–	–	10	–	–	–	–	1	–	1	–	–	–	–	–	–	–	11
	50–80cm	1	4	1	2	2	10	–	2	–	9	1	–	32	1	–	2	–	–	–	3	–	–	–	1	–	–	1	36
	80–100cm	–	2	1	2	1	9	–	–	–	4	–	–	19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19
	>100cm	–	–	–	–	–	1	–	–	2	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Haddock	15–30cm	–	1	1	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	30–50cm	–	–	3	–	–	–	–	–	–	–	–	–	3	–	–	1	–	–	–	1	–	–	–	–	–	–	–	4
	50–80cm	2	2	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	80–100cm	–	–	–	–	–	–	–	2	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Saithe/pollack	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2	2
	15–30cm	–	3	1	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	30–50cm	–	–	3	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	50–80cm	1	–	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–	1	–	1	–	–	–	–	–	–	–	3
	80–100cm	–	–	1	–	–	–	–	–	–	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	-	–	–	2

Table 42 (continued)
Fish sizes, summary

Recovery		Hand collected													Coarse sieved							>2mm							*Grand Total*
Trench		EP	I					II	III	IV	V	VI	VI/ central cairn	Total	EP	I					Total	EP	I					*Total*	
Cell/compartment			1	2	3	4	5									1	2	3	4	5			1	2	3	4	5		
Common name	Total length																												
Pollack	30–50cm	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	1	–	–	–	–	–	–	–	2
	50–80cm	–	3	1	–	–	3	–	–	–	1	–	–	8	2	–	–	–	–	–	2	–	–	–	–	–	–	–	10
	80–100cm	–	–	–	–	1	1	–	1	–	1	–	–	4	–	–	1	–	–	–	1	–	–	–	–	–	–	–	5
Saithe	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	2	8	8
	15–30cm	–	6	4	–	1	–	–	–	–	–	–	–	11	1	–	1	–	4	1	7	1	–	2	–	5	1	9	27
	30–50cm	–	2	5	–	5	2	–	–	–	–	–	–	14	1	–	–	–	–	–	1	–	–	–	–	–	–	–	15
	50–80cm	–	2	1	–	1	1	–	1	–	2	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
	80–100cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	>100cm	–	–	2	1	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Rockling	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	3	–	28	20	53	53
	15–30cm	–	–	–	1	–	3	–	–	–	–	–	–	4	1	–	–	–	–	–	1	1	–	2	3	30	12	48	53
	30–50cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Five-bearded/ northern rockling	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	5	–	5	6
	30–50cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Ling	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	1
	30–50cm	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	50–80cm	–	1	–	–	4	–	–	–	–	5	–	–	10	1	1	–	–	–	–	2	–	–	–	–	–	–	–	12
	80–100cm	–	1	–	1	–	1	–	1	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	>100cm	2	3	2	2	9	8	–	1	–	5	1	1	34	–	1	–	–	–	–	1	–	–	–	–	–	–	–	35
Angler?	>100cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Sea scorpion family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	–	33	15	52	52
	15–30cm	–	1	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–	1	–	1	–	–	2	1	12	5	20	23
Bull-rout	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	2	–	2	3
	15–30cm	1	–	–	–	1	2	–	–	–	2	–	–	6	–	–	–	–	1	–	1	–	–	1	–	3	–	4	11
Sea scorpion	15–30cm	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Perch family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	2	2
Wrasse family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	1	2	–	3	–	6	7
	15–30cm	3	3	–	–	–	5	–	–	–	–	–	–	11	4	1	1	–	2	–	8	1	1	–	–	1	–	3	22
	30–50cm	–	–	–	–	–	6	–	–	–	–	–	–	6	1	–	–	–	–	–	1	–	–	–	–	–	–	–	7

Table 42 (continued)
Fish sizes, summary

Recovery		Hand collected													Coarse sieved							>2mm							*Grand Total*
Trench		EP	I					II	III	IV	V	VI	VI/	Total	EP	I					Total	EP	I					*Total*	
Cell/compartment			1	2	3	4	5						central cairn			1	2	3	4	5			1	2	3	4	5		
Common name	Total length																												
Ballan/cuckoo wrasse	15–30cm	2	3	–	–	–	15	–	–	–	–	–	–	20	2	1	1	–	2	–	6	–	1	–	–	–	1	2	28
	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	3	3
Ballan wrasse	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
	15–30cm	12	12	3	–	1	38	–	–	–	–	–	–	66	15	3	–	–	3	–	21	–	1	–	–	2	–	3	90
	30–50cm	6	1	–	2	2	12	–	–	–	1	–	–	24	7	1	1	–	9	–	18	–	–	–	–	2	–	2	44
	50–80cm	–	–	1	–	2	4	–	–	–	–	–	–	7	2	–	1	–	–	–	3	–	–	–	–	–	–	–	10
Cuckoo wrasse	15–30cm	2	3	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Corkwing wrasse/ goldsinny	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	1	4	4
	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	4	4
Corkwing	<15cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	15–30cm	4	2	–	1	–	8	–	–	–	–	–	–	15	2	–	–	1	–	1	4	–	–	–	–	–	–	–	19
	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Goldsinny	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
Eelpout family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
Viviparus eelpout	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1	
Butterfish	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	3	3
	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	3	3
Blenny family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2	2
Dragonet	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
Turbot family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	1
	15–30cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	1	2
	30–50cm	–	–	1	–	–	1	–	–	–	–	–	–	2	1	–	–	–	–	–	1	–	–	–	1	–	–	1	4
	50–80cm	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Megrim	30–50cm	4	2	–	2	1	3	–	–	–	1	–	–	13	3	–	1	–	–	–	4	–	–	–	–	1	–	1	18
	50–80cm	–	–	3	–	–	–	–	2	–	1	–	–	6	1	2	–	–	–	2	5	–	–	–	–	–	–	–	11
Scaldfish	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
Halibut family	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1
	15–30cm	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1	2	3
	30–50cm	–	1	–	–	–	2	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	1	–	1	4

Table 42 (continued)
Fish sizes, summary

Recovery		Hand collected													Coarse sieved							>2mm							Grand Total
Trench		EP	I					II	III	IV	V	VI	VI/ central cairn	Total	EP	I					Total	EP	I					Total	
Cell/compartment			1	2	3	4	5									1	2	3	4	5			1	2	3	4	5		
Common name	Total length																												
Flatfish Order	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	3	3
	15–30cm	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Perciformes order	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1
Scorpaeniformes	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	3	3
	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	1
Tiny perciformes	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	2	17	3	25	25
	15–30cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4	6	6
Totals		49	68	45	19	44	159	2	12	2	42	2	1	445	51	13	13	1	34	4	116	6	9	31	10	232	98	386	947

that are very commonly found in the coastal waters around Orkney today (eg Fenton 1978, 527–40; Nicholson 2005). The few haddock, pollack and saithe/pollack identifications again represented a variety of sizes, from less than 15cm in the sieved material to over a metre in the hand collected. The rocklings, small, mostly inshore fish which tend not to get very large, were generally less than 30cm total length.

The wrasse family fishes were predominantly in the 30 to 50cm length category, with a few smaller ones found in the sieved material and a few larger, predominantly ballan wrasse, found in the hand-collected fraction. An abundance of 15–30cm ballan wrasse in the hand-collected material from cell 5 may suggest a deliberate fishery for this size of fish. When examined at the context level, this was particularly apparent in context 2; corresponding sieved and coarse material showed no such focus on this fish, however.

The flatfishes were again repre-sented by a variety of sizes, from less than 15cm to 50–80cm total length. Almost all of the conger eels recorded were substantial, at over a metre in length. The few identified common eels that could be sized were typically much smaller, at 15–50cm in length. Herring and salmon and trout family were both small, at 15–30cm total length. The one tentative angler identification was very large, at over 100cm total length, while species and families like the small perciformes, the sea scorpions, bull-rout, perches, eelpout, scaldfish and butterfish all tended to be very small at 30cm or less in length.

Aside from a slight tendency for cell 5 to contain larger cod and ling (contexts 1 and 3), and to contain an abundance of 15–30cm ballan wrasse (context 2), there were few general trends through space or time. The recovery methods were the greatest divider of sizes, with the sieved material containing much smaller fish than the hand-collected material. The lack of any larger fish in the sieved material suggests that they had previously been removed during hand collection, as this was particularly apparent in cases where both hand collected and sieved material were available from the same area.

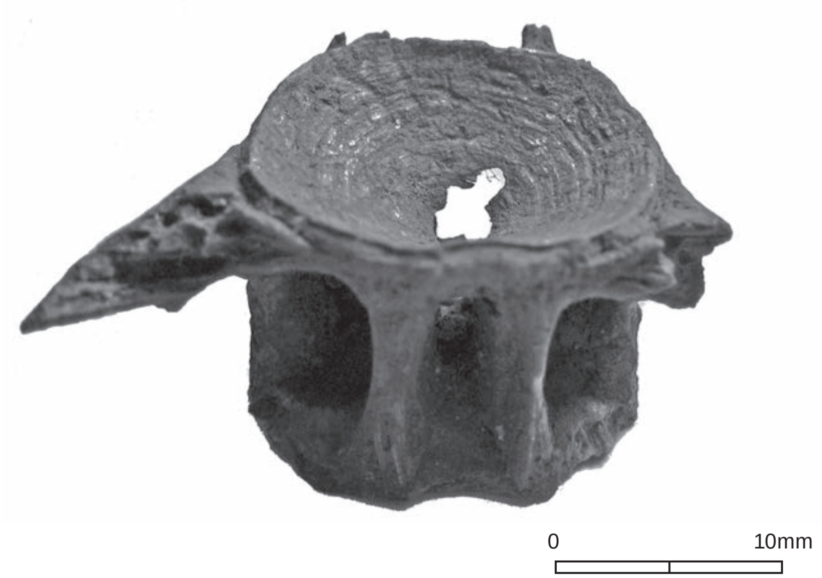
The fish species and sizes represent a variety of habitats, from coastal inshore waters that would have been relatively easy to exploit, to deeper, offshore habitats that would have required considerable effort to fish. Most of the ling found at the Holm are sizable, and thus represent mature adults – who prefer to live at depths of 100 to 400m (Froese & Pauly 2007). Even

Table 43
Fish sizes, detail

Recovery		*Hand collected, Trench I*																								
Cell/compartment		1			2						3			4								5				*Total*
Context		1			1		2		3		1	3		1		2			3	4	6	1	2	3	4	
Sub-sections			E	W	E	W	E	W	E	W	W	E	W	NE	SE	W	SE	W	NE	NW	NE					
Common name	Total length																									
Cod family	15–30cm	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	4
	30–50cm	–	–	1	1	–	–	1	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	5
	50–80cm	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	3
	80–100cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	1	–	–	–	3
	>100cm	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Cod/saithe/ pollack	15–30cm	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	50–80cm	–	–	–	–	–	–	–	–		1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Cod	15–30cm	–	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	4
	30–50cm	–	1	–	–	–	1	1	–	–		–	–	–	–	–	–	–	–	–	–	–	–	4	–	7
	50–80cm	–	3	1	–	–	–	1	–	–	2	–	–	1	–	1	–	–	–	–	–	5	–	5	–	19
	80–100cm	–	1	1	–	–	–	–	–	1	1	1	–	–	–	1	–	–	–	–	–	3	–	6	–	15
	>100cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Haddock	15–30cm	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	30–50cm	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	50–80cm	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Saithe/pollack	15–30cm	–	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	30–50cm	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	50–80cm	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	80–100cm	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Pollack	30–50cm	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	50–80cm	1	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1	7
	80–100cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	2
Saithe	15–30cm	–	2	4	2	–	–	2	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	11
	30–50cm	–	1	1	2	2	1	–	–	–	–	–	–	–	–	5	–	–	–	–	–	1	–	1	–	14
	50–80cm	–	1	1	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	5
	80–100cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1

Table 43 (continued)
Fish sizes, detail

Recovery		*Hand collected, Trench I*																								
Cell/compartment		1			2						3			4								5				*Total*
Context		1			1		2		3		1	3		1			2		3	4	6	1	2	3	4	
Sub-sections			E	W	E	W	E	W	E	W	W	E	W	NE	SE	W	SE	W	NE	NW	NE					
Common name	Total length																									
	>100cm	–	–	–	–	–	–	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Rockling	15–30cm	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	3	–	4	
	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
Five-bearded/ northern rockling	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
Ling	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
	50–80cm	–	–	1	–	–	–	–	–	–	–	–	–	2	–	1	–	–	1	–	–	–	–	–	–	5
	80–100cm	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	3
	>100cm	1	1	1	1	–	–	1	–	–	1	–	1	–	–	8	–	–	–	1	–	7	–	1	–	24
Wrasse family	15–30cm	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	1	–	8
	30–50cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	1	6
Ballan/cuckoo wrasse	15–30cm	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15	–	–	18
Ballan wrasse	15–30cm	–	–	12	–	3	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	31	7	–	54
	30–50cm	–	–	1	–	–	–	–	–	–	2	–	–	–	–	–	–	1	–	–	1	–	4	8	–	17
	50–80cm	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	3	1	–	7
Cuckoo wrasse	15–30cm	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Corkwing	<15cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
	15–30cm	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	8	–	–	11
Totals		3	21	35	14	7	2	7	3	4	14	1	1	4	2	24	1	2	1	1	1	21	70	47	2	288



Illus 45
Pierced ling abdominal vertebrae, from trench V.1 (id 708). Dorsal surface broken, possibly caused by piercing device slipping and breaking the vertebral body. Note the series of small overlapping holes, apparently made with an approximately circular device of about 1.5mm diameter (scale 10mm)

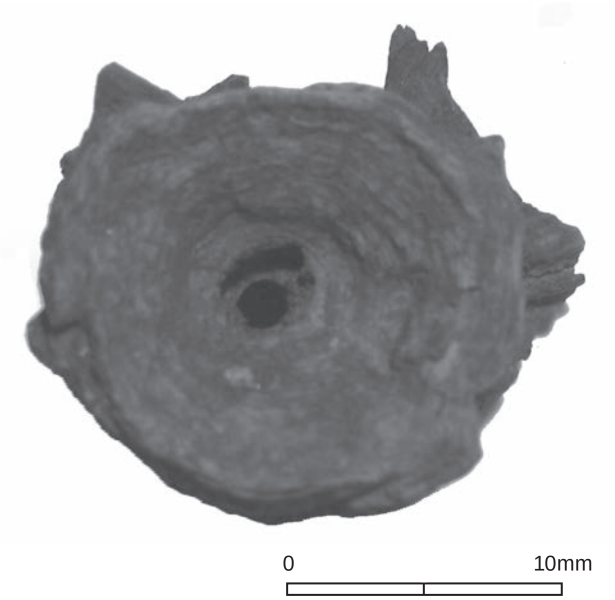
without taking into account the slightly lower sea levels in the Neolithic, the inhabitants would have had to travel considerable distances to reach waters of this depth, as discussed below.

Butchered and pierced vertebrae

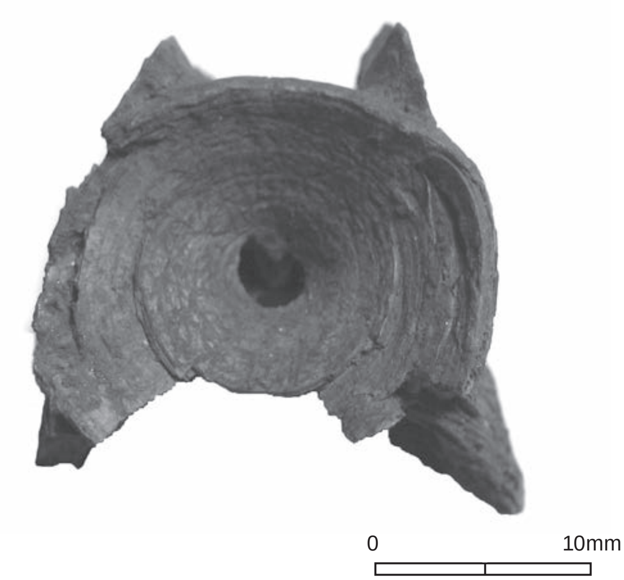
Eleven pierced vertebrae were discovered during analysis of the fish bone assemblage (summarised in Table 44 and illustrated in illus 45, 46, 47), and one further vertebra showed evidence of butchery, most probably using a stone tool. All of these modified vertebrae were from the cod family fish, and all were from large or very large fish. Other pierced vertebrae are known from Neolithic Orcadian contexts, as will be discussed below, but this is believed to be the first evidence of butchery.

The one butchered cod vertebra was from trench V.1 (illus 49). This was from a fish of about 80–100cm total length, and was from the caudal or tail region. A single cut was made in the transverse plane, and as it had a broad ‘v’-shaped profile that was wider than is usually made with metal tools, this was most likely to have been made with a stone tool (Mark Edmonds, pers comm). This butchery mark was shallow, but immediately adjacent to it, the vertebral body may have been chopped; the poor condition of the bone makes this difficult to distinguish. The profile of the butchery mark is consistent with that of the decorated stone knife from Skara Brae (Saville 1994). If the vertebra had indeed been chopped, the single cut could represent an abortive attempt at dividing the vertebral column, with a later, successful cut or chop made immediately adjacent. This action would have divided the tail into sections, perhaps for ease of cooking or for preserving. No other butchery marks were noted in the assemblage.

Of the 11 pierced vertebrae, nine show definite evidence of having been selected and pierced with a small, round object, while the remaining two have only been tentatively attributed to anthropogenic action, given poor condition or recent fragmentation. Nine of the vertebrae, including the two tentative identifications, were made from very large ling of over 1m in length, some of which may have been from fish as large as 1.5m in length. One smaller cod of about 80cm total length

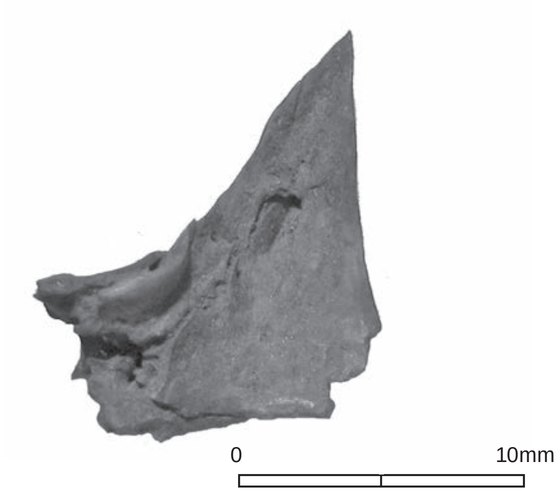


Illus 46
Pierced cod/saithe abdominal vertebra from trench V.1 (id 731) (scale 10mm)



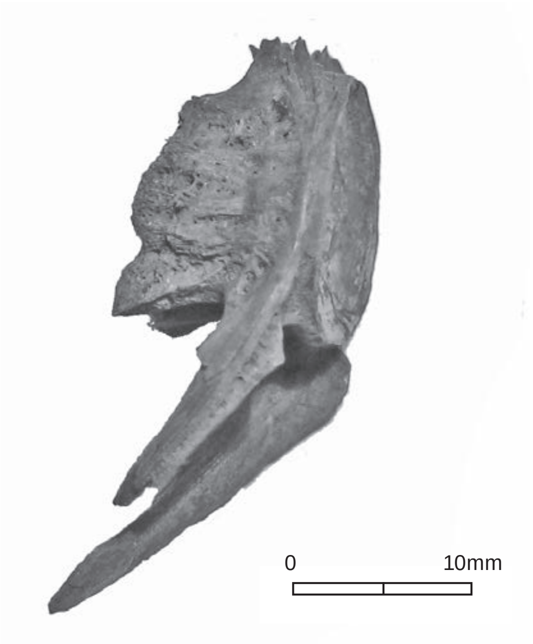
Illus 47
Pierced ling abdominal vertebra from compartment 4NW (id 240) (scale 10mm)

contributed another vertebra, and one final vertebrae was in poor condition and thus difficult to identify, but was most likely cod or saithe. Again, this was from a fish of 80–100cm in length. Almost all vertebrae were from the anterior part of the vertebral column. The large size of these fish, plus the apparent choice of anterior positioning, would indicate deliberate selection. All of these vertebrae were missing their neural and haemal spines, perhaps because they had been deliberately removed – although these are naturally fragile and are frequently broken off through natural taphonomic attrition, even on the larger fish vertebrae.



Illus 48
Example of carnivore gnawing on a wrasse articular, from cell 5.5 (scale 10mm)

The pierced vertebrae were found throughout the assemblage, both inside and outside of the tomb. Seven were found in compartments 1, 2, and 4 and cell 5. Four were found in trench V.1, although as two of these were tentative identifications, this concentration is perhaps not as great as it seems. There was no particular species, size or element patterning associated with an area, but the four found in trench V were in poorer condition (despite the overall similar taphonomic patterning in all areas; see above). Both whole and partial vertebrae were found in both areas. One ling vertebrae from trench V had a broken dorsal surface that may have been caused by the piercing device slipping upwards (illus 45).



Illus 49
Butchered cod caudal vertebra, from trench V.1 (id 725) (scale 10mm)

Table 44
Pierced fish vertebrae

Trench	*Cell/ Comp.*	*Context (Co-ords)*	*Species*	*Fish size (TL)*	*Element*	*Description*	*Size and shape of anterior hole (width × height)*	*Size and shape of posterior hole (width × height)*
I	1	3 (W)	Ling	>100cm	Abdominal vertebra group 3	Anterior, ventral part of vertebral body, missing spines; id 10719	5.1 × 4.3mm; comma shape with two overlapping circles	
I	1	1 (W)	Cod	c. 80cm	Abdominal vertebra group 1	Whole vertebral body, missing spines; possibly pierced from posterior to anterior when still relatively fresh; id 399	3.7 × 2.8mm; three overlapping circular holes visible	1.7 × 2.0mm; circular hole
I	2	2 (W)	Ling	>100cm	Abdominal vertebra group 2	Whole vertebral body, missing spines; also chewed on dorsal surface; id 493	2.4 × 2.9mm; rough ellipse shape	3.9 × 3.5mm; very rough circular shape
I	4	1 (W)	Ling	>100cm	Abdominal vertebra group 3	Whole vertebral body, missing spines, in very poor condition; id 200	3.0 × 2.5mm; roughly circular	3.3 × 2.4mm; roughly oval
I	4	4 (NW)	Ling	>100cm	Abdominal vertebra group 3	Dorsal vertebral body, missing spines; id 240	2.0mm wide; approximately circular	3.1 × 3.0mm; comma shape
I	5	1	Ling	>100cm	Abdominal vertebra group 3	Whole vertebral body, missing spines; id 10135	2.2 × 2.0mm; slight comma shape	1.7 × 1.9mm; circular
I	5	1	Ling	>100cm	Abdominal vertebra group 2	Ventral part of vertebral body, missing spines; id 10134	Estimated hole *c.* 8 or 9mm diameter	
V		1	Cod/ saithe	80–100cm	Abdominal vertebra group 1	Whole vertebral body, missing spines; chewed and in poor condition; id 731	2.1 × 1.7mm; circular	2.9 × 3.1mm; recessed smaller hole in larger opening
V		1	Ling	>100cm	Abdominal vertebra group 3	Whole vertebral body, missing spines; dorsal surface broken, possibly caused by piercing device slipping; id 708	3.3 × 4.1mm; larger hole in centre, with two smaller holes overlapping indicating a device of about 1.5mm diameter	2.8 × 3.1mm; oval shape
V		1	Ling	>100cm	Caudal vertebra group 1	Ventral, posterior vertebral body, missing spines; fragmentation makes this a tentative piercing; id 715		1.7 × 1.9mm; circular
V		1	Ling	>100cm	Abdominal vertebra	Small fragment of articular surface; has some recent fragmentation so tentative identification of piercing; id 710	4.2 × 5.3mm; circular	

This same vertebrae has a series of small overlapping holes that could have been made by a device that was approximately circular and about 1.5mm in diameter, as could have been fashioned by a sturdy mammal bone point like those found in quantity at Skara Brae (Childe 1931b).

While anthropogenic action is the most likely source of these pierced vertebrae, a few other alternatives must be discussed. Firstly, root etching was apparent on some of the larger fish bones analysed, particularly those from hand collection or coarse sieving (Table 34), the recovery method for all found here. Roots were sometimes apparent in the pierced holes, making it possible that they had, over millennia, enlarged the naturally occurring small openings in the centre of these vertebrae. However, had this been the case, not only would this have been expected on other of the very large vertebrae, but other naturally occurring holes should have also been enlarged. None was observed.

Carnivore gnawing is another alternative explanation. Much of the assemblage had indeed been gnawed or crushed during the process of chewing. Carnivore teeth puncture and crush bones in a distinctive manner, creating triangular-shaped holes or linear depressions, as shown in illus 34. The 'holes' in these vertebrae were rather more rounded, making it likely that they were deliberately cut or bored. It is also worth noting that had the vertebrae been chewed, holes and crushing marks would have been present on all surfaces, not just the centres. Inevitably, some ambiguity remains; a few 'pierced' trout vertebrae recovered at Skara Brae were recently interpreted as evidence of chewing and digestion (Jones 1993), which is possible given their relatively small size. However, the very large size of the ling and cod from the Holm make it very unlikely that they had passed through the digestive system of any omnivore or carnivore in the Orcadian Neolithic. Together with the presence of pierced fish vertebrae at other Neolithic sites, and their absence from sites of other dates in the Northern Isles (eg Harland 2006), these are most likely to have been deliberate, anthropogenic, creations.

None of the pierced vertebrae shows any sign of wear or polish, either on the outside or in the immediate area of the piercing. However, if they had been worn on a fibre or sinew thread, the small opening in the vertebrae may have ensured a snug fit, without any movement and thus without any polish or wear.

Discussion

FISHING IN THE NEOLITHIC

Several sites of Neolithic date have been excavated in Orkney, but few have large fish bone assemblages like that from the Holm of Papa Westray North. That said, the results presented here are very similar to those from other Neolithic sites, as there is surprisingly little variation throughout the Orcadian Neolithic. This is partly a reflection of the small number of sites available for comparison, once recovery biases, taphonomic patterning (including otter spraint) and quantification methods are all considered. The hand collected and coarse sieved remains from the Holm of Papa Westray North are very similar to those found at most other sites (see Table 45 for a summary of comparative sites), both in terms of species composition and fish sizes.

Skara Brae stands out among the comparative material, as the recent excavations produced a fish assemblage that was over 50% salmon and trout family (Jones 1993, 14). Although bones from this family are difficult to distinguish, analysis of the cranial bones showed that of those that could be identified to species, all were trout (Jones 1993, 14). Eels were also relatively more common at Skara Brae than at other sites, suggesting that freshwater fishing was of primary importance, perhaps even a 'highly targeted fishing activity' (Jones 1993, 18). Skara Brae is located close to the freshwater lochs of Mainland, which could easily have supplied these species, while the inhabitants of sites on the smaller north isles, like Westray, would not have had access to such large freshwater resources.

Leaving aside the otter spraint, which is discussed separately below, it is clear that (anthropogenic) fishing is represented in the assemblages from Neolithic Orkney, and that at least some of the fish remains recovered from tombs would have been directly placed there by humans. Was this a deliberate act, or were these remains discarded with no formality in the vicinity following meals? There are several different options to consider, not all of which are mutually exclusive. Hedges attached such an importance to what he saw as the 'totemic' qualities of certain species, that he named an entire book after the eagles found at Isbister. For him, the inclusion of other animal remains was '. . . part of a larger ritual wastage of economic resources (with possibly some element of ceremonial consumption)' (1983, 269). Hedges articulated a distinction between 'totemic' animals and others, which became

Table 45
Summary of comparative Neolithic fish assemblages

Site	*Site type*	*Recovery*	*Otter remains*	*Otter spraint*	*Anthropogenic origin*	*References*
Isbister	Cairn	Special deposit sieved to 5mm, also hand collection	Yes	Sieved deposit likely otter spraint	Larger hand-collected bones were probably anthropogenic	Barker 1983; Colley 1983
Point of Cott	Cairn	Hand collection and sieving, but the sieved material wasn't identified	Yes, they were likely living between the revetting walls, using them as holts	All deposits likely otter or bird activity	A few of the larger conger and cod might have been caught by humans, but as they were chewed and crushed, they may have been caught or at least scavenged by otters	Coy & Hamilton-Dyer 1997; Halpin 1997
Skara Brae	Settlement	Hand collection and sieving, including some 5mm	?	Some bones were crushed and chewed, particularly the vertebrae; some otter and other animal activity therefore suggested	Yes, most of the remains were likely anthropogenic	Jones 1993
Tofts Ness	Settlement	Mostly hand collection, some sieving to 3mm and 0.5mm	Yes	Yes, from a floor context of Late Bronze Age/early Iron Age, likely an abandoned building used as a holt	Yes, including deep-water fishing from boats	Nicholson 2007a; Nicholson & Davies 2007
Quanterness	Cairn	?some sieving to 2mm	Yes, but not in the main chamber	Yes, most of the remains were probably caught by animals, including birds (large quantity of owl pellets)	Possibly, as some of the larger fish like ling prefer deeper water so might have been fished from boats	Clutton-Brock 1979; Wheeler 1979
Knap of Howar	Settlement	Mostly hand collected, with some sieved material presented separately	Yes, but only found in the topsoil		Definitely some deeper-water fishing from boats; one possible fishing spear or gorge found	Noddle 1983; Ritchie 1983; Wheeler 1983
Pool	Settlement	Hand collection and 3mm sieving			Very small collection of poorly preserved Neolithic bones so difficult to interpret	Nicholson 2007b
Pierowall Quarry	Cairn		Yes		No Neolithic fish remains	MacCormick 1984; Swinney 1984
Howe	Cairn	Very little sieving	No		No fish recovered from Neolithic layers	Locker 1994; Smith 1994
Links of Noltland	Cairn and ?Settlement	Sieving and hand collection	Not specified if otter remains were found; coprolites were found containing fish bones, likely from scavengers larger than otters, possibly dogs or humans	Yes	Larger hand collected fish were possibly remains of human consumption; a few bones were burnt, even from deposits positively identified as otter spraint, indicating some anthropogenic influence and possible scavenging from human meal remains	Nicholson & Jones 1992

Table 45 (continued)
Summary of comparative Neolithic fish assemblages

Site	*Site type*	*Recovery*	*Otter remains*	*Otter spraint*	*Anthropogenic origin*	*References*
Cliff sample 1979, Brough of Birsay (Late Neolithic/ early Bronze Age)	Midden	Sieving to 1mm	No	Discussed as likely	Only two bones from large fish, so unlikely but possible	Nicholson 1989
Area 6, Brough of Birsay (early Bronze Age)	Midden	Sieving to ?2mm	No	Most likely explanation for almost all of the fish	A few larger bones could represent human activity	Rackham 1989
Cuttings 5 and 6, Brough of Birsay (Middle Bronze Age)	Midden	Sieving	No	No	Some of the larger fish, including large gadids, might have been caught by people off shore; presence of butchered seal and domestic mammals indicates anthropogenic assemblage	Rackham *et al* 1989
	Midden	Sieving	No	No		

incorporated as a result of funerary consumption, or direct interment as food for the dead. His choice of the eagle is, perhaps, easy for us to understand, but in the past, concepts of totemism might be equally valid for explaining deposits of more 'mundane' animals, among them, for example, the dogs from Cuween Hill. More importantly, it may well be that those species that were subjects of consumption were themselves of some symbolic or metaphoric importance, because of their character, their origins or simply their inclusion in certain events. We cannot dismiss the fish remains, or the remains of the domestic mammals, as simple foodstuffs without other meanings.

Certainly, there is evidence to suggest that food was being prepared for consumption, by the living or by the dead. At Isbister for example, the domestic mammal remains had been prepared and jointed prior to inclusion in the tomb. While there is only one butchered cod from the Holm of Papa Westray North, this may suggest that prepared food on these occasions extended to fish. However, we should also allow that some of the larger, deliberately caught fish might be present in the tomb as a consequence of animal (including otter) scavenging of food remains left behind after acts of consumption outside (Nicholson & Jones 1992, 5; O'Sullivan *et al* 1992). How we interpret these deposits is a matter for conjecture. Chesterman thought the animal remains found in association with the human remains from Quanterness were the result of 'jollification' during the internment and ceremonial processes (1979, 107), which is certainly a possibility.

Other deposits hint at the complexity of the processes that we are dealing with and thus the difficulties involved in interpreting them. For example, some of the fish from the Holm were found in the sealing deposits of the entrance passage and cell 5. It might be tempting to attach some importance to their presence here. However, it is rather more likely that they became incorporated as part of a matrix of midden material deliberately introduced as blocking in this area. This effectively sealed the tomb and may thus have been a significant act, but it is doubtful whether or not the presence of fish remains in the matrix was explicitly regarded as important at that moment.

Davidson and Henshall describe an apparent dichotomy between the animals deliberately placed in the tombs, like eagles, red deer and dogs, and those that may have been found within 'midden' and thus with little deliberate or explicit symbolism read into their presence – including the fish and other bird remains (1989, 84). We could argue that this secondary category

Table 46
Latin and common names for species referred to in the text

Common name	*Latin name*
Dogfish families	Scyliorhinidae/Squalidae
Dogfish family	Scyliorhinidae
Ray family	Rajidae
Eel	*Anguilla anguilla*
Conger eel	*Conger conger*
Atlantic herring	*Clupea harengus*
Salmon and trout family	Salmonidae
Cod	*Gadus morhua*
Cod family	Gadidae
Cod/saithe/pollack	Gadus/Pollachius
Five-bearded/northern rockling	Ciliata
Four-bearded rockling	*Rhinonemus cimbrius*
Haddock	*Melanogrammus aeglefinus*
Ling	*Molva molva*
Pollack	*Pollachius pollachius*
Rockling	Ciliata/Gaidropsarus
Saithe	*Pollachius virens*
Saithe/pollack	Pollachius
Angler?	*Lophius piscatorius?*
Stickleback family	Gasterosteidae
Three-spined stickleback	Gasterosteus aculeatus
Scorpaeniformes	Scorpaeniformes
Scorpion-fish family	Scorpaenidae
Gurnard family	Triglidae
Bull-rout	*Myoxocephalus scorpius*
Sea scorpion	*Taurulus bubalis*
Sea scorpion family	Cottidae
Perch family	Percidae
Atlantic horse-mackerel/scad	*Trachurus trachurus*
Ballan wrasse	*Labrus bergylta*
Ballan/cuckoo wrasse	*Labrus bergylta/Labrus bimaculatus*
Corkwing	*Symphodus (Crenilabrus) melops*
Corkwing wrasse/goldsinny	*Symphodus (Crenilabrus) melops/Ctenolabrus rupestris*
Cuckoo wrasse	*Labrus bimaculatus*
Goldsinny	*Ctenolabrus rupestris*

Table 46 (continued)
Latin and common names for species referred to in the text

Common name	*Latin name*
Wrasse family	Labridae
Eelpout family	Zoarcidae
Viviparus eelpout	*Zoarces viviparus*
Butterfish	*Pholis gunnellus*
Blenny family	Blenniidae
Dragonet	Callionymus
Tiny perciformes	Tiny perciformes
Megrim	*Lepidorhombus whiffiagonis*
Megrim?	*Lepidorhombus whiffiagonis?*
Scaldfish	*Arnoglossus laterna*
Turbot family	Bothidae
Turbot family	Scophthalmidae
Halibut family	Pleuronectidae
Flatfish order	Heterosomata (Pleuronectiformes)
Perciformes order	Perciformes

definitely includes animals that were not merely food remains. The presence of fish bone beads at several sites indicates that fish had metaphoric or symbolic potential. Indeed, the apparent choices made relating to species used for necklaces may indicate some aspect of territoriality. At Skara Brae, freshwater trout were the preferred species, whereas on the Holm of Papa Westray and on Sanday, deep-water ling were seen as more desirable; Wickham-Jones believed that animal remains can be 'interpreted as indicative of totemic spirits that were attached to the different communities' (Wickham-Jones 2006, 39). These two species groups appear to have been deliberately chosen from a wide range of species that could have been made into beads. Various social identities may have been articulated through the wearing of these beads made from specific species. This may have been important during social gatherings when people from different areas or islands met. These beads were probably deliberate inclusions in the tombs, perhaps as grave goods, perhaps to signify the connections between respective species and territories, or perhaps left as gifts by visitors to the dead. The discovery of the discrete, separate caches of beads at Skara Brae would further this interpretation, that beads were an important and specially curated aspect of the Neolithic life and death. The sample size of pierced fish vertebrae is very small to make such generalisations, but they must be considered, particularly in the light of other beads made from mammals. The use of whale teeth as beads from Point of Cott may be a means of referring to and conveying the 'fearsome nature' of killer whales, as suggested by Jones and Richards (2003, 47). It is possible that the wearing of fishbone beads suggests some form of 'ownership' or control over the waters they were fishing (following Clarke *et al* 1985, 58), or even signified some form of respect for the skills involved in fishing.

FISHING METHODS

Although difficult to ascertain the boat technology used, the Neolithic inhabitants of the Northern Isles must have had boats of sufficient strength and size to transport livestock and people across some very treacherous waters. Knowledge of tides, currents and winds would have been considerable in order to travel from island to island, and must not be underestimated

(Noble 2006, 109). Even if fish were not consumed with sufficient regularity to produce elevated marine isotopic signatures (Schulting *et al* 2004 and this volume), it is clear that the sea was routinely interacted with, as can be demonstrated by the frequent orientation of monuments towards the sea or sea-views (Phillips 2003), and the importance of the conjunction of a marine and freshwater loch at the heart of Neolithic Orkney (Sturt 2005).

The large ling found at the Holm and other sites, including the Knap of Howar and Skara Brae, are indicative of deep-water fishing, probably undertaken with hook and line or long lining. Modern sources vary in their descriptions of ling habitats, but there is a consensus that larger mature ling live in waters of 300 to 400m depth, with occasionally a few of these large specimens straying into shallower waters (Wheeler 1969, 175–6). Depths of about 100m could be reached by travelling from the Holm of Papa Westray approximately 37km in a north-west by west direction, past the north end of Westray. Other waters of comparable depth could be reached by travelling about 63km in a north-easterly direction, towards Shetland. Reaching depths of 300m or more would have required a trip of over 100km in a north-westerly direction (Anon 2008). All of these options would have been risky, given the powerful currents that operate in this region of the North Atlantic. Perhaps the more likely fishing grounds would have been the stretch of deep water of over 100m between Shetland and Orkney, as this area is immediately to the west of Fair Isle and, on a clear day, it would have been possible to reach without losing site of land (Hunter 1996, 1). Neolithic settlers to Shetland would have certainly passed close to this region of deep water, as it is thought likely that Fair Isle was a staging post on the route from Orkney (Hunter 1996, 4). If this area was being exploited for the larger cod, saithe and flatfishes, then perhaps an occasional large ling may have strayed from deeper waters into this region and been caught. However, fish that are now considered deep water may have been found closer to shore in the past, before large-scale commercialised fishing began to alter habitats and ecosystems. We must therefore bear in mind that the larger gadids may therefore have been slightly easier to catch in the Neolithic (Jones 1993, 18; Nicholson 2007a, 214).

The large numbers of limpet shells found in the entrance passage could have been used as bait on a hook and line for catching small, inshore gadid species (Maleszka-Ritchie, this volume; Fenton 1978, 535). Colley and Wheeler have both suggested that the small, inshore fish from Isbister and the Knap of Howar could have been caught using spears, sticks, hook and line, baited drop nets or could have been scooped out of rock pools (Colley 1983, 153; Wheeler 1983, 104), although at these site these fish may also represent otter spraint. Wrasse are generally shallow water fish that could also be caught inshore, using traps or nets (Treasurer 1996). An experimental study of Neolithic Swedish fishhooks suggested that bone hooks were sufficient for hooking even large cod of up to 13kg (Olson *et al* 2008), well within the size range of the larger gadids found in the Orcadian Neolithic. The authors hypothesised that these hooks would have been attached to hand lines and would have been hung off the side of a boat, while the smaller cod found in the Swedish Neolithic could have been caught with the nets or leisters (pronged spears) found at the site (Olson *et al* 2008). A direct parallel can be seen in the possible fishing artefact found at the Knap of Howar, which could be a composite barbed spear or double-ended gorge, possibly suitable for fishing from boats (Ritchie 1983, 55; Wheeler 1983, 104).

Fishing in deeper water was obviously a high risk activity, but one undertaken relatively often during the Neolithic. At a time before overfishing, depleted fish stocks and altered ecosystems, when a wealth of coastal resources would have been available to the inhabitants of the Northern Isles, one does wonder why deeper waters were occasionally fished and why fish bones representing these deep waters were chosen for decorative purposes. At Tofts Ness, the presence of the deeper-water fish led to much speculation: ‘Why such risks should have been taken, when a rich and plentiful source of fish must have been available close to the shore, is worthy of debate. Burial monuments testify to community organisation in the Neolithic and Bronze Age, and a stratified social structure demanding risk-taking above the level required for simple subsistence could fit the fish-bone evidence from these periods at Tofts Ness’ (Nicholson 2007a, 215). The status and prestige associated with bringing home a large fish may have been sufficient reward, or deep-water fishing may have been seen as an important rite of passage, signifying mastery of the sea and its strengths.

OTTER SPRAINT IN NEOLITHIC TOMBS AND SETTLEMENTS

Comparative sites to the Holm are summarised in Table 45, showing the likely taphonomic history of each site, particularly whether or not the analysts identified the fish bone material as deriving from otter spraint, anthropogenic activity, or both. Otters and other animals have been responsible for a large quantity of the fish bones found in Neolithic tombs, and it is therefore crucial to be able to separate the two types of material in order to understand human fishing and fish consumption.

Otter spraints have long been identified in archaeological assemblages from the Northern Isles, including some of Neolithic date. Wheeler suggested that animals may have been responsible for the accumulation of remains in the Quanterness chambered tomb, mentioning that '[s]hore dwelling otters … would be capable of catching most of the species of fish' found in the tomb (Wheeler 1979, 147). However, he doubted that otters would actually spraint in their holts, and together with the undigested nature of the fish remains, he concluded that they were the result of anthropogenic fishing activities (Wheeler 1979, 148). We now know that not only will otters readily spraint within their holts, but also that fish found in spraints characteristically do not appear acid etched following digestion (Nicholson 2000, 55, 61). The Quanterness material has therefore been reassessed as otter spraint in the literature (Nicholson & Jones 1992). A few years after Wheeler's publication, Colley examined the fish remains from Isbister chambered tomb, and found quantities of tiny and very small fish in the sieved material. As these included many fish of less than 300g (including small gadids, wrasses and flatfishes), as well as some tiny ones of less than 100g, she concluded that the assemblage was likely the result of both anthropogenic activity and natural accumulation (Colley 1983, 152–3). Otter spraints have since been identified from a variety of other settlement and cairn sites (see Table 45). As we will demonstrate, the identification of otter spraint is of importance to understanding site use and history, particularly when otter spraint is found to be contemporary with the use of a cairn.

As well as being found throughout the Holm of Papa Westray North, otter spraint has been identified at the following cairns: Isbister (Colley 1983), Point of Cott (Coy & Hamilton-Dyer 1997), Quanterness (Wheeler 1979) and Links of Noltland (Nicholson & Jones 1992). Otter spraint was also identified in an abandoned building of Late Bronze Age or early Iron Age at the Tofts Ness settlement (Nicholson 2007a), and some otter activity was likely represented in the fish assemblage from Skara Brae (Jones 1993) and in some of the small samples from the Brough of Birsay area of Neolithic and Bronze Age date (Nicholson 1989; Rackham 1989). At each of these sites, otters were either contemporary with the human settlement or use, as at Isbister (Barker 1983, 134), or immediately followed it, as at Point of Cott (Barber 1997, 59). There is no suggestion that the otters represented recent disruptions to the archaeology. Indeed, both direct dating and secure stratigraphic sequencing involving infilling and sealing events suggests that otters were active in the Neolithic, using cairns as holts. The analysis of the human remains from the tombs suggests repeated visits, internments, and perhaps removal of the bones; 'all tombs seem to have been designed to be entered repeatedly' (Wickham-Jones 2006, 39). Not only would this allow animals like sheep and otters to make use of the tomb, but it would also provide occasions for food to be brought into the tombs, as sustenance for the people visiting and/or as offerings.

At the Holm of Papa Westray North, the presence of large quantities of neonatal and foetal lambs has suggested the tomb was open over a long period of time, allowing naturally occurring deaths to accumulate within the tomb (Balasse *et al* 2008, 171; this volume). These were contemporary with the tomb's use, and were thus likely to have been contemporary with the otter activity as well. These pre-date the sealing events that filled in the tomb, implying that live animals were not discouraged from using the tomb even when it was being used for recently deceased people. Davidson and Henshall have speculated that the tombs were temporarily sealed between use events, even with masonry blocking (1989, 59), but the ubiquity of contemporary animal usage would suggest otherwise.

As it appears otters were not discouraged from living in the tombs, even when they were in active use (Ritchie 2004, 102), it must be assumed that the Neolithic human inhabitants of the islands did not mind the occasional disruptions to the dead. It may be possible that otters were seen as an intrinsic part of the life of the tombs, or, alternatively, the tombs may have provided a useful means for capturing otters; their fur provided a fine, waterproof skin (Fenton 1978, 526).

COMPARATIVE BONE AND SHELL 'BEADS'

Comparable examples of fish bone beads are known from a variety of other Neolithic Orcadian sites, including Skara Brae, Quanterness and Tofts Ness, Sanday. Beads made of mammal bone and shells were also very common on Neolithic sites.

Fish bone beads were noted in early excavations at Skara Brae in conjunction with beads made from mammalian bone, though not discussed in any detail (Childe 1931b, 96, 145). Several thousand beads were identified from the antiquarian excavations at Skara Brae, most of which were made from domestic mammal long bones, or teeth from domestic mammals or whales (Petrie 1868, 212; Traill 1868, 436; Stewart & Dawkins 1914, 352; Callander 1931, 109; Childe 1931b, 144, 145, 149). At least one discrete deposit contained about 3000 beads and amulets, suggesting some sort of curation while another deposit of a few hundred beads in a doorway was interpreted as evidence of a hasty retreat from the settlement (Childe 1931a, 49, 56). The analysis of fish bones from the more recent excavations at Skara Brae included several trout vertebrae that were pierced in antiquity, and although interpreted as evidence of chewing and digestion (Jones 1993), the presence of previously identified anthropogenically modified fish bones from so many comparative sites makes this an unlikely explanation. At Skara Brae, these trout vertebrae were very small, with a centrum width of approximately 4 to 5mm (interpolated from photographs in Jones 1993); the pierced holes would therefore have been slightly smaller than those from the Holm.

A single fish vertebra bead was found at Quanterness and described as 'an unusual item', comparable to those from Skara Brae (Henshall 1979, 80–9). The illustration shows a moderately large elasmobranch vertebra with an enlarged vertebral centrum.

A number of beads were found at Tofts Ness, Sanday, including some made from fish vertebrae, as well as antler and mammal long bones. These included two pierced ling vertebrae from Phase 1 and one of unknown species from Phase 4. Those from Phase 1 were made by piercing small holes through the middle of large vertebrae, creating a hole of about 1.5mm in diameter; the fish sizes are not given, but from the dimensions provided, it is clear these were large ling of over 100cm total length. The spines had been removed, although, as with the beads from the Holm, it is not clear whether this was by natural taphonomic attrition or deliberate action.

Beads were noted from Isbister, but not of fish bone; instead, some were made of mammal bone and were noted as similar to those from Skara Brae, and additionally, some were made from pierced limpet shells (Henshall 1983c, 45). Marine mammal teeth were used to make beads at both Skara Brae (Traill 1868, 436; Stewart & Dawkins 1913–14, 352) and Point of Cott on Westray, where 16 modified and, in some cases, pierced, whale teeth were found. These included killer whale, pilot whale and sperm whale teeth (MacSween & Finlay 1997).

In summary, it appears animal remains were often used as ornaments in the Neolithic, and a wide variety of bones, shells and teeth were utilised for this purpose. The overlaps between different site types and areas, such as the whale teeth used at both the Skara Brae settlement and the Point of Cott tomb, suggest some uniformity in this practice across the Neolithic period in Orkney. However, at the same time, there does appear to be some species that are site-specific. For example, Skara Brae appears to focus on pierced trout vertebrae, while the inhabitants of the Holm preferred deep-sea ling and other large gadids. This trend towards site-specific specialisation is particular apparent within the pierced fish vertebrae, although this could simply be a product of the small numbers of sites with sieved fish remains available for study. If viewed as part of the larger picture of animal usage, it could be interpreted as evidence of totemism, with specific animals identified with in certain regions of the Northern Isles. It might be no coincidence that the Westray island group is associated with deep-sea fish, as they are on the edges of the Orkney island archipelago and thus may have had a greater knowledge of the sea than the inhabitants of Mainland.

Conclusions

The large assemblage of fish remains found at the Holm of Papa Westray North represents both deliberate fishing and the remains of otter spraint, indicating otters were living in the tomb even while it was in contemporary use. Cod family and wrasse family fish were the most commonly exploited taxa, though a wide variety of fish taxa were found indicating broad exploitation of the coastal and deeper marine waters surrounding the islands. Little spatial or temporal patterning was found within or around the tomb. Some of the fish, including large ling, would have been caught in deep waters at some distance from Orkney, suggesting detailed knowledge of the sea and its inherent risks. These larger, deep-water fish may have been caught with hooks and lines. Smaller fish like the wrasses and some smaller cod family fish, including cod and saithe, may have been caught from inshore waters using hook and line, nets or traps, based on ethnographic parallels.

The deliberately caught fish may have been placed in the tomb as grave goods, or they might represent food eaten while visiting the dead. The fish found in the infilling deposits might have inadvertently been incorporated in the tomb, and it is possible that otters living in the tomb scavenged the remains of human meals and thus introduced fish into the tomb. The presence of several fish bone 'beads' at the Holm and a number of other Neolithic Orcadian sites may indicate that fish had a meaning beyond simply that of food.