Zooarchaeology in the Viking Age to Medieval Northern Isles, Scotland: An investigation of spatial and temporal patterning

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Abstract

This thesis explores patterning in Viking Age and medieval zooarchaeological assemblages from Orkney, Shetland and Caithness in northern Scotland. Its goals are to disentangle the relative importance of spatial and temporal trends in the interpretation of the animal bone record from this region of the Norse North Atlantic – and their impact on our understanding of wider developments such as the intensification of economic production at the end of the first millennium AD in North-western Europe. Existing published and archival sources are augmented by primary analysis of two substantial assemblages, including fish from Earl's Bu, Mainland Orkney, and fish, mammals and birds from Quoygrew, Westray, Orkney. Broad trends and variations in site type, function and status are identified. Multivariate methods, including correspondence analysis, and more traditional methods of zooarchaeological quantification are both employed, and any biases caused by differential recovery or taphonomy are factored into the conclusions. Evidence for intensification of fishing is linked to the wider Fish Event Horizon of the late Viking Age and early medieval periods in Europe, and evidence of fish trade was found, including both consumer and producer sites. Earl's Bu, a high status site, received substantial quantities of prepared gadid (cod family) fish, possibly produced at Quoygrew and other sites. The high proportions of neonatal cattle found throughout the region are interpreted as evidence for an increasing intensification in dairying, while the unusual absence of this material from the Birsay area suggests a correlation with the high status political and ecclesiastical elite settlement there. Evidence of species introductions and extirpations are also presented, focussing firstly on the decline of the red deer during the Viking Age and medieval periods, and secondly, on any changes to livestock at each chronological transition. Future work will help illuminate the patterning identified here, including additional zooarchaeological analysis and new bioarchaeological research examining the diet of humans and livestock, and the origin and consumers of traded fish.

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Author's Declaration

The recording system used to record the primary bone assemblages in this thesis was published as:

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Chapter One: Introduction

1.1 Aims of thesis

This thesis explores the zooarchaeological record of the Northern Isles of Scotland from the Viking Age to the medieval period (c. AD 800 to the 15th century), particularly focussing on the identification and explanation of spatial and temporal patterning visible at both the intra- and inter-site levels. Recent archaeological work in the Northern Isles has produced a wealth of sites with well organised sampling strategies, which has led to the production of a number of detailed zooarchaeological reports (e.g. Allison 1989; Colley 1989; Rackham 1989; Allison 1995; Gidney 1995; Jones 1995; Allison and Rackham 1996; Colley and Rackham 1996; Rackham 1996a; Cerón-Carrasco 1998b; Hamilton-Dyer 1998; McCormick 1998b; Barrett and Oltmann 2000). Two substantial bone assemblages from the Northern Isles have also been analysed by the author during this thesis, including the fish assemblage from Earl's Bu, Mainland Orkney (completing work began by Barrett (1995; 1997)), and the fish, mammal and bird from Quoygrew, Westray. The results of these primary sites will be presented here, and together with both comparative data in the published literature and made available to the author, these form a substantial dataset suitable for in depth spatial and temporal analysis.

More specifically, this thesis aims to identify and define correlations between the zooarchaeological evidence and site type, function and status. In so doing, it will explore a number of key issues in Northern Isles archaeology. The first of these is the extent and detailed chronology of the intensification of fishing visible from the late Iron Age – Viking Age transitional period, expanding to form the "Fish Event Horizon" of c. AD 1000 (Barrett *et al.* 1999; Barrett *et al.* 2004a). The role of fish trade within the Fish Event Horizon will also be examined using both the new evidence provided by the primary sites, and by a critical assessment of published literature (Hamilton 1956; Ritchie 1976-77; Hunter and Morris 1982; Hedges 1983; Bigelow 1984; Hunter 1986; Morris and Emery 1986; Colley 1988; Morris 1989; Morris *et al.* 1995; Morris 1996a; Buteux 1997; Nicholson 1998; Sharples 1998; Barrett 2000a; Barrett and Oltmann 2000; Harland 2001b). Thirdly, the meaning and intensification in deposition of neonatal cattle bone will be examined with reference to possible changes in the dairying economy of the Northern Isles (Bigelow 1989; Bigelow 1992; Bond 1998). The concurrent analysis of both time and space, linked to site function and status, will be crucial to achieving these aims. These latter aspects of zooarchaeological analysis are critical to the understanding of patterning not only within the Northern Isles, but within all facets of zooarchaeology (see Chapter Two).

In her survey of methodological issues surrounding fish bone identification in the Northern Isles, Colley emphasised that

> "[t]here is considerable variation in the representation of different species, sizes, ages and skeletal elements of fish bone between sites and between different contexts at the same site... it is necessary to consider how much this inter- and intra-site variability could be caused by past human behaviour, and how much could be due to factors such as differential preservation and the excavation methods employed" (1984, 119).

This observation can also be extended to the study of the mammal and bird bone assemblages, and forms an important facet of this thesis. Variation in recovery methods between sites can greatly influence the interpretation of the faunal assemblages, because fish bone recovery is particularly susceptible to recovery biases (Jones 1982; Wheeler and Jones 1989; Nicholson 1996). Different context types (e.g. midden versus occupation deposits) and differential preservation will clearly also influence zooarchaeological patterning, as discussed in Chapter Two. These variables need to be examined wherever possible, in order to reduce the misinterpretation of patterning caused by these biases. Despite the importance of this approach to zooarchaeology, it has not been consistently applied in the past. For example, some zooarchaeological reports considered in this thesis grouped all bone at the phase level, without taking into account intra-site variation between different structures or middens. Moreover, the treatment of differences in bone preservation has been very uneven (c.f. Barrett 1997; Barrett *et al.* 2001, 148).

As early as the 1970s, Noddle recognised that behavioural practices might differ across a site, leading to contextual variation (Noddle 1976-77, 201). Nevertheless, many bone reports continued to group all bone at the phase level without regard for intra-site variation, including those of Noddle herself (1976-77; 1997). Spatial approaches to zooarchaeological patterning have been applied or considered at some of the more recently excavated sites in the Northern Isles, including at Brough Road, the Beachview sites and Freswick Links (Morris 1989; Rackham 1995; Rackham 1996a; see Appendix

One for a brief description of each site considered). However, despite a realisation that spatial patterning could equal chronological patterning in importance at Brough Road, many of the analyses nevertheless combined different context types at the phase level (e.g. Morris 1989, 293). Colley believed that the differences between phases and areas at the Brough Road sites were due to a number of factors, including differences in context types studied, sample size and differentially applied sampling strategies, and yet she chose to present her data by phase because "this is the unit favoured for archaeological interpretation" (Colley 1989, 249). This is also illustrated in the 1995 environmental summary for Freswick Links. Rackham states, rather belatedly as this follows rather than precedes the specialist reports, that the

> "comparisons [already made] between the areas therefore provide rather poor generalisations. The sequence in each trench needs to be interpreted, the layers with human influence identified and the nature of each of these determined. Comparisons between trenches should then be made on the basis of either changes in the manner of deposit formation, and what this might mean in terms of the human activities on the site, or on a comparison of layers with either probably or definitely similar formation processes, in order to establish the nature of any variability and to make valid interpretations" (Rackham 1995, 228).

However, by the following year, Rackham concluded that

> "[v]ariations in the assemblages [of the Beachview area] have been attributed to behavioural, rather than chronological or economic patterns. Recognition of such patterns...permit functional and spatial reconstructions of importance to the interpretation of the settlement organisation and social structure, which it may be impossible to recover from other data" (Rackham 1996a, 191).

These three sites illustrate the increasing realisation of the importance of spatial analysis throughout the late 1980s and 1990s, when used in conjunction with more traditional chronological approaches. Barrett approached this subject in the 1990s by studying the identification and recognition of fish middens in the Northern Isles. A number of methods were used to successfully define these specific types of midden deposit, including studies of inter-class variation and multivariate analyses (Barrett 1995, 193-221), thus illustrating the importance of studying patterning of one type of deposit. However, the relationship between different deposit types can be just as important, and, once defined, shall be investigated throughout this thesis.

The growing importance of spatial analysis in the Northern Isles mirrored general trends in zooarchaeological methodologies elsewhere. Zooarchaeological reports from the late 1970s reached new conclusions that would not have been possible without the increased awareness of intra-site variation between context types, or the realisation that differing degrees of preservation within a site could influence the relative importance of species (e.g. Halstead *et al.* 1978; Maltby 1979). "Structured deposition" was a concept introduced in the mid 1980s that reflected changing thoughts about the role of animals within human societies; they were not just functional objects, but instead held meaning and importance beyond producing food and secondary products – and their presence in archaeological deposits could likewise have intentional and symbolic meaning beyond that of mere rubbish disposal (Richards and Thomas 1984). These concepts will be discussed further in Chapter Two.

Bone preservation and other taphonomic factors are extremely difficult to quantify, as will become apparent during the primary analysis (Chapters Four to Seven), and to compare between different methods of faunal analysis. Some comparative reports have discussed preservation explicitly (e.g. Jones 1995; Barrett 1997), while others barely approach the subject. Few quantitatively analyse preservation, making it difficult to compare at either the intra- or the inter-site level, but we are fortunate that bone preservation throughout the Scottish islands is generally excellent compared to the rest of the British Isles (Mulville *et al.* 2005, 171). Any comments regarding preservation at the comparative sites will be taken into account, but it can only be quantitatively assessed during the analysis of the primary assemblages from Quoygrew and Earl's Bu.

Building upon these observations, this thesis will attempt to review all the relevant published and available comparative data to perform a retrospective analysis of recovery, spatial and chronological trends in the data, also taking preservation into account where practicable. It is hoped that it will therefore clarify the cultural and economic changes that took place in the Viking Age and medieval periods, as will be summarised below.

As noted above, two primary bone assemblages have been analysed as part of this study, including the fish assemblage from Earl's Bu and the mammal, fish and bird assemblages from Quoygrew (see Chapter Three for details). Earl's Bu is a high status site of Viking Age and medieval date on Mainland Orkney with a wealth of environmental material, some of which has already been studied (Batey and Morris 1992; Mainland 1993;

Mainland 1994; Barrett 1997; Mainland nd.b). The faunal assemblages from Quoygrew are part of the ongoing excavation and analysis of this Viking Age and medieval settlement site on Westray (Barrett 2005). The Quoygrew material is particularly valuable because two different types of midden have been recovered: a farm mound, or multi-purpose midden, spanning the Viking Age and medieval periods, and a fish midden containing material from the medieval period (see below for further discussion of these terms). In depth intra-site analysis of each of the primary sites will be undertaken to consider recovery, preservation, spatial and temporal patterning, before extending the dataset by the inclusion of comparative material from throughout the Northern Isles.

1.2 Setting

This section will review the spatial and temporal settings of this thesis, thus defining the limits of the study. Terminology shall be introduced, particularly relating to the various time periods and the different definitions given to them in the literature. Finally, the comparative zooarchaeological material will be introduced, which will be used to compliment the results of primary faunal analysis of material from Quoygrew and Earl's Bu. Rather than providing a site-by-site summary, the emphasis shall be placed upon introducing the ways in which spatial and temporal analyses have been applied to these other sites, and how useful they will be to this study. Full details of these comparative sites, including context type variation, analytical methods used and dates of each phase are provided in Appendix One.

1.2.1 Spatial setting

This thesis considers the Northern Isles, two archipelagos off the north coast of the Scottish mainland. Orkney is the southernmost of these groups, while Shetland is located about 80 kilometres to the north-east of Orkney. For the purposes of this study, the term "Northern Isles" also includes the northern tip of Caithness, just across the Pentland Firth from the southernmost islands of Orkney, where two additional sites are located. This territory was part of the Earldom of Orkney, and had cultural and economic ties to Orkney and Shetland (Pálsson and Edwards 1978; Morris *et al.* 1995, 16-19; Graham-Campbell and Batey 1998, 67-70).

This area of northern Scotland is predominantly treeless and cool throughout the year. Few areas are more than a few kilometres from the sea, and the North Atlantic weather conditions can be harsh (Johnston 1999; Berry 2000). Structures have tended to be sturdily built using local stone, which together with the lack of modern development in most of the areas, has led to good archaeological survival and recognition (Mulville *et al.* 2005, 167). Coastal erosion is a problem throughout the area, with the more exposed Orcadian coastlines eroding at a rate of 10m per century (Berry 2000, 45), but this has led to the discovery and excavation of several of the sites used in this study. Faunal material generally survives exceedingly well in Orkney and Caithness, with most excavated sites producing substantial quantities of bone. The environmental conditions of Shetland make bone survival less certain, and although large and well preserved assemblages have been recorded from some sites, at others, like the Viking Age and medieval farmstead of The Biggings on Papa Stour, very little bone survived (Crawford and Ballin Smith 1999; Smith 1999). This discrepancy is being overcome by recent work (e.g. the Old Scatness Project, Nicholson and Dockrill 1998; Hunter 2003, 245), but fewer relevant bone assemblages are available from Shetland at this time.

The Orkney archipelago is illustrated in Figure 1.1, with Quoygrew and Earl's Bu, the two primary sites, emphasised. This figure includes Robert's Haven and Freswick Links from Caithness, illustrating the close proximity of these sites to Orkney. Figure 1.3 illustrates the locations of the four sites from Shetland. The nature of these two island groups is different, in both terrain and environment: Orkney is very fertile and Orcadians have typically been viewed as farmers who fished, while Shetland is more rugged, less fertile, and Shetlanders tend to be categorised as fishers who farmed (Fenton 1978). The soils and environmental conditions of Orkney allow most of the islands to be suitable for arable agriculture, with a few areas only suitable for grasslands and grazing, but the reverse is applicable to Shetland (Edwards and Ralston 2003, 51, 52, Figure 4.2). Conditions for Caithness tend to be similar to Orkney (Edwards and Ralston 2003, Figure 4.2).

Orkney, Shetland and Caithness in the Viking Age and medieval periods are only a few of the areas in the North Atlantic settled by the Norse, and although this thesis remains focused on the Scottish material, the wider setting needs to be considered. The faunal remains from Viking Age and medieval settlements of the Faroes, Iceland and Greenland have also been investigated (e.g. McGovern 1985; Bigelow 1990; Morris and Rackham 1992; Arneborg and Gulløv 1998; McGovern *et al.* 2001; Enghoff 2003; Outram 2003;

Amundsen 2004; Tinsley 2004; Amundsen *et al.* 2005; Church *et al.* 2005; Dugmore *et al.* 2005; Krivogorskaya *et al.* 2005; Mainland and Halstead 2005). Barring possible minor Irish settlement in the Faroes and Iceland, and indigenous presence in Greenland, these other regions of the North Atlantic were first colonised by the Norse (Vésteinsson 2000; Hunter 2003, 248). Consequently, research designs from these excavations have not focused on the temporal cultural and economic transition from the late Iron Age. The environmental conditions of the north-western regions of the North Atlantic are not directly comparable to the Northern Isles, particularly given the detrimental influence of the Little Ice Age on the Greenland colony (Fagan 2000), and nor is the range of wild fauna in Iceland and Greenland equivalent to that from the Northern Isles (e.g. contrast McGovern 1985 and Berry 2000). These factors therefore complicate zooarchaeological comparison across the North Atlantic region. The excavation of Norse settlement in the Western Isles has produced a limited number of sites with published zooarchaeological data – Bornais Mound 3 being one of the few relevant sites with fully published animal bone reports (Smith and Mulville 2004, 55; Cerón-Carrasco 2005; Mulville 2005; Sharples 2005, 6-7). Ongoing work will ultimately produce important assemblages from this region (Sharples 2005). However, the nature of Viking Age settlement in the Western Isles is not directly comparable to that of the Northern Isles, because onomastic and material culture evidence suggest a greater role for the pre-Viking inhabitants in the Western Isles, a theory matched by the genetic evidence (Graham-Campbell and Batey 1998, 37; Barrett 2003b; Goodacre *et al.* 2005).

The biogeography of Orkney, Shetland and Caithness developed separately over several millennia, although many similarities are applicable to the entire area. Following the last glaciation, by 10,000 to 12,000 BP Shetland was likely a separate archipelago (Lambeck 1995, Fig. 3), and one without any native terrestrial mammals (Johnston 1999). Orkney maintained its connections to mainland Scotland slightly longer, but was likely isolated by 9,500 to 11,000 years ago (Berry 2000, 20). These events will have had an influence on the fauna and flora of each island group, as well as on the human settlement of each area (and the resulting introductions brought deliberately or accidentally by humans). Although there is neither the time nor the space to fully approach this subject, some species introductions and extirpation are applicable to the Northern Isles region and will be discussed below in section 1.3.

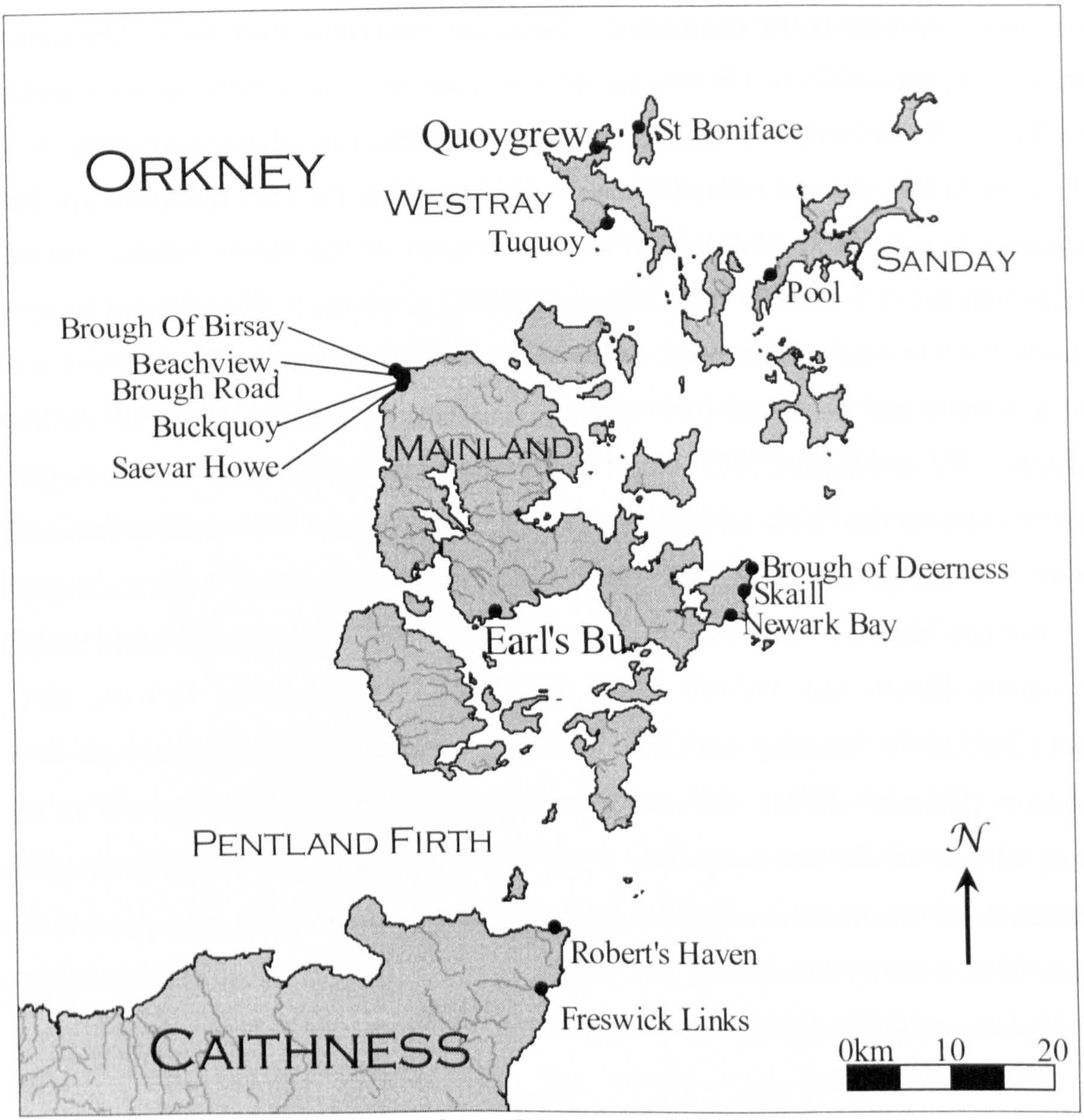

Figure 1.1: Map showing sites from Orkney and Caithness

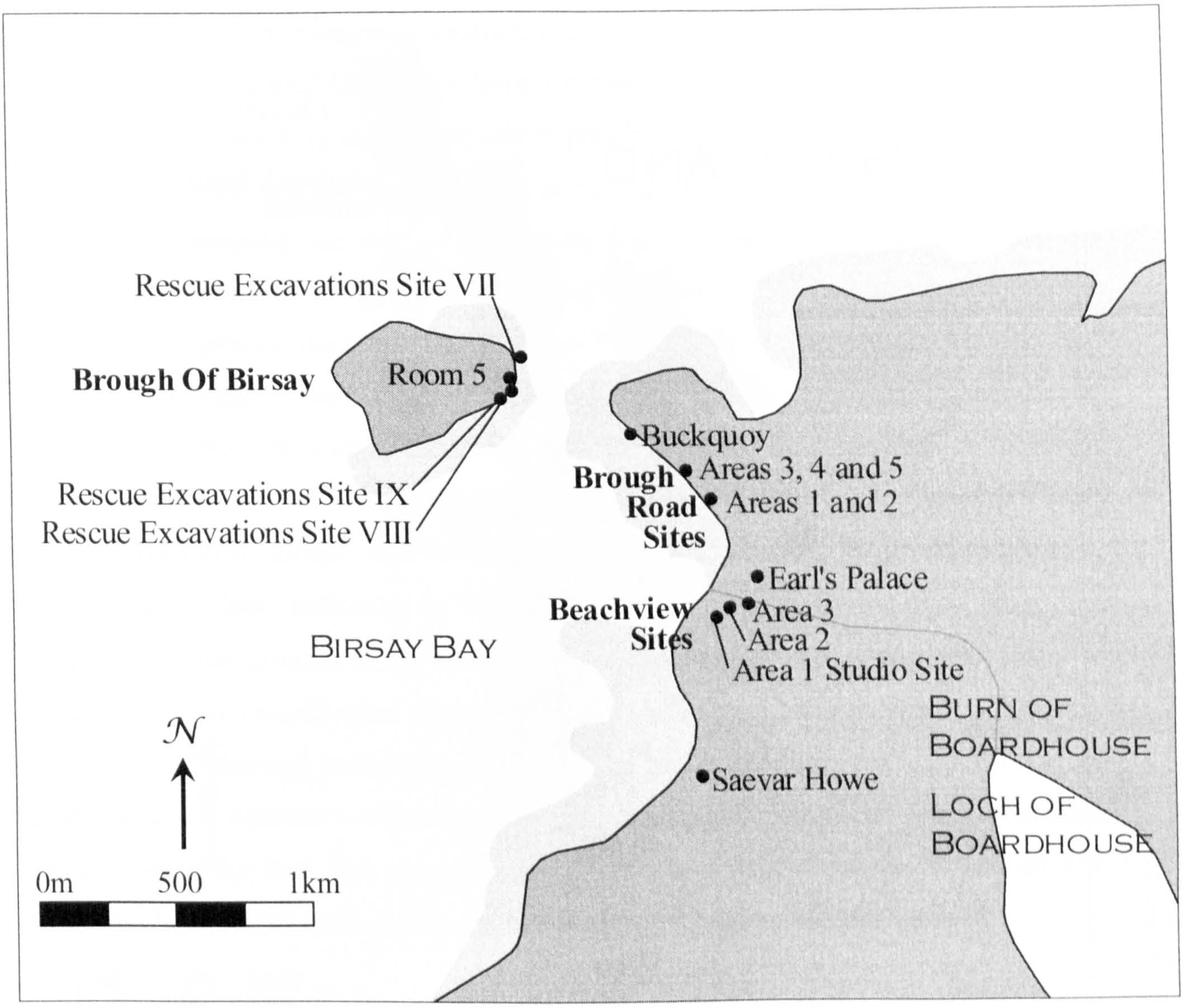

Figure 1.2: Map showing details of all sites in the Birsay Bay area

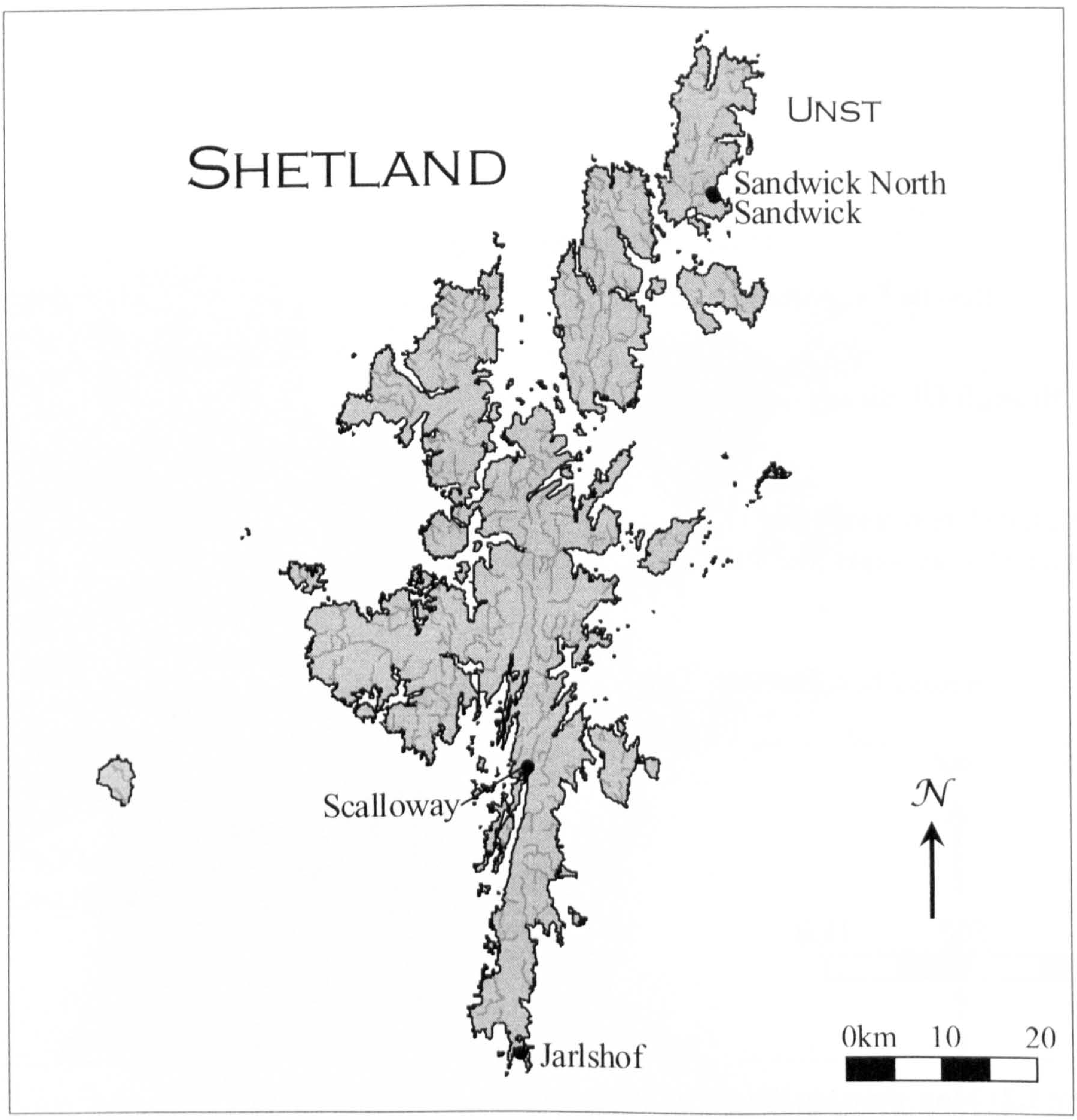

Figure 1.3: Map showing sites from Shetland

1.2.2 Temporal setting

The beginning of the 9th century is often used as the start of the Viking Age in Scotland, even if it appears slightly arbitrary given the absence of historical sources (Graham-Campbell and Batey 1998, 2; Barrett 2003b). A starting date of approximately 800* shall be used throughout this thesis. The Viking Age typically ends about 1050 (Graham-Campbell and Batey 1998, 2), a date that shall be used here. The period that follows the Viking Age has been given a variety of names, including Late Norse or Middle Ages (Barrett 1995, 3-4; Graham-Campbell and Batey 1998, 2), but the term "medieval" shall be used for convenience to refer to the period from the mid 11th century to the 15th century. From the late 15th century the Northern Isles became part of Scotland, but Norse

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* Here and throughout, the 'AD' may be assumed to prefix all dates unless explicitly stated as 'BC'.

cultural connections and language continued until the 18th century (Thomson 2001). Few zooarchaeological assemblages have been precisely dated, but those that have will be referred to by half-century increments where possible. Often, a grouping of time periods must be used, including late Iron Age to Viking Age or Viking Age and medieval. The late Iron Age precedes the start of the Viking Age, and alternative names include the "Pictish" period and the "Early Historic Period" (Ritchie 1976-77; Edwards and Ralston 2003). For simplicity, the term "late Iron Age" shall be used throughout. Although the Iron Age is not the primary focus of this thesis, it is necessary to include a number of sites with Iron Age dates. None that date exclusively to the Iron Age shall be included, but sites with transitional settlements that date from the late Iron Age and into the Viking Age and medieval periods will be included in detail, including Pool and Buckquoy. Others contain finds indicative of Norse material culture yet have a date range that includes the final decades of the late Iron Age, an example being Quoygrew, phase ii, dated to 779-981 (see Chapter Three). These are important because they can illustrate the nature of settlement in this crucial, transitional phase, and they may shed light on the agricultural and economic transitions that accompanied the arrival of the Viking Age. The earliest of the Iron Age assemblages included here dates from the 3rd century (St. Boniface phase 7), but most date to the late Iron Age – Viking Age transition.

Use of the term 'Norse' refers to Scandinavian people and their culture throughout the Viking Age and medieval periods (Barrett 2003d, 4). The arrival of the Norse people in the Viking Age brought about a cultural and linguistic change in the Northern Isles, with recognisably different artefactual and architectural styles (Graham-Campbell and Batey 1998; Barrett 2003c). Various theories of settlement have been put forward, ranging from a peaceful integration with natives (Ritchie 1974; Bäcklund 2001) to the complete destruction of preceding cultures (Smith 2001; Smith 2003), with ramifications for agricultural and economic change (see Barrett 2003c for a review). Recent work on the modern populations of the Northern Isles and the North Atlantic region has shed light on the nature of settlement in the Viking Age. It appears likely that families settled in both Orkney and Shetland, because about 30% of the modern Orcadian population and 44% of the Shetlandic population is of Scandinavian ancestry, and importantly, equal proportions of the modern male and female population reflected this background (Goodacre *et al.* 2005, 133). In contrast, other areas of the North Atlantic, including the Western Isles and Iceland, have much higher rates of male Scandinavian ancestry, with more females of British origin (Helgason *et al.* 2000; Helgason *et al.* 2001; Goodacre *et al.* 2005, 133). The genetic studies on modern populations in the Northern Isles imply the arrival of substantial numbers of people from Scandinavia, and given that males and females were equally represented, implies that families arrived together in Orkney and Shetland. This in turn has ramifications for livestock and animal husbandry, as well as general economic patterning. Animal husbandry regimes might change as well, if different emphases were placed upon different species, or if wild resources become more important to the diet and economy. These issues will be considered in more detail, in section 1.3 below.

1.2.3 Comparative zooarchaeological material

A number of previously excavated sites in the Northern Isles have published or archived zooarchaeological data that can be used as comparative material for Earl's Bu and Quoygrew. The locations of all sites are included in Figure 1.1 and Figure 1.3, and brief summaries, with full references for all faunal data, are provided in Table 1.1. In addition, this table summarises the potential of each site for intra- and inter-site spatial analysis. Further details regarding each site and the analytical methods applied are summarised in Appendix One. In geographical order, from North to South (a convention that will be used throughout this thesis), these comparative sites comprise:

- Sandwick North, Unst, Shetland (Barrett and Oltmann 2000): Small-scale rescue excavations in the 1990s produced quantities of midden associated with structures, dated from the 11th to the 14th centuries
- Sandwick, Unst, Shetland (Bigelow 1984): Research excavations in the late 1970s produced a stone structure and enclosure dating from the 12th to 14th centuries, with three separate areas of midden deposition
- Scalloway, Shetland (Sharples 1998): Rescue excavations in the late 1980s revealed a lengthy settlement and cemetery, including midden deposition in a disused broch from a putative nearby Viking Age settlement
- Jarlshof, Shetland (Hamilton 1956): The 'type-site' of early Viking Age and medieval Northern Isles settlement archaeology, including middens excavated in the late 1940s and 1950s but with little thought to bone recovery
- St. Boniface, Papa Westray, Orkney (Lowe 1998): A multi-period secular and ecclesiastical site excavated in the early 1990s, including a 12th to mid 13th century fish midden

- Tuquoy, Westray (Owen 1993): Excavations in the early 1980s revealed substantial Viking Age to medieval middens, structures (including a probably high status hall dating to the mid 12th century), and a waterlogged pit of Viking Age date
- Pool, Sanday (Bond 1994; Bond 2003; Bond *et al.* Forthcoming): Soon to be published excavations in the late 1980s uncovered a multiperiod settlement spanning the late Iron Age to Viking Age transition, as well as phases dating solely from the Viking Age and medieval periods
- Brough of Birsay Rescue Excavations, Orkney (Hunter 1986): Coastal erosion led to the excavation of secular, domestic and industrial late Iron Age to medieval deposits on the Brough in the mid 1970s to early 1980s
- Brough of Birsay Room 5, Orkney (Hunter and Morris 1982): A small scale research excavation in the mid 1970s revealed features from the late Iron Age to medieval period, including possible domestic occupation evidence
- Buckquoy, Orkney (Ritchie 1976-77; Brundle *et al.* 2003): Excavation in the early 1970s indicated "Pictish" style structures of late Iron Age date and associated midden material, now known to include ritualistic bone deposits, as well as putative Viking Age structures and midden material
- Brough Road, Orkney (Morris 1989): Research excavations from the mid 1970s to the early 1980s revealed a variety of deposits from several areas dating from the 7th to the 12th centuries, including midden
- Beachview, Beachview Studio and Burnside, Orkney (Morris 1996a): The continuation of research excavations (above) included deposits from the late 10th century to the medieval period, from a variety of deposit types including substantial quantities of midden
- Saevar Howe, Orkney (Hedges 1983): Coastal erosion prompted this excavation in the late 1970s, revealing late Iron Age midden and Viking Age structures and midden of c. 9th century date
- Brough of Deerness, Orkney (Morris and Emery 1986; Morris 1996b): Excavation of this isolated sea stack in the mid 1970s revealed deposits of late Iron Age to medieval and later date, first thought to be an early Christian monastery, but now interpreted as a secular settlement with a chapel

- Skaill, Orkney (Buteux 1997): These excavations from the 1960s to 1980s included a variety of Viking Age and medieval structures and middens, including one structure of possibly high status
- Newark Bay, Orkney (Brothwell 1977; Barrett *et al.* 2000b; Harland 2001b; Barrett and Richards 2004; Molleson 2005): These unpublished excavations from the late 1960s and early 1970s revealed an extensive multi-period site that included Iron Age souterrains, a 10th century and later chapel and a 7th to 15th century cemetery containing 250 bodies, and a 16th or 17th century laird's house
- Robert's Haven, Caithness (Barrett 1995; Barrett 1997): These excavations of an eroding coastal section in the early 1990s revealed large quantities of midden material of 11th to possibly 15th or 16th century date with some associated structural evidence
- Freswick Links, Caithness (Morris *et al.* 1995): These extensive research excavations in the early 1980s investigated a number of areas, revealing material of late Iron Age to medieval date, including structures, middens and ploughed surfaces

The dates for all sites and phases were reviewed prior to inclusion in any analysis, taking into account all relevant publications that post-date the site report (e.g. "Buckquoy revisited", Brundle *et al.* 2003), as well as recalibration of radiocarbon dates where possible (Bronk Ramsey 2001). A special note must be made of the material from Freswick Links. Jones labelled the deposits from the Southern Cliff Area as "Pictish", yet the calibrated dates for this phase include 560-810, 640-870 and 720-1020 (Morris *et al.* 1995, 277; Bronk Ramsey 2003), placing two of the three within the range of the Viking Age. All of these were taken on material that underlay the main "deflated" middens that contained much of the animal bone, which would imply that the deflated material was more recent, and thus more likely to be of Viking Age date. Furthermore, finds include an antler comb fragment and a bone pin of "Viking" type, both of which originated from layers that *pre-date* the main midden material. Pictish items were found at Freswick (e.g. the copper alloy pin from Area 3 but "essentially unstratified"), so there is no doubting that the site includes material from the late Iron Age, the Viking Age and the medieval periods, but the attribution of a "Pictish" date must be questioned. Instead, the Southern Cliff Area deposits shall be termed late Iron Age to Viking Age. Full date and context information is provided for each discrete group of bone (e.g. context, area, phase, phase group) in Chapter Eight, and together with context type, this information is displayed in the data tables in Appendix Five that list quantities of all fish, mammal and bird bone found in the Northern Isles.

Site	Class	Dates	Quantities	Spatial analysis considered?	Recovery	Species	Element	Ageing	Metrics	Context separation?	Use
Sandwick North (Barrett and Oltmann 2000)	Mammal	Medieval	TNB 5571, NISP 858	Yes	Hand collected and sieved to >2mm	Yes	Yes	-	Yes	Yes	Useful for both intra-site spatial analysis, and inter-site
Sandwick North (Barrett and Oltmann 2000)	Fish	Medieval	TNB 12,659, NISP 4023	Yes	As above	Yes	Yes	Yes	Yes	Yes	As above
Sandwick North (Barrett and Oltmann 2000)	Bird	Medieval	TNB 271, NISP 152	Yes	As above	Yes	Yes	No	Yes	Yes	As above
Sandwick (Bigelow 1985)	Mammal and fish (bird unidentified)	Medieval	TNB 100,000+ for all classes, NISP 1832 (mammal), NISP 2329 (fish)	Yes, including density analysis of middens and more general considerations of spatial analysis	Mixed hand collection and sieving to >1.5mm and >3mm	Yes for mammal and fish, no for bird	Qualitative only	No	Fish measurements only	All midden	Inter-site midden comparison, and some intra-site potential, but limited as not fully quantified (also will be useful when fully published)
Scalloway (O'Sullivan 1998b)	Mammal	Late Iron Age to Viking Age	NISP 3121	Some general consideration of 9th to 10th century Block 7.1 spatial variation	Hand collection and sieving, results combined	Yes, NISP and MNI	No	Yes	No	Yes by species only, can't be related to other data	Difficult to use as no element data, but context types provided so intra-site comparison possible, and inter-site potential is good for species
Scalloway (Cerón-Carrasco 1998a)	Fish	Late Iron Age to Viking Age	MNI 252	As above	As above	Yes but MNI only	No	-	No (but sizes included)	Yes by class only	Difficult to use as MNI quantification; archival material is available but lacks definitions of codes used in recording
Scalloway (O'Sullivan 1998a)	Bird	Viking Age (Block 7.1 only, bird from Late Phase 3 not separately quantified)	NISP 177	As above	As above	Yes	No	No	No	Yes by class only	Inter-site comparison possible with other sites of mixed recovery methods

Jarlshof (Platt 1956)	All	Viking Age to medieval	-	Implicitly	Selective hand collection	Qualitative	Qualitative	No	No	No	Qualitative only
St. Boniface (McCormick 1998b)	Mammal	Late Iron Age to medieval	NISP 52	No, sample sizes too small (but some general spatial analysis of farm mound)	Sieved to >1mm	Yes	No	Yes	Yes	No	Very limited as sample size too small
St. Boniface (Cerón-Carrasco 1998b)	Fish	Late Iron Age to medieval	TNB 30,977, NISP 11,938	No (but some general spatial analysis of farm mound)	As above	Yes	Yes for later phase	-	Yes	No	Limited intra-site, but useful for inter-site comparison
St. Boniface (Hamilton-Dyer 1998)	Bird	3000 BC – AD 1250	60 (total)	As above	As above	Qualitative only	No	No	No	No	Little value because unphased and unquantified
Tuquoy (Colley 1988)	Fish	Viking Age to medieval	TNB 140,442, NISP 31,530	Yes	Mixed hand collected and >1mm, >5mm	Yes	Yes	-	Yes	Yes	Large assemblage, very useful for intra- and inter-site comparison with other sieved and hand collected assemblages; all context types known but lack of publication hinders interpretation
Tuquoy (Hamilton-Dyer 1991)	Bird	Viking Age to medieval	TNB 657, NISP 486	Yes	As above	Yes	No	No	Yes	Yes	Limited intra-site potential because of small sample size, but very useful for inter-site comparisons
Pool (Bond 1994)	Mammal	Late Iron Age to Viking Age	TNB 24,965, NISP 16,105	Yes, but details must await the published report	Mixed hand collection and sieving to >3mm and >10mm	Yes	Qualitative	Yes, but qualitat-ive	Sum-mary available	No	Limited inter-site as includes a variety of context types and not fully quantified; will be useful once published
Pool (Nicholson 1998)	Fish	Late Iron Age to Viking Age	TNB 12,871, NISP 8828	Yes, but details must await the published report	As above	Yes	No	-	No	No	Limited inter-site as includes a variety of context types; will be useful once published

Site	Class	Dates	Quantities	Spatial analysis considered?	Recovery	Species	Element	Ageing	Metrics	Context separation?	Use
Brough of Birsay Rescue Excavations (Sellar *et al.* 1986)	Mammal (and fish and bird)	Late Iron Age to medieval	NISP 6085 (mammal), NISP 96 (fish), NISP 47 (bird)	No	Mixed hand collection and some sieving	Yes; bird and fish not quantified	Yes, only main domestics quantified	Yes	No	No	Only useful for inter-site comparison with sites of mixed hand collected and sieving; fish and bird not quantified so very limited use overall
Brough of Birsay Room 5 (Sellar 1982)	Mammal (and fish)	Late Iron Age to medieval	NISP 3821 (mammal), NISP 546 (fish)	Implicitly	Hand collection	Yes, only main domestics quantified	Yes, only main domestics quantified	Yes	No	Yes	Hand collected inter-site analysis, some intra-site analysis possible
Brough Road (Rackham 1989)	Mammal	Late Iron Age to medieval	TNB 5623, NISP 5280	Some; element quantification for cattle and caprines for midden contexts only	Mixed hand collection and sieving to >1mm and >10mm	Yes	Yes, main domestics only	Yes	No	Some	Very little intra-site potential, but useful for inter-site comparison with mixed assemblages
Brough Road (Colley 1989)	Fish	Late Iron Age to medieval	TNB 12,059, NISP 4967	Yes	As above	Yes	Yes	-	Yes	Some	Very useful for both intra-site context type and chronological analysis, and inter-site comparison with other mixed assemblages
Brough Road (Allison 1989)	Bird	Late Iron Age to medieval	TNB 224, NISP 131	No	As above	Yes	No	Qualitative discussion	No	Some	Inter-site comparison with other mixed assemblages
Beachview Studio Site and Burnside (Rackham 1996a)	Mammal	Viking Age to medieval	TNB 23,583, NISP 12,541	Some results presented by layer but context types mixed; spatial variation investigated using sample weights	Hand collection, >2mm sieving	Yes	Yes, for main domestics for major layers, but overall grouped by area	Yes	No	Yes	Separation of hand collected and sieved material (species only) so inter-site comparison with wide range of sites; intra-site analysis also possible

Beachview Studio Site and Burnside (Colley and Rackham 1996)	Fish	Viking Age to medieval	TNB 111,285, NISP 10,030	As above	As above	Yes	Yes, but combining recovery methods	-	Yes	Yes	As above
Beachview Studio Site and Burnside (Allison and Rackham 1996)	Bird	Viking Age to medieval	TNB 389, NISP 277	As above	As above	Yes	No	No	No	Yes	As above
Saevar Howe (Rowley-Conwy 1983)	Mammal (and bird)	Late Iron Age to Viking Age	NISP 459 (mammal), NISP 41 (bird)	No; too few data to explore spatially	Sieving to >5mm	Yes	Only those with measurements quantified	Yes	Yes	Discussed but not quantitatively	Limited inter-site potential as includes a variety of context types
Saevar Howe (Colley 1983b)	Fish	Late Iron Age to Viking Age	NISP 1673	No	Sieving to >5mm	Yes	No	-	Yes	Discussed but not quantitatively	Limited inter-site comparison potential; abnormal sieve size
Buckquoy (Noddle 1976-77 and unpublished archive material analysed by the author)	Mammal	Late Iron Age to Viking Age	TNB 12,555, NISP 3356	Some spatial and functional separation	Hand collection	Yes	Yes	Yes	Yes	Supposedly all midden	Hand collected intra-site midden variation between a byre/barn, a threshing barn and a dwelling house; inter-site comparisons with other hand collected assemblages
Buckquoy (Wheeler 1976-77)	Fish	Late Iron Age to Viking Age	54 quantified by MNI	As above	Hand collection	Yes	Qualitative	-	Qualitative estimates of total fish size	Supposedly all midden	Very limited as MNI quantification
Buckquoy (Bramwell 1976-77)	Bird (and small mammal and amphibian, not quantified)	Late Iron Age to Viking Age	TNB 241, NISP 229	As above	Hand collection	Yes	No	No	Some	Supposedly all midden	As mammal

Site	Class	Dates	Quantities	Spatial analysis considered?	Recovery	Species	Element	Ageing	Metrics	Context separation?	Use
Brough of Deerness (Rackham 1986)	All	Mid 10th c to medieval and later	TNB 2659, NISP 757 (mammal), TNB 51, NISP 27 (fish), TNB 84, NISP 61 (bird)	Implicitly, broadly; spatial separation into three units, including a chapel	Mixed, predominantly hand collection with limited sampling of unknown quantity; list and text give contradictory contexts	Yes	No	No	No (some fish sizes discussed)	No	Domestic vs. religious context provide useful inter-site variation but of limited use as only basic quantification provided; some limited intra-site potential between phases and areas
Skaill (Noddle 1997)	Mammal	Viking Age to medieval	NISP 690	No	Hand collection only	Yes	Only those with measurements quantified	Yes, by MNI only	Yes, comprehensive	No	Limited to inter-site hand collected assemblages, as of mixed context type, period, status and function
Skaill (Potts unpublished report)	All	Viking Age to medieval	NISP 690	Implicitly	Hand collection only	Yes	Yes	No	Yes	All midden	Intra-site high status vs. normal Norse domestic deposits, hand collected mammal only, but small sample size
Skaill (Nicholson 1997)	Fish	Viking Age to medieval	NISP 1697	No	Hand collection only	Yes	No	-	No	No	Limited to inter-site hand collected, of mixed context type, function and status, also not equal to area and phases of mammal bone reports
Skaill (Allison 1997)	Bird	Viking Age to medieval	TNB 309, NISP 255	No	Hand collection only	Yes	No	Qualitative	No	No	Limited as not equal to the same area and time as Noddle and Nicholson's reports
Newark Bay (Harland 2001b)	All	Late Iron Age to medieval	TNB 639, NISP 392	Implicitly, Norse chapel compared to later domestic deposits	Hand collection	Yes	Yes	Yes	Yes	Yes	Small assemblage but useful for secular and deposits associated with chapel

Newark Bay (Noddle 1979 and archive)	Mammal (and amphibian)	Viking Age to medieval	NISP 216	No	Hand collection	Yes	Yes, for main domestic species	Yes	Yes	Not directly,	Can be used with caution to augment Harland 2001b
Newark Bay (Cowles in Brothwell *et al.* 1981)	Bird	Viking Age to medieval	TNB 132, NISP 131	No	Hand collection	Yes	No	No	No	No	Large bird assemblage, but grouped without contextual data
Robert's Haven (Mainland nd; Williams nd)	Mammal	medieval	TNB 2528, NISP 641	Yes	Sieving to >1mm	Yes	Yes	Yes	No	Yes	Limited as small sample size, but could be used for inter-site analysis
Robert's Haven (Barrett 1995; 1997; 2000a; Parks pers. comm.)	Fish	medieval	TNB 104,366, NISP 32,686	Yes	Sieving to >1mm; select elements identified from 1-4mm, all from >4mm	Yes	Yes	-	Yes	Yes	Both intra- and inter-site spatial analysis possible; good sample size and context types known
Robert's Haven (Parks pers. comm.)	Bird	medieval	TNB 637, NISP 46	Yes	Entirely sieved to 1mm	Yes	Yes	Yes	Yes	Yes	This is raw data so is only limited by the small sample size
Freswick Links (Gidney 1995)	Mammal	Late Iron Age to medieval	TNB 12,555, NISP 3356	Good inter-class comparisons using weights and volumes	Hand collection, >2mm sieving	Yes	Yes	Yes	No	Yes	Intra-site spatial analysis between areas, periods and context types possible, valuable for inter-site analysis because of separation by recovery method, and context types
Freswick Links (Jones 1991; Jones 1995)	Fish	Late Iron Age to medieval	NISP 3625, but not all elements counted, no TNB count	As above	>2mm sieving	Yes	Yes, but only a subset id'd from gadids	-	Yes	Yes	Problematic because only 4 gadid elements were identified for some areas
Freswick Links (Allison 1995)	Bird	Late Iron Age to medieval	TNB 1054, NISP 511	As above	Hand collection, >2mm sieving	Yes	No	No	No	No	Limited to inter-site analysis, but with some potential; some intra-site analysis possible but limited

Table 1.1: Summary of comparative zooarchaeological data and potential for intra-and inter-site comparison

1.3 Research questions: temporal patterning

Analyses of chronological patterning have been undertaken in most of the relevant published zooarchaeological literature, wherein any changes in species composition, sizes and ages tend to be interpreted as changing economic patterns, sometimes associated with different cultures (particularly indigenous versus Norse). These putative changes, sometimes based on the analysis of single sites, provide a number of key hypotheses to be explored in this thesis. Firstly, one must consider the introduction, extirpation and extinction of species from the Northern Isles, particularly the red deer. It has been proposed that it was extirpated from Orkney in the Viking Age or medieval periods (Bond 1998). Secondly, it is essential to investigate the evidence for economic intensification in the Viking Age and medieval periods (see Barrett *et al.* 2000a). This may take the form of more intensive dairying (Bigelow 1989; Bond 1998) and of the "Fish Event Horizon" of c. 1000, during which is has been argued open water fishing increased dramatically (Barrett 1995; Barrett 1997; Barrett *et al.* 1999; Barrett *et al.* 2000a; Barrett *et al.* 2004a; Barrett and Richards 2004). Finally, one must consider possible changes surrounding the use of certain foods during Christian fasting (c.f. Barrett and Richards 2004). Each of these hypotheses shall be introduced below.

As briefly mentioned above, the biogeography of Shetland, Orkney and the northernmost tip of Caithness share certain chronological trends across all areas. Deliberate early introductions include the domestic mammals, probably in the Neolithic (McCormick and Buckland 2003, 91), although later reintroductions may have taken place, particularly during Viking colonisation. It was often assumed by earlier researchers that the arrival of Scandinavians in the Viking Age corresponded to wholesale introductions of new domestic and wild animals, but more recently attempts have been made "to dispel the orthodoxy which ascribes much of the character of the modern farmscape, including the species [sic] of sheep, the size of horses, the varieties of sea-fowl, and even the presence of certain mice to the influences of Vikings" (Hunter 2003, 249; see also MacHugh *et al.* 1999, 100; Edwards and Ralston 2003, 264). However, faunal changes are still attributed to the arrival of the Norse, because there appears to be some validity to this approach: livestock metrical changes at Pool correlate with the late Iron Age to Viking Age transition (Cussans in press), and house mice are not found in Orkney prior to the Viking Age, although they were present in Shetland (Nicholson *et al.* 2005). As noted above, it has also been argued that the extirpation of red deer also happened in the Viking Age or medieval period (Bond 1998).

We know Norse migrants transported livestock from Scandinavia, because domestic mammals were not naturally found in Iceland and Greenland, and were unlikely to have been present in the Faroe Islands prior to the Norse arrival (Li *et al.* 2005). The situation in the Northern and Western Isles upon arrival of the Norse was rather different, because the indigenous population kept domestic livestock. The possible reintroduction of these species can help elucidate the nature of this important transitional time period. However, it must be stressed that although this thesis examines sites with a chronology spanning the late Iron Age and Viking Age periods, a full analysis of all Iron Age material from the Northern Isles was outside of its scope. That said, this thesis can contribute by examining species introductions, extirpations and changing usages (including evidence for intensification of use) within the Viking Age and medieval periods. Furthermore, the addition of biometrical data from the Quoygrew mammal bone assemblage may contribute to an understanding of livestock size changes both in the Viking Age and in the medieval periods. A biometrical approach was applied to data from Pool, suggesting the efficacy of this method. No differences in cattle sizes were observed from the Iron Age to the medieval periods throughout the Northern Isles, but substantial differences were found among the caprine* assemblage from Pool (Bond *et al.* Forthcoming, 35). This was possibly linked to the arrival of new and smaller stock in the late Iron Age to Viking Age transitional period (Cussans in press; see also Noddle 1980). This will be further investigated using the metrical dataset from Quoygrew and comparative sites.

Red deer remains have been recovered from a number of Northern Isles sites dating from at least the Neolithic (e.g. Sharples 2000), but this species no longer survives on Orkney today. The date of this extirpation is difficult to determine, given the trade in red deer antler as a craft material (Weber 1992; Vretemark 1997). Evidence has suggested a decline in red deer numbers from the Iron Age to the Iron Age – Viking Age transitional period (Ballin Smith 1994, 128; Bond *et al.* Forthcoming). This thesis will be able to investigate this in greater detail, using the data from the Quoygrew mammal assemblage.

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* Sheep and goat have been referred to throughout this thesis as "caprines", following Yalden (1999, 95), because of the difficulty of distinguishing between these species

The existence of economic intensification in the Viking Age and medieval periods is a well recognised phenomenon in the Northern Isles. In terms of zooarchaeological evidence, this manifests as increased evidence of dairying in the Viking Age and/or medieval periods (Bond 1998; Barrett *et al.* 2000a, 23; Barrett 2005), and a marked increase in deep sea fishing, first at the late Iron Age – Viking Age transitions, followed by the appearance of fish-rich middens from the Viking Age to medieval transitional period, termed the "Fish Event Horizon" for convenience (following Barrett *et al.* 2004a; Barrett and Richards 2004). The evidence for an intensification of dairying and the Fish Event Horizon will now be explored in detail.

Throughout the Northern and Western Isles, considerable proportions of neonatal cattle have been recovered from sites of varying dates from the Neolithic onwards (Bigelow 1992; McCormick 1998a; Mulville 1999, 271; Bond 2002; Bond 2003; Craig *et al.* 2004; Smith and Mulville 2004, 59; Mulville *et al.* 2005; Bond *et al.* Forthcoming). Increases in the proportions of neonatal cattle found have previously been identified at two sites: Sandwick, Unst, and Pool, Sanday. At Sandwick, this intensification dates to the 12th century, but at Pool, it dates to the late Iron Age – Viking Age transitional period, with a further increase in intensification in the Viking Age to mid 11th century phase (Bigelow 1992, 10; Bond 1998, 85; Bond 2003, 108). Neither site has been published, but the Pool assemblage has been thoroughly investigated. Conversely, the results for Sandwick are still preliminary and have yet to be fully quantified (see Barrett 1995, 554). The argument for the intensification at Sandwick in the medieval period is therefore not (yet) fully explored. This thesis will provide an additional dataset, Quoygrew, which given that the mammal bone dates to the Viking Age and medieval periods, should provide an assemblage with detailed chronological resolution to contribute to this ongoing issue. Furthermore, by exploring the comparative datasets at the intra- and inter-site levels, it should be possible to assess all evidence for chronological variation, as well as correlations with space, function and status.

Two explanations have been put forward to account for this abundance of neonatal cattle, both of which shall be investigated using all available data. Firstly, it has been interpreted as evidence of an economy based on dairying, where newborn calves were killed to allow human exploitation of milk. Secondly, these deaths have been attributed to natural causes, namely poor winter fodder and harsh climate conditions. The evidence for each argument will be discussed with regard to both the zooarchaeological material and complementary evidence drawn from biomolecular studies.

In unimproved cows – such as would be found in the Viking Age and medieval Northern Isles – the milking process would be less straightforward than it is today. Various historical Irish and Scottish sources from the first millennium AD to the 18th century indicate that the calf needed to be present at milking to stimulate the let-down reflex. However, these same sources indicate that the skin of the dead calf could be made into a simulacrum that would suffice (McCormick 1992, 202-03). Other methods of stimulating the reflex without the calf being present are known from ethnographic and historical sources, therefore disproving the argument that calves needed to be present during milking: there are "many and devious means by which the human intellect dupes that of the cow" (Legge 2005, 12; also Amoroso and Jewell 1963; Ryan 2005; Tani 2005). It therefore appears likely that milk could be collected from cows without calves being present, thus providing one potential explanation for the prominence of neonatal cattle: these were calves not needed to replace the herd and thus killed soon after death. This corresponds to the known ethnohistorical and historical sources that suggest dairy products played an important role in the Norse economy, including for the payment of taxes and rent (Bond *et al.* Forthcoming, 9, 15). Dairy produce, particularly in the form of cheeses and butter, is an easily portable, storable product, high in calories and useful for periods when fresh milk and other produce are not available (Challinor 2004; Legge 2005, 12-13).

High proportions of neonatal cattle have also been interpreted as the result of fodder shortages, disease and "marginality" in the Northern and Western Isles (McCormick 1998a; Bond *et al.* Forthcoming, 10, 14). Neonatal caprines have been found, but rarely to the same extent as cattle. This will be investigated in detail using both the primary and comparative datasets, because the varying proportions of neonates of each species may shed light on this issue. Winter fodder can be supplemented with seaweeds, fish oils or fish bones, as suggested from ethnographic sources (Fenton 1978, 428; Mulville *et al.* 2005, 178), and the evidence for or against this will be reviewed in the light of new isotopic studies at Newark Bay and elsewhere in the Northern Isles (Richards *et al.* 2006).

The sex profile of cattle herds could determine the proportion of older females present (Legge 2005, 10), and thus lead to hypotheses about the nature of animal husbandry, but this is rarely possible given the frequent fragmentation of diagnostic elements and the small numbers of measurable adult metapodials in the assemblages considered (c.f. Albarella 1997). The use of adult cattle as traction animals may complicate this picture, given that ethnohistorical and palaeopathological sources suggest cattle were frequently used and may have been castratrated males (Fenton 1978, 318; Hunter 2003, 251). However, any evidence for the sex profiles in either the primary or comparative datasets shall be reviewed during this thesis.

Finally, one further aspect of the neonatal cattle debate needs to be discussed. Early historic Ireland has a wealth of historical sources describing the importance of dairying to the economy, and yet few neonatal bones were found there (McCormick 1992, 203). The lack of neonates in Ireland could be a reflection of the addition role cattle played within the Irish economy, because they were viewed as portable wealth and status indicators (Lucas 1989). This in turn may have influenced the decision not to cull neonatal cattle; the resultant reduction in milk available for human consumption may have been an acceptable consequence of having larger herds (McCormick 1983, 253). In contrast, there is little evidence that cattle were viewed as status symbols and items of wealth to the same degree in the Northern Isles (in contrast to Greenland, see McGovern 1985), but this will be considered during the analysis of the material from the primary and comparative sources. This is not solely an economic issue: the role of dairying in both the Northern Isles and the Western isles "may have been a cultural practice beyond simply adaptation to the environment" (Mulville 1999, 271).

Turning now to the evidence of an intensification in fishing in the Northern Isles, there is both zooarchaeological and isotopic data to suggest a real increase in the use of marine resources around the end of the first millennium AD (Barrett 1995; Perdikaris 1999; Barrett *et al.* 2004a; Barrett and Richards 2004). Fish bone was found in late Iron Age deposits in the Northern Isles, including some evidence of deep sea fishing (e.g. Old Scatness, Nicholson 2004. Fig. 1), but at a small scale. The initial expansion in fishing at the late Iron Age – Viking Age transition may have been caused by "the introduction of new food preferences by Norse migrants" (Barrett *et al.* 2004a, 624), aided by the Norse knowledge of boat technology and the sea (Barrett *et al.* 2001, 152). Then, from the 11th to the 14th centuries, and starting c. 1000, an even greater level of intensification occurred. During this time, the distinctive fish-rich middens were produced at sites like St. Boniface, Quoygrew and Robert's Haven. These are middens with a high density of fish bone, mostly very well preserved, including some articulations (series of elements still in anatomical order, implying very little disturbance), with little mammal bone but with high quantities of marine shell (Barrett and Richards 2004, 266). This increase in fishing and fish consumption from c. 1000 – the Fish Event Horizon – is recognised not only in the Northern Isles, but also in the rest of the British Isles and in continental Europe (Enghoff 1999; Barrett *et al.* 2004a; Barrett *et al.* 2004b). The species and sizes found within these distinctive fish middens, and within all sites of broader Viking Age to medieval date, will be investigated in detail in Chapters Eight and Nine. Briefly, they comprise large cod and related species, caught from open waters (e.g. cod, ling, haddock and large saithe) and from the shore (e.g. small saithe and rocklings). The results from recent isotope studies will also be used to illuminate dietary practices associated with chronological changes.

These middens also contain evidence of the production of dried fish, a storable and tradable product that can be recognised by distinctive butchery marks, body part representation and choice of fish size, as shall be discussed in Chapter Two. There are a number of terms that can be used to describe dried fish products, including stockfish and klippfisk, but these tend to have ambiguous cultural and size connotations, and will therefore not be used (Cutting 1955; Fagan 2006). Instead, the product shall simply be referred to as dried, prepared fish. Evidence from other North Atlantic coastal excavations suggest that dried fish were being produced in Iceland and Norway, particularly between the 12th and 14th centuries (Amundsen *et al.* 2005, 134-35), and other archaeological and historical sources suggest that dried cod and related species were in demand in Europe and Britain (Barrett 1997, 616; Barrett *et al.* 2004a). Evidence for the production and export or import of this product will be discussed, with new evidence from Earl's Bu and Quoygrew contributing to the debate. While it may be difficult to demonstrate the international trade in prepared fish from the evidence, this thesis will illuminate the trade and movement of this product within the Northern Isles, strengthening the possibility that it could also have been exported. The production and export of dried fish has already been identified from the medieval fish midden at Robert's Haven, while initial work at Earl's Bu speculated that the site may be receiving prepared fish (Barrett 1997). By examining the rest of the considerable assemblage from Earl's Bu, it will be possible to clarify the nature of prepared fish consumption at this high status site (the issue of status in the Northern Isles will be addressed in section 1.4).

The primary dataset from Quoygrew will also provide a substantial contribution to the analysis of the intensification of fishing in the Northern Isles and the Fish Event Horizon. The full analysis of preservation and other taphonomic factors will enable conclusions to be drawn regarding element representation and butchery patterning, which in turn should contribute to our understanding of the fish trade. Moreover, Quoygrew is also of great importance because of its intra-site spatial and chronological relationships. The contemporary nature of the farm mound and the fish midden will allow a detailed comparison of these types of midden, something that has not yet been possible at any other site. Indeed, the entire concept of the fish midden has been questioned as a potential by-product of changing refuse disposal patterns: "[p]ut simply, did large fish middens appear in medieval Orkney because fish became more important (possibly for trade) or because people began to discard their fish bone in one place and their mammal bone in another?" (Barrett 2005, 264). The fish from Quoygrew should provide an answer to this question, while the detailed study of intra- and inter-site variation, linked to function and status and drawing upon the primary data from Earl's Bu, will enable a greater understanding of fishing intensification across the Northern Isles. The primary and comparative evidence will also be investigated to test and clarify the chronology of the two stages of fishing intensification: the initial Viking Age intensification and the subsequent Fish Event Horizon. Comparisons between classes of faunal material (mammal, fish and bird) will indicate the relative importance of fish from the late Iron Age – Viking Age transitional period onwards, while inter-class midden densities (typically measured as grams of bone per litre of excavated sediment) will examine the varying rates of bone deposition as well as the varying proportions of fish. Linking these data to function and status will provide an added dimension to our knowledge of fishing and the Fish Event Horizon.

At a broader scale, considering the evidence from throughout the British Isles, both cod and herring were involved in the Fish Event Horizon (Barrett *et al.* 2004a). Herring have been recovered from some Northern Isles sites, but only at trace levels, and there is nothing to suggest they were deliberately exploited (see Chapter Eight). This is in contrast to both contemporary evidence from the Western Isles (Smith and Mulville 2004, 59; Cerón-Carrasco 2005; Ingrem 2005, 157-58, 192-94; Sharples 2005, 75-80) and early modern evidence from the Northern Isles (e.g. Sands 1791-99; Fenton 1978, 603-15; Melton 2004, 244). The additional datasets provided by Quoygrew and Earl's Bu will contribute to the interpretation of use of both the cod and herring families within the Northern Isles.

The demand for dried cod family fish in consumption centres, including urban areas in England and continental Europe, was partially caused by the changed dietary requirements of Christianity. Although the evidence is not conclusive, Christian fasting likely prohibited the consumption of a number of meats, but importantly, fish was permitted (Barrett *et al.* 2004a, 629-30; Fagan 2006). Returning to the Northern Isles again, Christianity may have influenced the production and consumption of fish at this scale as well. According to *Orkneyinga Saga*, the Northern Isles converted to Christianity in the late 10th century, a date matched by some of the archaeological evidence (Graham-Campbell and Batey 1998, 248). The two chapels on the eastern Mainland, at Newark Bay and the Brough of Deerness, were both built by the mid 10th century, but contemporary with these are pagan graves from the Birsay area (Barrett *et al.* 2000a, 14). It appears likely the high status centre at the Brough of Birsay converted to Christianity by the mid 11th century (Barrett 2003a, 221). The introduction of Christianity to the Northern Isles may have changed dietary practices, and not just involving an increase in fish consumption on fasting days. The consumption of horse (hippophagy) was prohibited in the Christian church from the 8th century (Smith 1998, 876), a fact reiterated in *Njal's Saga* in reference to the 11th century conversion of Iceland (McCormick 1981, 315). Butchery evidence of horses has been found in Christian contexts, even at the monastic site of Iona (McCormick 1981, 315; Murray *et al.* 2004, 183), and butchered horse bones at Kilpheder in the Western Isles were contemporary with pendant crucifixes in the 10 to 13th century Norse settlement (Smith and Mulville 2004, 55), suggesting that horse may have been consumed regardless of religious proscription. A restricted range of species was permitted during Christian fasting, including fish, sea mammals, and possibly red deer, the latter being unusually frequent on Iona (Edwards and Ralston 2003, 237; McCormick and Buckland 2003, 102). The evidence for these species will be investigated in detail at both Quoygrew and at all comparative sites, particularly focussing on those sites with ecclesiastical structures in order to explore any associations.

To summarise, a number of temporal trends can be reflected in the zooarchaeological record and will be investigated in this thesis. The introduction and extirpation of species will be analysed, particularly the decline of the red deer in the Northern Isles. The significant presence of high quantities of neonatal cattle will be addressed from a variety of perspectives, investigating both their meaning – dairying or harsh environmental conditions – and their potential increase during the Viking Age and/or the medieval periods. Finally, the intensification in fishing, linked to the larger, pan-European Fish Event Horizon that started c. 1000, will be investigated in some detail. Particularly, the distinctive medieval fish middens will be defined and explored, and a spatial approach to their analysis will be applied to complement or challenge their implications regarding the chronology of fishing intensification. As shown, this dual chronological and spatial analysis may prove crucial to the understanding of the Fish Event Horizon in the Northern Isles.

1.4 Research questions: spatial patterning

Two levels of spatial analysis will be applied to the primary and comparative data. The first, intra-site, is necessary because it permits a detailed understanding of the variation between different context types within a single settlement. The second, inter-site, can illustrate differences in site type, function and status, once recovery and taphonomic biases have been taken into account (where practicable). This will facilitate the comparison of sites of similar type, thus reducing one potential cause of variation, but it can also reveal important distinctions within a single settlement or area.

During excavation at Quoygrew, it was recognised that the coastal fish midden contained much higher quantities of fish than the inland farm mound, another area of midden deposition (Barrett 2005; see Chapter Three for details). The latter appeared to contain much higher proportions of mammal bone. These two areas are now known to be approximately contemporary, yet intra-site spatial patterning has the potential to illustrate how the site was being used, and how bone was discarded. It appears deliberate choices were made about where bone was discarded, yet had an entirely chronological approach been applied to the site, this important intra-site spatial patterning would have been lost.

Similar patterning has been found at Sandwick, where Bigelow (1984) noted one particularly fish-rich midden was contemporary with two other middens, both of which contained much higher proportions of mammal bone. As noted above, these examples illustrate that wherever possible, intra-site patterning must be considered prior to chronological analysis and inter-site data exploration, particularly to illuminate the Fish Event Horizon.

Spatial patterning at the inter-site level can reveal differences in site function and status. The issue of fish midden sites has been discussed above, but the distinction between 'secular' and 'ecclesiastical' sites needs to be considered. The majority of sites were interpreted as domestic, secular structures and associated middens. However, a number of sites have ecclesiastical links, including St. Boniface, Tuquoy, the Brough of Birsay, the Brough of Deerness, Skaill, Newark Bay and Earl's Bu. These sites associated with ecclesiastical structures have facets in both aspects of spatial patterning. Functional differences between assemblages directly associated with ecclesiastical structures and those associated with secular deposits are self evident. In the Northern Isles, early Christian churches have a further value because they are associated with high status settlements. Examples are well known and include the round church and putative feasting hall at Earl's Bu, both closely associated with the midden deposits recently excavated (see Chapter Three). There is a natural overlap between the functional and status differences associated with ecclesiastical structures, but it is possible to separate these into two groups. The first of these comprises the two sites with small Christian chapels where faunal remains have been found in direct association with the religious structures; these shall primarily be discussed in the context of functional differences. Other sites, including Earl's Bu, have assemblages associated with secular settlement, but found in close proximity to Christian chapels. The faunal assemblages from these sites were not recovered directly from the ecclesiastical structures. This second group will be discussed mainly in the context of differences in status.

Newark Bay and the Brough of Deerness are two sites in east Mainland, both of which have zooarchaeological assemblages directly associated with chapels. Newark Bay is a complex and important site with a wealth of human remains spanning the late Iron Age to medieval periods, and a chapel dating from at least the mid 10th century (Barrett *et al.* 2000a, 13). Unfortunately, the small quantities of animal bone recovered have limited potential. There are problems with the dates of the bone material, all of it was hand collected making the fish assemblage unrepresentative, and it was analysed by two people, making intra-site comparisons difficult (see Harland 2001b). The Brough of Deerness was originally thought to be an early Christian monastery (Morris and Emery 1986, 301). After re-evaluation, the "'Celtic' monastery has evaporated", replaced by the idea of a small private chapel of mid 10th century and later date, with associated settlement of secular nature (Morris 1996b, 191, 197; Barrett *et al.* 2000a, 13). Spatial and chronological bone analysis was very good, with each type of deposit separately quantified. However, the lack of consistent recovery methods, the small sample size of the bone assemblage, and the possibility of non-anthropogenic and post-abandonment accumulation (Rackham 1986, 348) combine to limit the potential comparative use of this material.

Few of the sites considered have bone deposits that have been defined as ritualistic during excavation (but see Chapter Two for a more detailed discussion), thus limiting one potential source of intra- and inter-site spatial patterning. However, the late Iron Age deposits at Buckquoy likely contained at least one special deposit in the centre of a circular chamber, under a stone setting (Brundle *et al.* 2003, 75). This was not noted in the faunal report, nor was it discussed in the original excavation report, probably reflecting archaeological trends at the time. Had there been more deposits of this nature, they would have needed to be included in any discussion of spatial variation, in terms of 'structured deposition', in the Northern Isles.

Turning to the issue of status, as already mentioned, the group of sites with contemporary churches and settlements have been interpreted as high status for a number of reasons. These include textual references, associations with high status place names, architectural evidence of well built, substantial structures, and associations with runic inscriptions. These churches and chapels were probably built for the private use of local elite settlements, until at least the 12th century (Sawyer 1988). The most ostentatious example of this association of secular and ecclesiastical structures is the Bishop's Palace and St. Magnus Cathedral in Kirkwall, both started in the 12th century (Graham-Campbell and Batey 1998, 261; Jesch 2005, 11, 13). Other sites with settlement found in close association with a chapel or church include Earl's Bu (fully introduced in Chapter Three), the Brough of Birsay, Tuquoy, Skaill, St. Boniface and Cubbie Roo's Castle on

Wyre (likely dated to the 12th century but without an associated faunal assemblage) (Graham-Campbell and Batey 1998, 258; Jesch 2005, 13). Additionally, runic inscriptions have been recovered from most of these sites, indicating a correlation with status and literacy (Jesch 2005, 13). These high status medieval structures were probably constructed using wealth partly derived from taxation (Graham-Campbell and Batey 1998, 226), which will have included a number of animal products and thus may be traceable in the zooarchaeological record.

Excavations at Earl's Bu will be discussed in more detail in Chapter Three, but the associations of high status need to be briefly introduced. A late 12th century chapel, built to a uniquely round plan, was located immediately adjacent to excavated medieval structures. The settlement was inhabited by some of the earls of Orkney, as indicated by repeated descriptions in *Orkneyinga Saga*. It likely functioned not only as a high status elite residence, but also as a centre for agricultural processing because a horizontal watermill has been excavated adjacent to the hall-like structures.

The group of sites from the Birsay Bay area are closely located in time and space, the furthest being only 1.6km apart, therefore providing an ideal opportunity for spatial analysis at the inter-site level. Excavations with faunal remains in this area include the Rescue Excavations and Room 5 on the Brough itself, both dating from the late Iron Age to medieval periods (see Figure 1.2 for site locations in the Birsay area). Buckquoy, on the mainland just opposite the Brough, has both late Iron Age and Viking Age structures and deposits. Slightly further south are the five areas of the Brough Road excavations, dating from the late Iron Age to the medieval periods. Located just south of the medieval Earl's Palace and the Burn of Boardhouse are the three areas that comprise the Beachview excavations, dating to the medieval period. Finally, the late Iron Age to Viking Age site of Saevar Howe is located about 500m further south of the Beachview sites. Together, these archaeological investigations have been undertaken over a long time period, from the antiquarian excavations that unfortunately left little animal bone information (e.g. Ralegh Radford 1959), to the excavations in the Beachview area in the 1970s and 1980s. As a unit, the Birsay Bay sites provide a good opportunity to investigate the issue of status as an aspect of spatial variation at a broad level, because although there are many sites contemporary with those at Birsay, few have the same elite associations. Historical sources indicate that the Birsay area contained both an Earl's residence and a Bishop's seat from at least the mid 11th century (Crawford 1987, 157; Thomson 2001, 224), indicative of a powerful centre in the medieval period. Its earlier origins are more enigmatic, with some scholars suggesting the site was an important late Iron Age 'Pictish' power centre (Graham-Campbell and Batey 1998, 11-14; Crawford 2005, 95; Wickham-Jones 2006, 110). However, recent reanalysis of artefacts and metalworking debris found on the Brough do not suggest it was an important Pictish power centre, and the structural evidence for an earlier church underlying the extant 12th century building is inconclusive (Brundle 2005, 77, 82). The historical and architectural evidence provided for the extant high status buildings indicate the Birsay Area was probably also a "Viking Age elite centre" (Barrett *et al.* 2000a, 15).

Tuquoy has yet to be fully published, but historical sources, land rentals and onomastic evidence combine to imply a wealthy and considerable settlement in the vicinity of Crosskirk, the extant 12th century church adjacent to the Tuquoy excavations (Owen 1993; Owen 2005, 197). The main structure identified at Tuquoy was originally a paved, well built and solid hall with artefacts indicative of high status, thus confirming the ecclesiastical and historical correlations. Eventually, this hall was reused and subdivided before becoming "used for storage or some other relatively lowly function" (Owen 2005, 200). The entire excavated settlement sequence at Tuquoy dates from at least the 10th to 14th centuries, but possible evidence for high status associations prior to the 12th century church were found in a 10th century waterlogged pit containing wood off cuts indicative of large-scale wood importation (Owen 2005, 206-207). After the hall became disused, another structure was built overlying it at right angles, but this was crude and lacked the sturdiness of the earlier structure. Industrial deposits suggest it may have functioned as a smithy (Owen 2005, 208). The fish and bird bone reports are phased, but there is not yet a clear correlation between phases and the interpretation of possibly changing site status.

Some of the structures excavated at Skaill were defined as high status during excavation, on the basis of construction techniques and possible correlations with *Orkneyinga Saga* (Edwards 1997, 80). The midden material associated with these structures was identified, but only the mammal bone was quantified separately, thus making comparisons difficult. Furthermore, the lack of accurate or consistent phasing and dating for each of the animal bone reports, and the lack of sieving, mean that any intra-site status differences have effectively been lost for this site (see Table 1.1).

The classification of other sites by status is rather more difficult. The extant 12th century church at St. Boniface suggest high status correlations with the midden material excavated nearby (Lowe 1998, 3, 5, 9). Other sites have yielded less evidence regarding site status. Examples include Sandwick North, Sandwick, Scalloway, Jarlshof, Pool, Robert's Haven and Freswick.

Rather than relying on interpretations provided by the excavators, site status and function can also be inferred through analysis of the faunal evidence itself, in combination with ethnohistoric sources. For example, the consumption of small saithe (a member of the cod family) may sometimes by indicative of low status based on post-medieval analogy (e.g. Izat 1791-99; Low 1813; Armit 1845; Baikie and Heddle 1848; Fenton 1978). These could be caught in inshore waters throughout the Northern Isles, either in small boats just off the coast, or from the shore (Fenton 1978, 527-31), and required little specialist knowledge. Ethnohistoric evidence suggests these fish were the most important part of the diet for many people, and "[t]hey must be regarded as a hunger-food, filling the gap when other sources failed, for the poor often had to live on them for many weeks at a time" (Fenton 1978, 528; see also Towsey 2002, 41-42; Nicholson 2005, 144). Other fish were much more desirable, and had more value, but were less easy to catch. Fish oil was probably exploited in quantity from small saithe as well, and is a product recognised historically from the early 17th century (Fenton 1978, 527; Nicholson 2005, 144). Livers from young saithe were boiled to release the oil, which was then stored and used for light, and was also an important means of payment of rents (Nicholson 2004, 157; Nicholson 2005, 144), particularly if little else was available. High proportions of these small saithe can therefore be interpreted as evidence of subsistence fishing, using an easily caught, probably local resource that was low-risk (because fishing them did not involve open water fishing) and readily available throughout most of the year.

Along similar lines, differences in the proportions of cattle, caprines and seals have been interpreted as evidence of status in Norse Greenland. Higher proportions of cattle were identified from higher status sites, which had better access to pastures, larger byres, and were often located near to a church. These sites also contained more caribou remains, possibly illustrating the importance of hunting to these high status residences. In contrast, high proportions of caprines and seals were associated with small, low status and more marginal settlements (McGovern 1985, 97-102). The zooarchaeological assemblages from Norse Greenland cannot be used as a direct analogue to the material from the Northern Isles, given the environmental differences in climate and native fauna, but this thesis will be able to explore any function and status associations with particular species.

It may be possible to investigate 'identity' within the zooarchaeological record of the Northern Isles, given the associations between the Norse arrival and the intensification of fishing. However, this is likely to be difficult because a detailed examination of the artefactual evidence that could provide information on cultural associations and identities is outside the scope of this thesis. It will also be difficult to distinguish between assemblages associated with indigenous and incoming Norse communities at the late Iron Age – Viking Age transition, but this will be attempted wherever possible.

To summarise, this thesis will be able to explore a number of spatial themes. The identification and analysis of fish middens during the medieval period may reflect both spatial and chronological changes, and will be investigated in detail using the contemporary evidence of Quoygrew's fish midden and farm mound. Questions of site status and function will be approached firstly through the completion of the fish assemblage from the high status site of Earl's Bu, and secondly, by a comparison of sites of similar and different status from the Northern Isles. Finally, ethnographic and comparative material will be used to help interpret some of the patterns observed, and may prove useful for correlating site status and function to specific species usage.

1.5 Structure of thesis

The following chapter shall discuss the methods used throughout the thesis, including a summary of spatial analysis in archaeology and zooarchaeology, a brief description of the recording methods used when analysing the primary material from Earl's Bu and Quoygrew, and a discussion of the zooarchaeological identification of dried fish production and trade. Chapter Three then briefly introduces the archaeological background of Earl's Bu and Quoygrew.

Chapter Four presents the results of the fish assemblage from Earl's Bu, applying statistical techniques to understand the temporal and spatial patterning present within the assemblage. Chapter Five discusses the results of the Quoygrew fish assemblage in the same way, focussing on spatial differences between the contemporary farm mound and the fish midden, as well as temporal patterning within the layers of the farm mound. Chapter Six then presents the Quoygrew mammal bone assemblage, primarily focussing on chronological patterning within the farm mound because little mammal was found in the fish midden. Chapter Seven then briefly discusses the results of the bird bone from Quoygrew.

Chapter Eight starts by summarising and contrasting the evidence from the two primary sites, before moving on to a wider discussion of spatial and temporal patterning within the Northern Isles. Comparative material will be introduced at this point, and multivariate statistical analysis will be applied to the various datasets to help identify patterning. Finally, Chapter Nine will draw conclusions from the patterning identified in the previous chapter, building upon the themes discussed in this chapter.

Chapter Two: Methods

This chapter will discuss the various methods applied throughout this thesis, from the basic identification of the bone assemblages through to their statistical analyses. Before discussing these in detail, the first section of this chapter will start with a short summary of spatial analysis in archaeology and zooarchaeology. This is by no means comprehensive, because several aspects of spatial analysis are not applicable to Viking Age and medieval zooarchaeological data from the North Atlantic region, but it will provide a short introduction to methods successfully used by others, and ways in which they can be applied during this study.

The second section will discuss the methods used in primary identification and recording of bone, with an emphasis on new methods not already discussed in Harland *et al.* (2003). The third section will present the methods used during the primary data analysis, including a summary of inferential and multivariate statistics applied. Examples of statistical techniques used in the following chapters will be provided, with explanations of how to read the results of these tests. The various primary methods used to recognise dried fish production will also be considered, because this is an important facet of Northern Isles zooarchaeology.

The final section will discuss the range of comparative material available, drawing on the published and prepared zooarchaeological reports from the Northern Isles. These comparative sites were introduced in the first chapter, when a brief summary of site type and function was provided. The range of written sources will also be presented, with indications of how they can be used to augment the zooarchaeological record.

2.1 Spatial analysis in archaeology and zooarchaeology

The primary aim of this thesis is to explore the zooarchaeological assemblages of the Northern Isles for spatial and chronological patterning. Spatial analysis is a widely-applied analytical method in archaeology, encompassing a range of statistical techniques. Many of these are not applicable to zooarchaeological assemblages from the Northern Isles, which are predominantly from thickly stratified middens, some associated with relatively simple structures, and without three dimensional co-ordinates for each bone fragment. This last characteristic alone limits the number of methods that could be applied, ruling out nearest neighbour analysis and some forms of cluster analysis. This section aims to define and review how spatial techniques have been used in the past, before continuing on to discussing the methods in detail in the following sections.

Clarke defined spatial archaeology as

> "[T]he retrieval of information from archaeological spatial relationships and the study of the spatial consequences of former hominid activity patterns within and between features and structures and their articulation within sites, site systems and their environments: the study of the flow and integration of activities within and between structures, sites and resource spaces from the micro to the semi-micro and macro scales of aggregation... Spatial archaeology deals, therefore, with human activities at every scale, the traces and artefacts left by them, the physical infrastructure which accommodated them, the environments that they impinged upon and the interaction between all these aspects" (Clarke 1977, 9).

Spatial analysis of archaeological objects has two purposes: it can be used to compare and contrast different archaeological areas or different artefactual or ecofactual assemblages, or it can define arrangements of archaeological objects and features within an archaeological area in order to better understand the activities and formation processes that occurred there (Carr 1985b, 297). By comparing and contrasting different areas, spatial analysis can be used to determine past activities and the location in which they occurred (or at least the location in which the material remains of those activities were deposited), or the different taphonomic processes – both human and natural – that acted on the archaeological areas being studied.

Two different approaches have been taken towards studying spatial patterning. One approach is methodological, involving the definition of patterning in quantitative terms, while the other is 'actualistic', using ethnographic studies and experiments to interpret meaning and understand the formation processes behind archaeological patterning (Bartram *et al.* 1991, 79; Kroll and Price 1991a, vii). Much of the literature concerning ethnographic approaches to spatial analysis has focussed on early hunter-gather societies (Yellen 1977; Hivernal and Hodder 1984; Kroll and Isaac 1984; Spurling and Hayden 1984; Gargett and Hayden 1991; Gregg *et al.* 1991; Kent 1991; O'Connell *et al.* 1991, etc.), and although the general concepts may be applicable to North Atlantic archaeology, the detail is not (c.f. Maltby 1985b, 34, 40-49).

Not all quantitative methods of spatial analysis use statistical methods to prove their observations. Some zooarchaeological studies have taken a simple but effective approach to spatial patterning that involves a degree of quantification followed by presentation of data in a form that permits visual pattern recognition. For example, three dimensional bar charts were used at Freswick (e.g. Rackham 1995, Fig. 144), Beachview (e.g. Rackham 1996b, Illus. 47) and at Scalloway (e.g. Sharples 1998, Fig. 69). At Freswick, these graphically displayed density data from samples linked to actual locations in space, enabling areas of denser deposition to be identified. A similar but less effective approach was applied at Beachview in the Birsay Bay area. There, sample weights were graphically presented using a three dimensional bar chart, but using the undefined and variable unit of 'the bucket', which was neither uniform in volume nor anchored in space. Still, this displayed broad spatial patterning at the area level, albeit difficult to relate to the published zooarchaeological evidence. At Scalloway, a simple but effective approach presented counts of fish and mammal bones using a three dimensional bar chart with the *x* and *y* coordinates reflecting the coordinates of the site grid, thus quickly indicating the areas containing the greatest quantity of bone.

Early literature on spatial analysis, particularly intra-site analysis, frequently aimed to discover activity areas within a site through the identification of spatial zones in which specific tools were used, producing distinctive refuse patterns. The basic assumption underlying such methods was that the distributions of objects in space could be used as a direct link to not just the activities they represented, but also the spatial locations of those activities, therefore allowing interpretations about resource use, social status and hierarchies to be made using contextual data from structures and other artefacts (Berry *et al.* 1980, 55). These early statistical procedures were oriented towards identifying whether or not a particular artefact or ecofact type was distributed randomly, evenly, or in a formation of clusters throughout the site, with interpretations of activities following the conclusions from initial tests. Sometimes statistical tests were not used, but instead distribution maps coded with symbols, colours, shading or contours (Blankholm 1991, 24). An early research and development program into analytical methods in archaeology (Binford and Binford 1966, 241) assessed the use of factor analysis to compare individual artefact types, with the aim of identifying how combinations of artefact types in space could reflect various activities that occurred in the past; this followed the premise that "the form and composition of assemblages...are directly related to the form and composition of human activities at a given location" (Binford and Binford 1966, 291).

By the end of the 1970s spatial studies in archaeology had developed three facets: the traditional visual site and distribution maps; statistical analyses drawing on inter-disciplinary methods, including nearest neighbour analysis, analysis of variance, etc. (Whallon 1973b; 1973a; 1974); and the ethnographic or actualistic approaches mentioned above, including work by Binford (1978) and Schiffer (1976) (as cited in Kroll and Price (1991b, 1)). Despite these advances, Clarke still commented that "[a]lthough every archaeological study, past and present, has some spatial component, nevertheless the archaeological discovery and conquest of space has only recently begun on a serious scale" (1977, 5). Spatial analysis was only then gradually being used as a technique for examining relationships between archaeological entities, corresponding to the general trends of the time towards looking more at processes and changes rather than just 'things' (Hodder and Orton 1976, 1; Clarke 1977, 5).

Within zooarchaeology, Gamble was writing about the need to link zooarchaeological assemblages to their contextual data and ask better and more specific questions of the bone material (1978). In particular, he advocated the use of spatial analysis in zooarchaeological studies, stressing that the relationships between ecofacts and other classes of archaeological material need to be studied in order to best interpret the results (Gamble 1978, 330); similar changes happened in archaeobotanical research at this time (Dennell 1972, 149-50; Dennell 1976, 232). Few faunal reports examined spatial variability between feature types, instead grouping bones by phase, if at all (a contemporary example from Orkney being Buckquoy, analysed by Noddle (1976-77)). Halstead *et al.* (1978) advocated a similar approach to faunal data after finding that different types of deposits could contain very different species and element proportions. They examined a number of features from an Iron Age and Romano-British site and identified differences in the disposal methods used by size of animal, and by whether or not the bones represented slaughter and butchery waste, kitchen waste, or table waste. Having established intra-site patterning through the use of triangular plots and NISP data, they realised the significance of this approach to faunal data. They successfully found patterns of resource use, and interpreted the activities that may have occurred on the site. These patterns could not have been found if grouping by phase had occurred; likewise, if only one type of deposit had been excavated or sampled, the conclusions regarding the use of animals on site would have been substantially different. In contrast with chronological analyses, they stated that "[m]ajor differences in the contents of different types of deposit are therefore more likely to be due to functional and activity variation within the site" (Halstead *et al.* 1978, 121). At the same time, it was realised such approaches were not practical on smaller scale sites, or those with poor preservation, where often the only meaningful faunal results were achieved by amalgamating all faunal data by period and comparing changes through time (Gamble 1978, 331).

Contemporary with work by Halstead *et al.* (1978) was Wilson's (1978) analysis of the Iron Age and Roman Ashville Trading Estate site at Abingdon. Wilson noticed different species and element distributions were found after he grouped his results by feature type, thus indicating spatial patterning might account for differences in assemblages. Although he found spatial differences in the assemblages between features – in this case, pits and ditches – he found it difficult to draw conclusions because insufficient data were recorded during excavation (Wilson 1996, 12-14). This highlights the importance of integration between the faunal analysts and the research design from the beginning of the excavation.

In the early 1980s, Maltby noticed a variation among feature types when he analysed the Iron Age and Romano-British site of Winnall Down: cattle were more prevalent in quarry and ditch features, caprines and pig in pits (Maltby 1981, 166; Maltby 1985a, 42). This was due to both differences in preservation and disposal practices at the site (Maltby 1981). Maltby observed that if he had not noticed the differences between the bones from various feature types, he may have grouped his results by phase, rather than looking at temporal changes within feature types – thus displaying biased species frequencies, as he acknowledges with hindsight occurred in part of an assemblage from Exeter (Maltby 1979, 11).

From this point onwards, spatial separation by deposit type and function began to be incorporated into zooarchaeological reports, sometimes incidentally and implicitly, and sometimes explicitly. Chapter One includes a brief summary of the ways in which spatial analysis has been incorporated into the zooarchaeological record of the Northern Isles. Some sites, like those at Beachview, Birsay, have taken a spatial approach to some aspects of zooarchaeological data, including NISP data, while element representation and fish measurements were grouped regardless of context type and function. The transition to context-level analysis also occurred in other facets of Scottish zooarchaeology, as demonstrated by Cerón-Carrasco's recent publications on Western Isles zooarchaeology (2002; 2005).

2.1.1 Structured deposition

At this point, a discussion of structured deposition and its effect on the zooarchaeological record must be introduced. 'Structured deposition' was a term introduced by Richards and Thomas (1984) to classify certain deposits found on Neolithic sites that were not of domestic origin, but were different, symbolic, intentionally placed and purposeful. It can be equated with Schiffer's 'ritual caches and discards' category of material (Schiffer 1987, 79-80). Richards and Thomas interpreted these deposits as evidence of ritual activity because they believed the creation of those deposits would have involved repetitive actions that were formalised. These deposits would therefore be distinguished in the archaeological record due to their "highly structured mode of deposition" (1984, 215). However, not all structured deposits should be seen as evidence for ritual activity, particularly as patterns can be caused by natural taphonomic processes. Differences in preservation need to be excluded prior to any conclusions regarding the structured nature of the deposits. Routine behaviour including daily "refuse maintenance strategies" can also lead to distinctly patterned deposits which although structured, may not provide the same information as a deposit classed as 'ritual' behaviour (Hill 1995, 96).

Traditional zooarchaeological reports take a functional, economic view of animal use, although it has become more common to recognise that non-economic factors can influence exploitation patterns (see Moore (1981, 1982) for an early paper, and contrast Noddle 1976-77 with Brundle *et al.* 2003). This has its origins in Hawkes' 'Ladder of Inference' (1954), which implied that religion and ritual cannot be analysed through archaeological inference (Richards and Thomas 1984, 189). Theoretical viewpoints are now more willing to accept alternative, non-functional explanations for archaeological phenomena. Grant states that "we should no longer need to fear or apologize for giving ritual a much more central and integrated place in our attempts at explanations of the past" (1991, 110). Only within the past few decades has ritual been routinely identified in the zooarchaeological record, although the symbolic importance of animals has been studied by ethnographers and historians for some time, using art, folklore, myths and legends, historical references, antiquarian and ethnographic accounts, etc. (Ryan and

Crabtree 1995, 7). Finds of animals in what we would consider a ritual context were rare, and when recognised were merely mentioned without any associated significance – an example being the complete dog skeleton found in a doorway at Maiden Castle (Wheeler 1943, 115). Annie Grant was one of the first zooarchaeologists to recognise and publish on the subject of ritual deposits (1984a). Her methodology was applied to deposits throughout southern England by Wait (1986), who recognised that the animals found in special deposits were not necessarily those used for food (Grant 1984a, 543; Wait 1986, 152). He then developed a criterion for distinguishing 'special' deposits from normal food refuse based on element selection and association.

Intentional ritualistic animal burials can be recognized by skeletal completeness, associations with human burials or architectural features, and less wear and trampling, or by association with religious structures (Grant 1991, 109; Reitz and Wing 1999, 114, 276; Parker Pearson 1999, 10). Most of the rituals that involve animals are probably not recognisable archaeologically, as they occur alongside 'secular routines' of domestic life. Differential, non-domestic use may be reflected in the choice of individual, age, sex, time of death, element representation, butchery patterning, and/or burning (Reitz and Wing 1999, 276). Beliefs and social status can be reflected by dining companions, time of year or month or day of certain foodstuffs being consumed, choice of ingredients, etc., all of which are almost impossible to recognise in the archaeological record without recourse to ethnographic or historical accounts, including food laws (Tambiah 1969; Reitz and Wing 1999, 273). That said, the identification of ritual deposits depends "most often on a definition of what is unusual" (Grant 1991, 109), and will therefore vary with experience and excavation methodology.

Zooarchaeologists have difficulty in interpreting assemblages according to the categories of 'ritual' or 'refuse', and if something is interpreted as ritual does that exclude those bones from usual zooarchaeological quantifications and descriptions? Some would argue yes, but others stress that ritual behaviour is found within the range of activities practiced by a society and does not deserve separation (Grant 1991; Hill 1995; O'Connor 1996; Campbell 2000). A case in point is the assemblage from Sollas, North Uist. When originally identified, the specialist felt it necessary to ignore all potentially ritual deposits as they were non-representative of the local stock population (Finlay 1991, 146). This material is not included in surveys of assemblages of the time and period (e.g. Gilmour and Cook 1998; Mulville 1999), although its value has been demonstrated by Campbell (2000). Hill states that "it would be surprising if animal sacrifice and feasting did not share similar technologies, procedures and metaphorical links with more mundane cuisine...[this] implies a gradation between ritual and non-ritual" (1995, 99). Such a progression was noted at Danebury by Annie Grant. During the first season of excavation, some special animal deposits were found, although their importance was not identified until later analysis (Grant 1984a). This influenced the following seasons' excavation strategy, and thus more attention was given to pit deposits. It then became clear that even pits filled with 'normal' refuse showed evidence of ritual patterning, because dog, horse and bird remains were found to be statistically significantly associated with each other (Grant 1991, 110), despite showing evidence of being consumed in a normal, domestic setting (Grant 1984b).

The identification of ritual in the Iron Age Western Isles is now becoming common (Campbell and Finlay 1991; Gilmour and Cook 1998; Parker Pearson *et al.* 1999a; Parker Pearson *et al.* 1999b; Campbell 2000), but its recognition in the Northern Isles is still a rarity. The bone report for Buckquoy was originally published in the late 1970s, with little regard for animal deposits that differed from the norm (Noddle 1976-77). Buckquoy has been the subject of recent reanalysis (Brundle *et al.* 2003) by the original excavator, Dr. Ritchie, who realised that the original publication (Ritchie 1976-77) made no reference to the potentially ritualistic deposits of animal bone found at Buckquoy. The bones at Buckquoy were found 'trodden into' the boulder clay layers beneath the Pictish houses, with one exception: a deposit found in a hollow in the middle of the circular chamber in house 4 (also discussed in Ritchie 1983, 56) and illustrated for the first time in Brundle *et al.* (2003, Fig. 1). This chamber can be interpreted as the 'head' of the house, although it could have once been a separate single roomed structure. Further evidence of the possible ritual function of this room was the discovery of a bone spoon behind a smooth and shiny upright wall slab, immediately opposite the entrance (Brundle *et al.* 2003, 95). Similar deposits were noted at the Udal, North Uist: lambs and other bone remains were found beneath figure-of-eight houses there (Crawford 1972, 7). Hebridean wheelhouses often have a 'ritual emphasis' placed on the area opposite the entrance, an appropriate analogy given that the figure-of-eight house design at Buckquoy appears to have origins in the Hebrides, and prior to that, in Ireland (c.f. Lynn 1987), and that the spindle whorl recovered from Buckquoy is now thought to have an Irish inscription on it (Forsyth 1995). During a repaving phase a painted pebble of a type common to the Northern and Western Isles (Ritchie 1998) was placed in the centre of the chamber, presumably overlying the ritual animal bone deposit mentioned above. The spoon found in this chamber was abnormal in that it was shaped such that it could not hold liquids, and is different in form from most Late Iron Age spoons (though spoons in general are unusual finds from Late Iron Age Orkney): thus, "the Buckquoy spoon is an unusual object apparently deposited in a significant context" (Brundle *et al.* 2003, 98). It is most unfortunate that no record is available for these ritually deposited animal bones. Nothing was found in the Noddle archive and the excavator had no additional information (A Ritchie pers. comm.).

An isolated find of a mature porpoise mandible from the St. Ninian's Isle hoard, Shetland, may be of ritual or symbolic significance. This treasure was buried about AD 800, possibly pre-empting a Viking attack, and comprises a number of Pictish items of silver (Laing and Laing 1993,145; Barrowman 2003). Despite a survey of historical accounts for the period, and a recognition that the bone must be of some significance, the authors of the original catalogue conclude that "[t]he deeper meaning of this bone remains an enigma" (Small *et al.* 1973, 124).

Barring the two examples mentioned above, no other published zooarchaeological record mentions ritual or structured deposition in the Viking Age and medieval Northern Isles. This is not necessarily a reflection of their absence in the archaeological record – Buckquoy demonstrates that published material can be re-evaluated – but instead indicates that structured and ritualised activity may be present throughout the zooarchaeological record, even if not defined as such during excavation.

2.1.2 Practical approaches to spatial analysis

In practise, the study of spatial analysis will use data provided by the excavators relating to the type and function of each discrete deposit. This will probably be better understood at the primary sites, where more information about the excavation will be known, but all published and archival sources will be consulted for information regarding phasing and deposit type at the context level. Contexts will be amalgamated into "phase groups" as the unit of analysis. These will be contemporary contexts of similar function (e.g. domestic midden, floor layers or fish-rich midden), with dating and phasing information provided by the excavators. It is also hoped that each phase group will have a similar taphonomic signature operating throughout all the contexts that contribute to it. This is not always possible to test, given that data relating to preservation, texture and fragmentation are not always published, but all available taphonomic data will be used. These phase groups will not necessarily correspond with the phases used by the faunal analysts, because sometimes context types have been grouped at the phase level, or sometimes additional dating information will have become available following publication of the zooarchaeological report.

During the intra- and inter-site analysis of these phase groups, minimum threshold levels will be set to exclude the phase groups with the least number of identifications. These smaller phases are likely to skew the results and appear as outliers on any correspondence analysis plots (see below, section 2.3.3), and are also likely to obscure any 'real' patterning among the phase groups with larger sample sizes. For example, when examining inter-class variation, each hand collected phase group needed a minimum of 300 identified bones, but when studying the biometrical patterning, each phase group only needed a minimum of five values for each measurement.

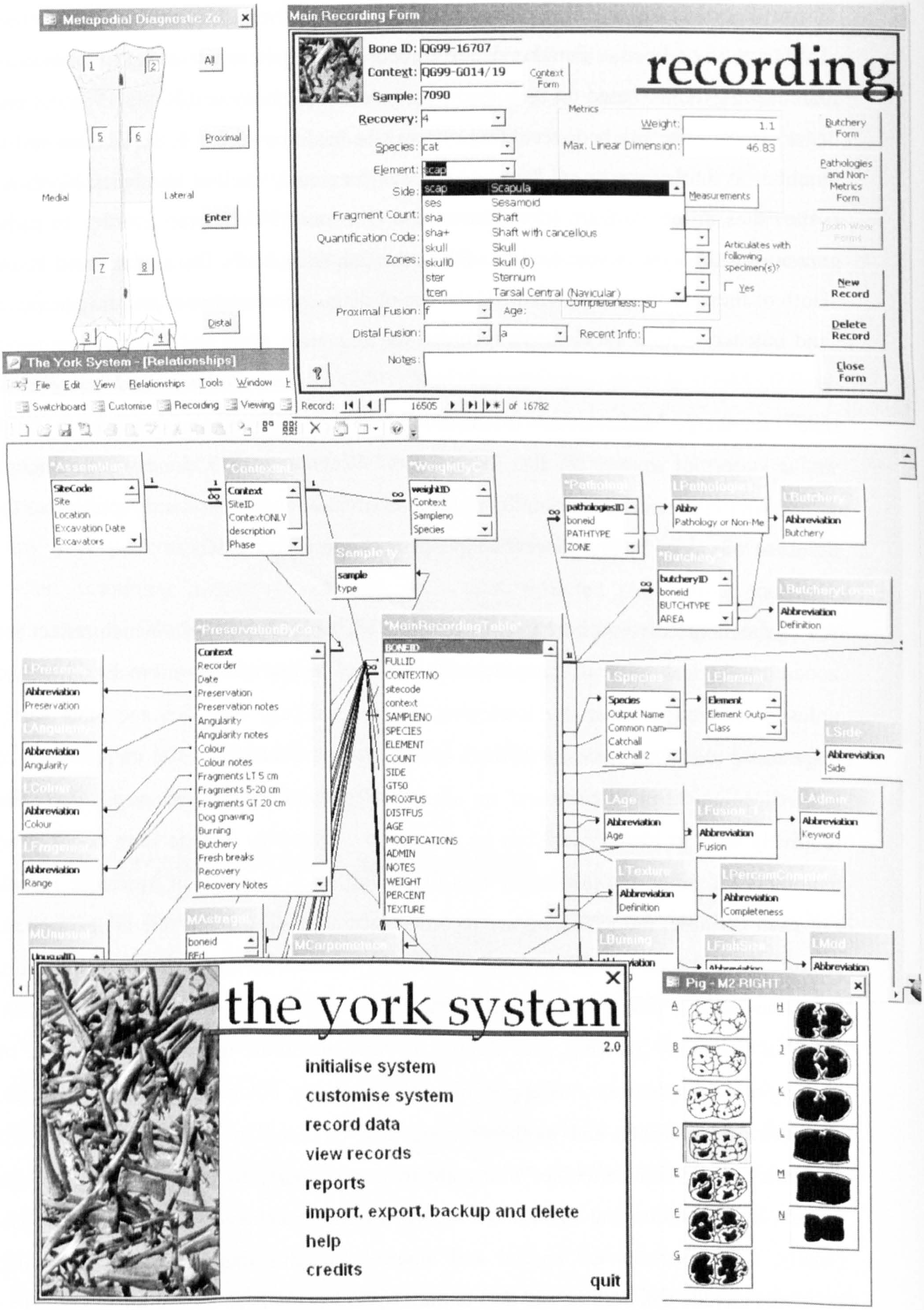
The following sections describes the primary identification and recording process, and the methods used during analysis of the data.

2.2 Primary identification and recording

The primary recording and identification of the Quoygrew material used the York System, a complex Microsoft Access database developed to record animal bone assemblages. This tool was developed by the author during her masters thesis (Harland 2001a), subsequently published as Harland *et al.* (2003). This publication and the help files found within the York System describe the process of recording, and provide explanations and justifications for why each attribute should be recorded; what follows is a brief summary of the origins of the recording system and the methods used to record certain attributes.

The York System has a number of built-in features to make recording easier and quicker than a paper-based system (Figure 2.1). Although the database was designed and programmed by the author, it is based on a number of recording methods and systems, drawn together for the first time in a single application. The concept was largely influenced by an earlier Paradox database recording system in use at the Environmental Archaeology Unit, based on their recording protocol (Dobney and Rielly 1988; Dobney *et al.* 1999). The fish bone recording system was based on *Fish 1.1*, the lab standard for Fishlab at the University of York, which was previously used at Sandwick North and other sites in the Northern Isles (Barrett and Oltmann 1997; Barrett 2000b); an earlier version of this system was used to analyse the fish from Earl's Bu, as discussed below. Both of these early systems involved the use of diagnostic zones to record fragmentation and butchery within the elements recorded for mammals, birds and fish (predominantly gadid). Mammal tooth wear followed Grant (1982) for cattle and pigs, and Payne (1973; 1987) for sheep. Measurements for mammals and birds followed von den Driesch (1976) and a variety of sources for fish (Morales and Rosenlund 1979; Jones 1991; Enghoff 1994; Watt *et al.* 1997). Integration of small mammals, amphibians and reptiles into the database was aided by Phil Piper (PJ Piper pers. comm.; Piper 2003).

All elements are divided into a series of Quantification Codes (QC), which reflect the zooarchaeological value of each element. QC0 elements are not normally identified unless butchered or otherwise interesting and unusual (e.g. ribs, fins and other easily fragmented elements, typically difficult to identify and quantify). QC1 elements are of zooarchaeological importance and are always fully identified and recorded. These are relatively easy to identify and can be quantified. Examples include limb bones from mammals and birds, and jaw bones from fish (a full list is provided in Appendix Three). For each of these, the following are recorded: quantity, side, diagnostic zones present, fusion states, general age for mammals and birds (neonatal, juvenile, sub-adult and adult, based on texture, size and comparative material), weight, maximum linear dimension, size (for fish), any gnawing, root etching or other alteration, texture, any evidence of burning and completeness. If applicable, measurements, butchery details, pathologies, non-metrical variations and tooth wear are also recorded for QC1 elements. QC2 elements are all fish vertebrae, which are treated similarly to QC1 elements, though texture, fragmentation and size are not recorded unless butchered or otherwise unusual. Finally, QC4 elements are special and unusual elements that are recorded in full; examples include fish otoliths and deer antler. (QC3 has not been used in this system.)



Bone ID: QG99-16707

Context: QG99-G014/19

Sample: 7090

Recovery: 4

Species: cat

Element: scap

Weight: 1.1

Max. Linear Dimension: 46.83

Proximal Fusion: f

Age: a

Record: 16505 of 16782

Figure 2.1: Screen shots from the York System

The recording methods used for the fish from Earl's Bu were slightly different, because they were based on an earlier system established by James Barrett and continued by the author. The basic identification method was very similar to the York System, but used a spreadsheet format, with the following differences: only nine cranial elements from gadid fish were recorded to species level (QC1), but a further 29 cranial elements were identified to family level at Earl's Bu (QC3), whereas at Quoygrew, 18 cranial elements were identified to species level (QC1) and none was identified to species level (i.e. QC3 was not used at Quoygrew). At Earl's Bu only QC1 elements (quantification code 1, the main cranial and appendicular elements identified) were weighed, whereas at Quoygrew all were weighed. This proved problematic for inter-class comparisons, when it was realised the Earl's Bu record of weights collected during the sample sorting process was not reliable. The Quoygrew dataset could be 'reduced' to the same suite of QC1 elements identified at Earl's Bu, which solved all comparison problems and permitted detailed comparison between sites with a limited 'loss' of data.

Outram's (1999; 2001; 2002; 2003; 2004) methods of identifying bone grease and marrow extraction was applied to the mammal bone during recording, although this was not an integral part of the York System. This method and its importance are summarised below. This was included because it has already been applied to sites in the North Atlantic (including Norse sites in Iceland and Greenland (Outram 2003), but not yet in Orkney) and has proved a useful and quick method of assessing the use of bone fats, an important but often ignored dietary indicator (Outram and Mulville 2005).

Bone fats are found within marrow cavities of cortical bone and within the cancellous tissue of long bone epiphyses and the axial skeleton (skull, vertebrae and ribs). The exploitation of these fats requires a differing amount of time and energy that is inversely proportional to the fat obtainable. Long bone marrow requires little energy to extract, but is rich in calories, whereas smaller appendicular elements, including the phalanges, contain small quantities of marrow but require a large investment in time and energy to extract. Long bone epiphyses will provide a good supply of fat once broken into fragments and boiled, while axial skeleton cancellous tissue will supply some fat once fragmented and boiled, but because blood is produced in these elements, the fats contained within contain quantities of protein and are less desirable (Outram 2004, 76, 79). Long bone cortical tissue will display distinctive attributes if fractured when the animal is freshly dead: helical curves will be found on fragment edges, angles across the thickness of the bone will be acute or obtuse, but not 90°, and the texture of the fracture will be smooth (Outram 2004, 81). Marrow is best extracted when the animal is freshly dead, although grease extraction does not need to occur immediately (Outram 2004, 75). The exploitation of fats may be age dependent, although very little experimental work has been carried out to determine the fat content of very young individuals; they are likely to contain much less fat than older animals (A Outram, pers. comm. 2005). If neonatal bones are unlikely to be exploited for fats, their levels of fragmentation and preservation are likely to be very different from adult material, an important factor to consider during taphonomic analysis.

Marrow and grease extraction has always focused on terrestrial mammals. Sea mammals do have fat, but this is usually in the form of easily exploitable blubber. Any further exploitation of within-bone fat would produce a much lower return on the energy invested compared to blubber usage. Fats derived from seal bones also have a much lower melting point than land mammals, making the production and storage of such fats much more difficult (Outram 2005, 34). As a consequence, sea mammals will be treated differently from the land mammals in the following discussion on bone and grease extraction.

A simplified version of Outram's Fracture Freshness Index was applied to the Quoygrew bone and integrated into the recording process. All cortical fragments were qualitatively recorded as either very freshly broken (all edges of the fragment display the freshness characteristics), moderately freshly broken (most of the edges display some of the characteristics, i.e. although initially fragmented for marrow, some additional fragmentation occurred at some point later), or not freshly broken (very few of the edges display any of the characteristics, thus indicative of fragmentation some time after death, but prior to excavation). Any axial bone tissue or shaft epiphyses that were fragmented were recorded as 'possibly used for grease extraction'. Fragments that contained both fragmented epiphyses and diaphyses could be recorded twice, once assessing potential freshness for marrow extraction, and once for potential grease extraction. In addition to recording the maximum linear dimension for all QC1 identifiable elements, the sizes of other fragments were quickly recorded using a series of concentric circles starting at 3cm and using a 2cm resolution, following Outram's method. This did not appreciably add to the recording time, but allowed a rough indication of size to be recorded for all fragments.

2.2.1 Methods of identifying and analysing dried fish production

This section is included here because it is one of the more important facets of the zooarchaeological analysis undertaken during this thesis, and because it needs to be explicitly discussed prior to the presentation of primary zooarchaeological data. The York System recording methodology was developed in part to provide a better opportunity for recognising dried fish production (and thus possibly trade) within the zooarchaeological record of the North Atlantic. The recording system used is therefore more detailed and explicit than many that preceded it; for example, the position of the vertebrae within the vertebral column are recorded to a greater degree of precision in the York System than in others. The York System's method of fish recording was based on an earlier system successfully applied to the fish bone from Robert's Haven and initial analysis of Earl's Bu material (Barrett 1997, later made explicit in Barrett 2000b). The archaeological significance of the fish trade was introduced in Chapter One, and discussed comprehensively in a number of recent publications (including Barrett 1995; Barrett 1997; Barrett *et al.* 1999; Perdikaris 1999; Barrett *et al.* 2004a).

The species ranges and sizes selected for preparation are known, and comprise large fish of the gadid family including cod, *Gadus morhua*, saithe, *Pollachius virens*, ling, *Molva molva*, haddock, *Melanogrammus aeglefinus* and related species (Barrett 1997; Barrett *et al.* 1999; Barrett *et al.* 2004a). Thus, at a broad level the recording of species counts and element sizes can identify whether the fish exploited were suitable for preparation and trading. A number of measurements have become standardised and are now regularly recorded (following Jones 1991; full details provided in the York System); regression equations can be applied to these to determine fish size distributions. In addition to measurements, the sizes of all identified cranial and appendicular elements were recorded to a number of categories (i.e. 'tiny', <150mm, 'large', 800-1000mm, etc.) based on comparisons with reference material. This permits a greater understanding of fish sizes exploited, because this includes all elements, including the appendicular elements which are not normally measured. The size ranges of these are important and can provide extra information, particularly if over- or under-represented compared to the size profiles of cranial elements.

The relative abundance of each element can be influenced by taphonomic patterning as well as import or export of prepared fish (e.g. Nicholson 1992). While it is always essential to analyse the fragmentation, texture and preservation of any bone assemblage, it is particularly important when trying to establish if some fish elements are over- or under-represented. A detailed taphonomic analysis will therefore precede the presentation of the species and, particularly, element distributions. When butchering large gadids for preparation as a dried and storable product, some elements were typically removed and left at the processing site, including the cranium and some of the more anterior vertebrae. Others, including the cleithra and possibly the supracleithra and posttemporals, were left in the prepared fish with the flesh, and thus removed from the processing site (Barrett 1997, 620). It is therefore crucial to record the position in the vertebral column, as well as a variety of elements from the cranial and appendicular skeleton. It has always been impractical to record all gadid remains, because the sheer quantity of elements present within the head would lead to redundancies in the data, but at the other extreme, enough elements need to be identified to establish both the taphonomic patterning, and any economically-based over- or under-representation.

Butchery marks have often been recorded, but not always in detail. These will be found on fish butchered and gutted for immediate consumption, as well as on fish intended for preparation and trade. Detailed recording and analysis, following the categories described in Barrett 1997, Fig. 7, permit these differences to be determined. Each butchery mark will be recorded separately in the database and will also be sketched on a diagram to allow easy analysis, rather than relying on descriptions.

2.3 Primary analysis

Initial analysis of the bone assemblages from Quoygrew and Earl's Bu was performed using Microsoft Access and Excel. The York System has a number of built-in quantification tools to provide summary data, which were used during the analysis of the Quoygrew material; very similar queries and reports were applied to the Earl's Bu fish data. These provided the basic data summaries, but further analysis made use of custom database queries and Excel pivot tables. Data could then be statistically analysed using SPSS or Minitab, and graphically displayed using Excel, SPSS or Minitab. Details of the statistical methods used throughout this thesis are included below, together with a discussion of the previous uses of some of these techniques in archaeology and zooarchaeology. The simple graphical methods used throughout the presentation and discussion of the data need no further introduction as they are widely used and easy to interpret. Following established zooarchaeological methods, data were presented using both NISP (number of identified specimens) and MNE (minimum number of elements), and not by MNI (minimum number of individuals). A discussion of the advantages and disadvantages of each can be found in the author's MSc thesis (2001a) and in Harland *et al.* (2003).

2.3.1 Inferential statistics

A number of inferential statistical methods were used throughout the thesis, all of which have a long history of use in archaeology and zooarchaeology, albeit not often in the Northern Isles (see Chapter One for the background on zooarchaeology and spatial analysis in the Northern Isles). While this is not the place for a summary of these techniques, which include Chi Square, Kruskal-Wallis, Kolmogorov-Smirnov, Spearman's Rho and Mann-Whitney U tests, Appendix Two details how the data were manipulated in order to perform the tests, and how the reader should interpret the results used throughout the text. An example question is provided in the appendix for each test, followed by the process used to test the question and determine the significance of the results. Further information about these methods may be found in Shennan (1997), Baxter (2003) or in the help files for SPSS and Minitab.

2.3.2 Multivariate methods

Multivariate methods need a somewhat longer introduction than inferential methods because they have not been as widely applied to zooarchaeological data, and they can be more complex to apply and interpret. That said, a few recent applications in zooarchaeology include the use of discriminant function analysis on equid biometrical data (Johnstone 2004), and the use of correspondence analysis to investigate patterning in fish assemblages from medieval England (Barrett *et al.* 2004a; 2004b).

The multivariate methods typically used in archaeology, particularly in the context of spatial analysis, are comprised of five techniques: cluster analysis, discriminant analysis, factor analysis, principal components analysis (PCA) and correspondence analysis (CA) (Baxter 2003, 66). Multivariate statistics, as opposed to the inferential tests mentioned above, allow many variables to be included in an analysis, including temporal and spatial data. During a study of the potential methods used to analyse assemblages of artefacts and ecofacts, it was found that "to explore the full richness of the data available, multivariate statistics are an invaluable tool", particularly correspondence analysis (Cool and Baxter 2002, 365). Multivariate statistics generally start with the creation of a table listing items (rows) against attributes (types, functions, measurements), a structure well suited to faunal data. This is then converted into measures of similarity and plotted in space (Lock 2003, 125).

Many of the early multivariate methods used were adapted from other disciplines, including biology and geography (Hodder and Orton 1976). In the 1980s a reaction against the use of statistics in archaeology occurred, due in part to the realisation that artefacts could not be equated with biological specimens – flint scatters were not subject to the same laws of nature as populations of flowers, thus the applicability of cross-disciplinary statistical methods was questioned (Orton 1992, 137). The need for congruence between archaeological theory and practical statistics was identified (Baxter 2003, 5): methods devised by and for archaeologists were seen as preferable over those from other disciplines, including K-means cluster analysis, local density analysis and unconstrained clustering (Whallon 1984; Carr 1985a; Doran and Hodson 1975, 180-185; Johnson 1978). Methods used today often have a history of development and use within archaeology, meaning that they do not necessarily include the latest advances in statistics (Baxter 2003, 8). However, it is necessary to balance the need for archaeologists to use statistical procedures that have a history in archaeological analysis, against new and therefore untried and untested techniques.

As with many computer-based applications, CA only became widely accessible to archaeologists with the development of easily usable software in the late 1980s onwards (Shennan 1997, 308; Lock 2003, 124). CA can be applied to contingency tables listing counts, or listing incidence (presence or absence). It is now "one of the most widely used multivariate methods in archaeology, ... and this is largely attributable to its ready availability as well as obvious utility" (Baxter 2003, 17). It is a method that allows relationships between variables to be explored through the creation of maps displaying data points. Bølviken *et al.* (1982) introduced correspondence analysis to the English speaking archaeological world, although CA has a long tradition within French and Scandinavian archaeology (Benzécri 1973; Djindjian and de Croisset 1976a; 1976b;

Boutin *et al.* 1977; Bourdieu 1984, as cited in Greenacre (1984), Shennan (1997, 308) and Clausen (1998, v, 1, 5)). Zooarchaeological examples are rare, although there are a number of published non-zooarchaeological examples including Bølviken *et al.* (1982), Axboe (1993), Cool and Baxter (1995), Lockyear (2000), and Cool and Baxter (2002). Moreno-Garcia *et al.* (1996) and Orton (1996) applied CA to faunal data, but within a software package designed for the analysis of pottery, a questionable analogy. CA has been directly applied to faunal data more recently, when it was successfully used to explore correlations between fish species, site type and data (Barrett 2002, 11-12; Barrett *et al.* 2004a, Fig. 2; Barrett *et al.* 2004b, Fig.1).

A number of factors makes this a viable multivariate method for exploring spatial and chronological zooarchaeological patterning, including the history of use of CA in archaeology and the inclusion of CA in modern statistical software packages like Minitab.

2.3.3 Correspondence Analysis (CA)

The following description of the method of CA is largely based on two accessible accounts of the procedure, namely Clausen (1998) in his introduction intended for social scientists, and Shennan (1997), in *Quantifying Archaeology*. Contingency tables display counts of objects of different type and/or with different variables, and are ideally structured to perform several forms of multivariate analysis. A contingency table with faunal data may display rows of provenance data, usually site name or context type, against columns of species or element categories. Table cells then display counts.

During CA processing the absolute counts in a contingency table are converted to relative values reflecting the 'profile' and 'mass' of each row or column in the table. Row profiles represent the relative frequencies of each column within a row, and across a row each profile will equal 1 (and vice versa for column profiles) (Shennan 1997, 309; Clausen 1998, 10). The row mass is equal to the proportion of points in that row compared to the total number of points, and is a measure of the weight or importance of that row to the data set (likewise column mass) (Shennan 1997, 313; Clausen 1998, 10). Distances can then be calculated between the relative values in each row and column using the profile and mass data to add weight to the values and convert them to coordinates, all automatically done during processing (Shennan 1997, 315, 317; Clausen

1998, 11). The origin, or centroid, of the data is the average row and column profile, located at the intersection of the axes (Clausen 1998, 11). If a profile is very different from the average, it will be located at a distance from the origin, in a particular direction representing the variation (Shennan 1997, 315, 318; Clausen 1998, 11). The row and column distances can then be portrayed on a map, or scatter plot, depicting their relationships and the ways in which they *correspond* to each other (Shennan 1997, 320).

Any CA will have a number of dimensions or axes that can be investigated in any combination that the user wishes to apply; this number will be one less than the lesser of the quantity of columns or rows, although only those axes that represent a substantial proportion of the total inertia (the total variation seen in the data set) need to be analysed (Shennan 1997, 318; Clausen 1998, 2). Each dimension's inertia is a measure of the relative importance of that dimension to the data set (Clausen 1998, 15).

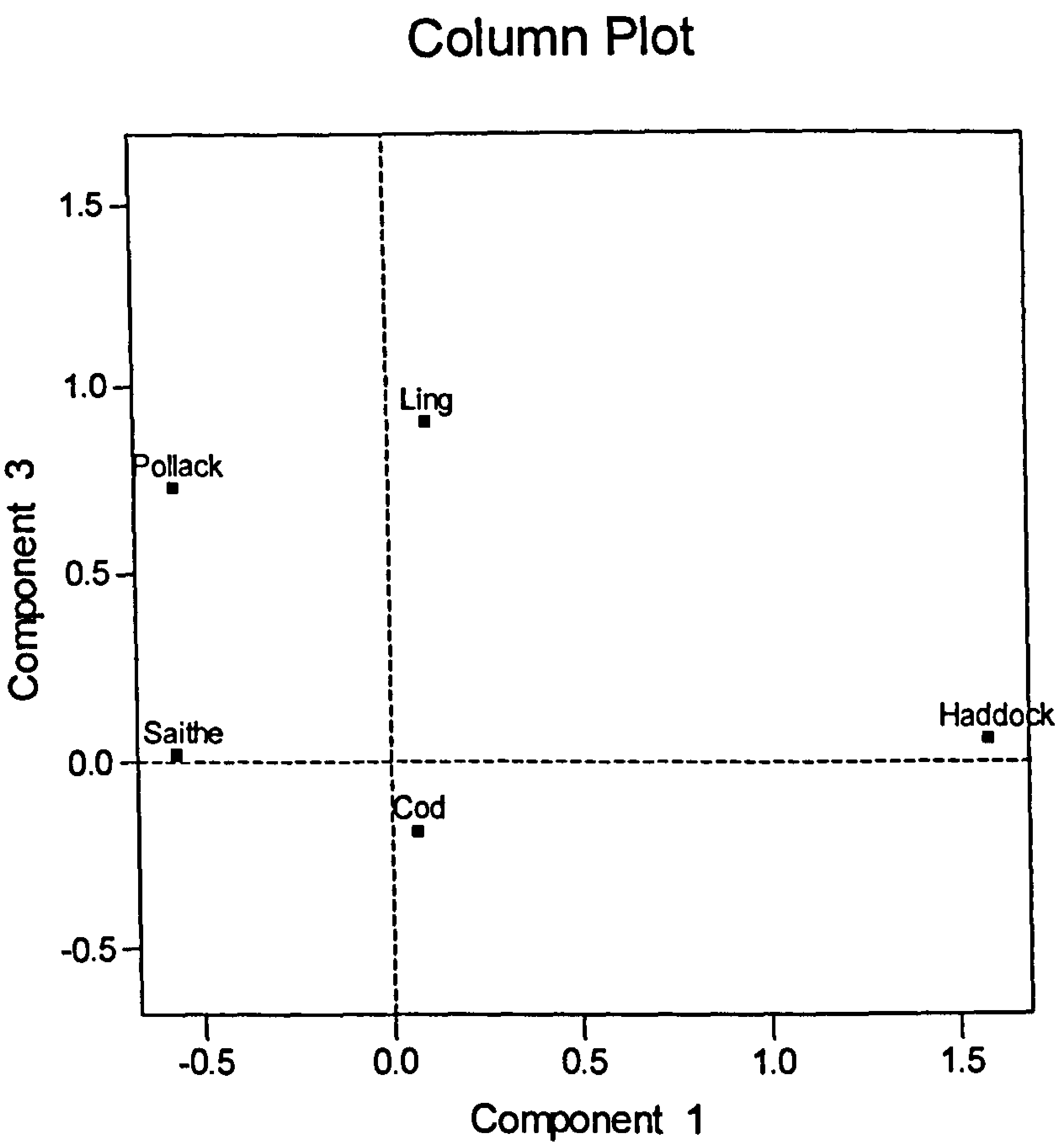
Two further statistics are generated by CA. The first of these is the 'contribution of points to dimensions' (after Clausen 1998, 17), which indicates the amount of inertia each point is responsible for, and thus values that have a high score are responsible for much of the inertia of their dimension (Shennan 1997, 324). The axis can then be interpreted and labelled through the examination of those points with large contributions (Clausen 1998, 17-18). The second statistic of note is the 'contribution of dimensions to points' (after Clausen 1998, 18), which is a measure of the amount of a point's inertia described by each axis; values that are close to 1 indicate that all of a point's inertia can be explained by one dimension (Shennan 1997, 325). This can be a useful indicator of which axes to display (Clausen 1998, 18-20).

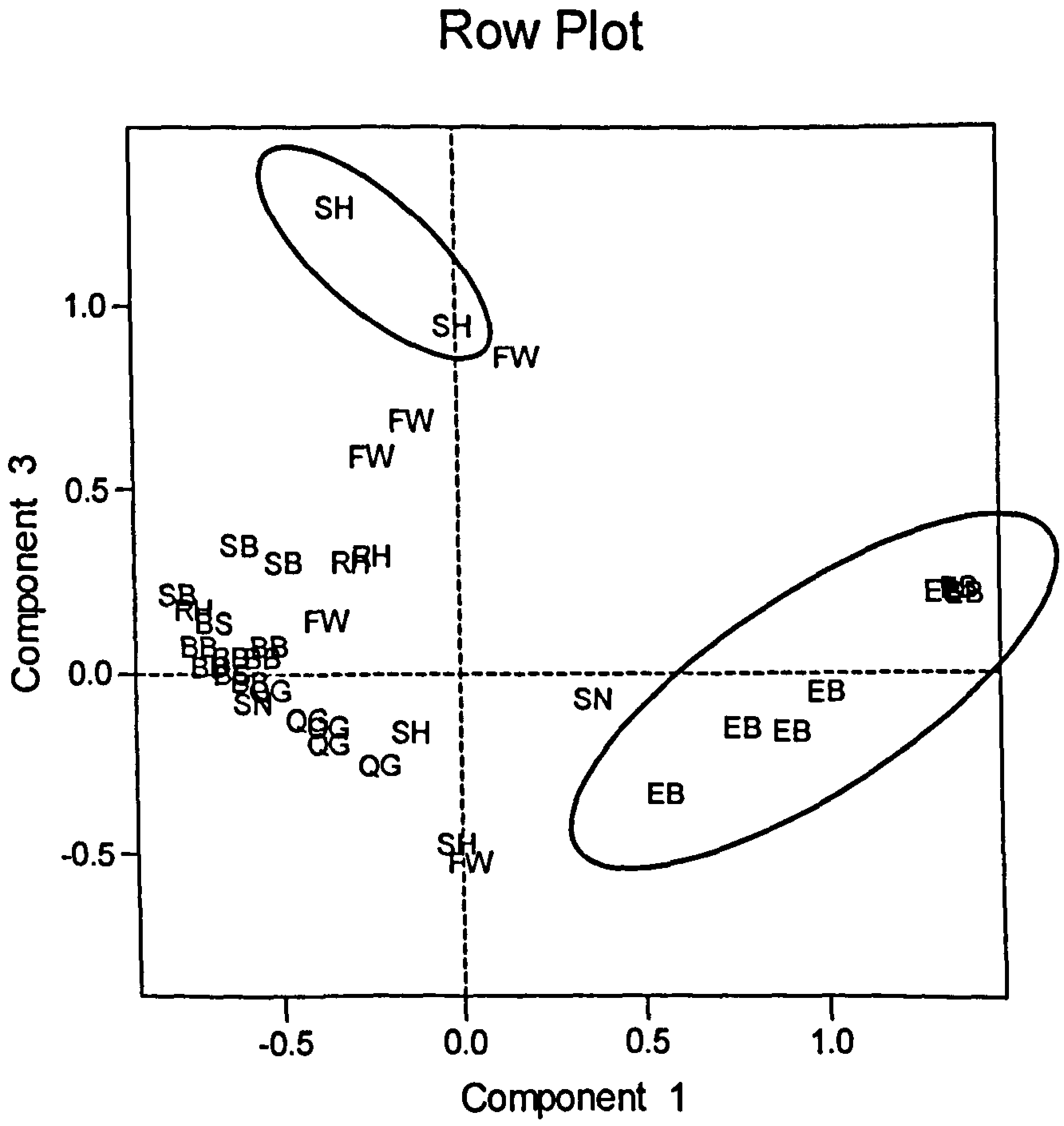
Outliers are commonly found during multivariate analysis, and if not removed they may mask real patterning (Baxter 2003, 123). They should not be ignored, but explanations should be provided for their removal; they are also useful for finding and correcting erroneous data points. This is illustrated by Moreno-Garcia *et al.* (1996), in which a peculiar series of outlying mandible data points from Saxon contexts were discovered to have been recorded following a different recording system from the rest of the assemblages. The easiest method for finding outliers is to perform the analysis (be it CA or any other method), locate, remove and check outliers, then redo the analysis (Kintigh 1990, 407).

Some authors prefer to combine the results of CA in one map, whereas others keep the row and column maps separate and compare them by eye. The distances between points within each variable are defined and can be compared, but although general comparisons can be made between points from each variable, the distances between them cannot be directly compared; this is further reason to present the results of CA as two plots which can be compared by eye for general patterning. Separate maps limit this potential confusion and will be used here.

2.3.4 Example CA plots: how to read and interpret row and column plots

Figure 2.2 shows an example of CA, using NISP counts for cod, saithe, pollack, ling and haddock from all sites in the Northern Isles that have been sieved, that have at least 100 identified fragments, and that were classed as midden by the excavators. The table of contributions is provided in Table 2.1. Data were correlated into a contingency table, with columns for NISP counts of each species, and rows for each stratigraphic unit, which was most often the phase. Results are presented in separate plots to avoid confusion and overlapping labels; the column plot indicates the positions of each species, and the row plots the position of each site phase. Two row plots are presented here, each displaying the same data but one coded by site, and one by period. Components 1 and 3 were chosen as they better displayed patterns in the data, compared to components 1 and 2. Component 1 represents 45% of the inertia, or variation, in the dataset, and component 3 6.6%. Looking at both the column plot and the table of contributions, the points that contribute the most to each axis can be determined, because they have higher contributions than other points. Axis 1 of the column plot displays patterning based on counts of saithe at one extreme (contributing 0.280 of the axis inertia, of a total of 1), and haddock at the other (contributing 0.701 of the axis inertia). Axis 3 displays patterning mainly based on ling, cod, and to a lesser degree, pollack. The corresponding row plots display a point for each phase, coded firstly by letter pairs to represent each site, and secondly by codes representing the time periods of each site. Two groups of points were conspicuous in the first row plot (circled), one representing 2 phases from Saevar Howe, and one representing all of the Earl's Bu phases. The Saevar Howe points tended towards ling and away from haddock, while the Earl's Bu points tended towards haddock and away from saithe. In the second row plot, only the group of Iron Age points was conspicuous (circled), with all other points mixed together regardless of date. This plot was relatively simple, but represents the way in which CA can be used to explore zooarchaeological data.





SN: Sandwick North

SB: St. Boniface

QG: Quoygrew

BB: Beachview Burnside

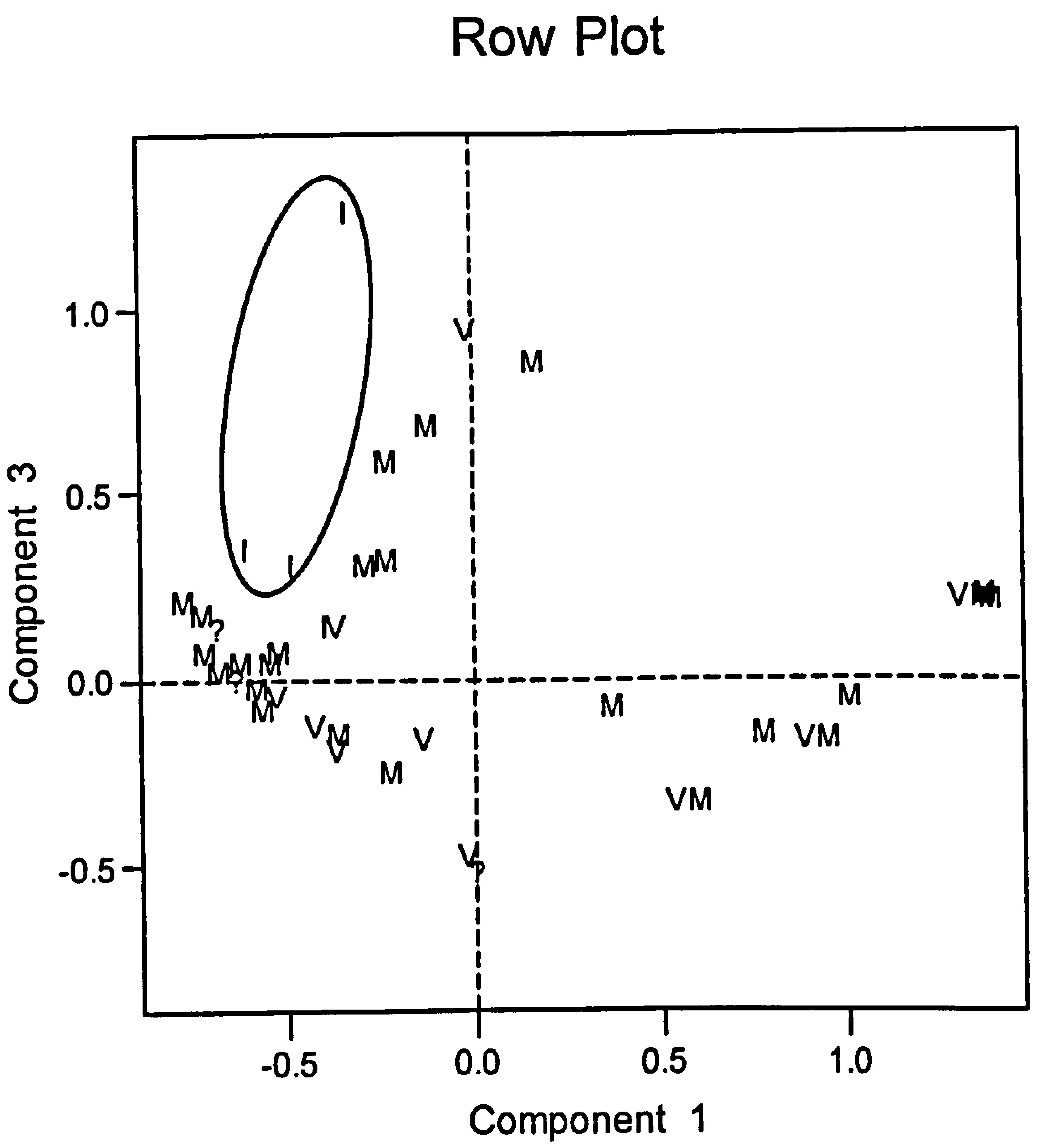
BS: Beachview Studio

SH: Saevar Howe

EB: Earl's Bu

RH: Robert's Haven

FW: Freswick



I: Iron Age

IV: Iron Age – Viking Age transition

V: Viking Age

VM: Viking Age – medieval transition

M: Medieval

?: Unknown or all

Figure 2.2: Example CA plots, showing two different coding methods for row plots

Rows:				Component 1			Component 3		
Site and phase	Quality	Mass	Inertia	Co-ordinate	Contri-bution to row inertia	Contri-bution of row to axis inertia	Co-ordinate	Contri-bution to row inertia	Contri-bution of row to axis inertia
Sandwick North 2	1.000	0.002	0.001	0.356	0.243	0.000	-0.135	0.035	0.000
Sandwick North 3	1.000	0.001	0.000	-0.581	0.660	0.000	-0.143	0.040	0.000
St. Boniface 7	1.000	0.005	0.010	-0.612	0.289	0.004	0.288	0.064	0.006
St. Boniface 8	1.000	0.035	0.075	-0.491	0.170	0.019	0.242	0.041	0.031
St. Boniface 9	1.000	0.012	0.022	-0.789	0.535	0.017	0.151	0.020	0.004
Quoygrew 1.2	1.000	0.005	0.002	-0.377	0.657	0.002	-0.254	0.298	0.005
Quoygrew 2	1.000	0.082	0.024	-0.377	0.722	0.026	-0.207	0.217	0.053
Quoygrew i	1.000	0.003	0.001	-0.432	0.730	0.001	-0.191	0.142	0.002
Quoygrew ii	1.000	0.113	0.062	-0.534	0.791	0.071	-0.109	0.033	0.020
Quoygrew iii	1.000	0.100	0.039	-0.237	0.221	0.013	-0.315	0.387	0.149
Beachview Burnside 3X	1.000	0.005	0.008	-0.729	0.534	0.006	0.012	0.000	0.000
Beachview Burnside W	1.000	0.001	0.002	-0.640	0.476	0.001	-0.020	0.000	0.000
Beachview Burnside X6	1.000	0.011	0.009	-0.591	0.643	0.009	-0.084	0.013	0.001
Beachview Burnside X7PG	1.000	0.002	0.002	-0.698	0.558	0.002	-0.045	0.002	0.000
Beachview Burnside X8	1.000	0.030	0.018	-0.537	0.733	0.020	0.010	0.000	0.000
Beachview Burnside X	1.000	0.044	0.029	-0.555	0.709	0.030	-0.019	0.001	0.000
Beachview Studio 1R	1.000	0.014	0.015	-0.638	0.613	0.013	-0.063	0.006	0.001
Beachview Studio 1S	1.000	0.015	0.019	-0.687	0.553	0.016	0.075	0.007	0.001
Saevar Howe I	1.000	0.001	0.004	-0.334	0.051	0.000	1.203	0.661	0.026
Saevar Howe IIb	1.000	0.004	0.005	-0.027	0.001	0.000	-0.538	0.359	0.019
Saevar Howe IIb/c	1.000	0.001	0.002	-0.019	0.000	0.000	0.881	0.384	0.008
Saevar Howe IIc	1.000	0.001	0.000	-0.146	0.061	0.000	-0.222	0.140	0.000
Earl's Bu M1	1.000	0.011	0.009	0.550	0.561	0.007	-0.396	0.290	0.026
Earl's Bu M3	1.000	0.012	0.036	1.360	0.954	0.051	0.168	0.014	0.005
Earl's Bu M3a	1.000	0.045	0.043	0.763	0.922	0.058	-0.213	0.072	0.031
Earl's Bu M3b	1.000	0.064	0.099	0.995	0.974	0.141	-0.114	0.013	0.013
Earl's Bu M3c	1.000	0.096	0.263	1.318	0.963	0.370	0.157	0.014	0.036
Earl's Bu R1	1.000	0.029	0.038	0.898	0.936	0.052	-0.225	0.059	0.022

Earl's Bu R3	1.000	0.006	0.019	1.375	0.949	0.026	0.152	0.012	0.002
Robert's Haven 1A	1.000	0.078	0.027	-0.248	0.274	0.011	0.258	0.297	0.079
Robert's Haven 1E	1.000	0.009	0.015	-0.736	0.482	0.010	0.114	0.012	0.002
Robert's Haven 1 all	1.000	0.088	0.025	-0.303	0.491	0.018	0.241	0.312	0.078
Freswick Inland 3	1.000	0.018	0.024	0.004	0.000	0.000	-0.585	0.397	0.095
Freswick Inland 9	1.000	0.004	0.005	0.150	0.023	0.000	0.794	0.638	0.034
Freswick SCA	1.000	0.008	0.002	-0.382	0.828	0.002	0.081	0.037	0.001
Freswick NCA 4TUV	1.000	0.038	0.041	-0.137	0.027	0.002	0.620	0.549	0.223
Freswick NCA 4X	1.000	0.006	0.004	-0.249	0.149	0.001	0.522	0.656	0.027

Columns:				Component 1			Component 3		
Species	Quality	Mass	Inertia	Co-ordinate	Contri-bution to row inertia	Contri-bution of row to axis inertia	Co-ordinate	Contri-bution to row inertia	Contri-bution of row to axis inertia
Cod	1.000	0.409	0.074	0.068	0.039	0.004	-0.184	0.285	0.209
Haddock	1.000	0.126	0.502	1.582	0.956	0.701	0.059	0.001	0.007
Pollack	1.000	0.018	0.093	-0.568	0.094	0.013	0.729	0.154	0.143
Saithe	1.000	0.394	0.234	-0.566	0.819	0.280	0.020	0.001	0.002
Ling	1.000	0.052	0.097	0.109	0.010	0.001	0.902	0.661	0.640

Table 2.1: Contributions for example CA plot

Figure 2.3 represents the *theoretical* process of creating and using CA plots during the course of this thesis, and was created prior to any data analysis. The actual process used did follow this pattern during the analysis of inter-site patterning across the Northern Isles, but CA proved less useful at the intra-site level than was hoped. CA was moderately useful during the analysis of the Earl's Bu fish, but standard techniques were more useful for the analysis of the Quoygrew bone. This was partly because Quoygrew contained only three major phases, and patterning was therefore easily visible, whereas Earl's Bu contained several phases and patterning was not always explicit in the dataset.

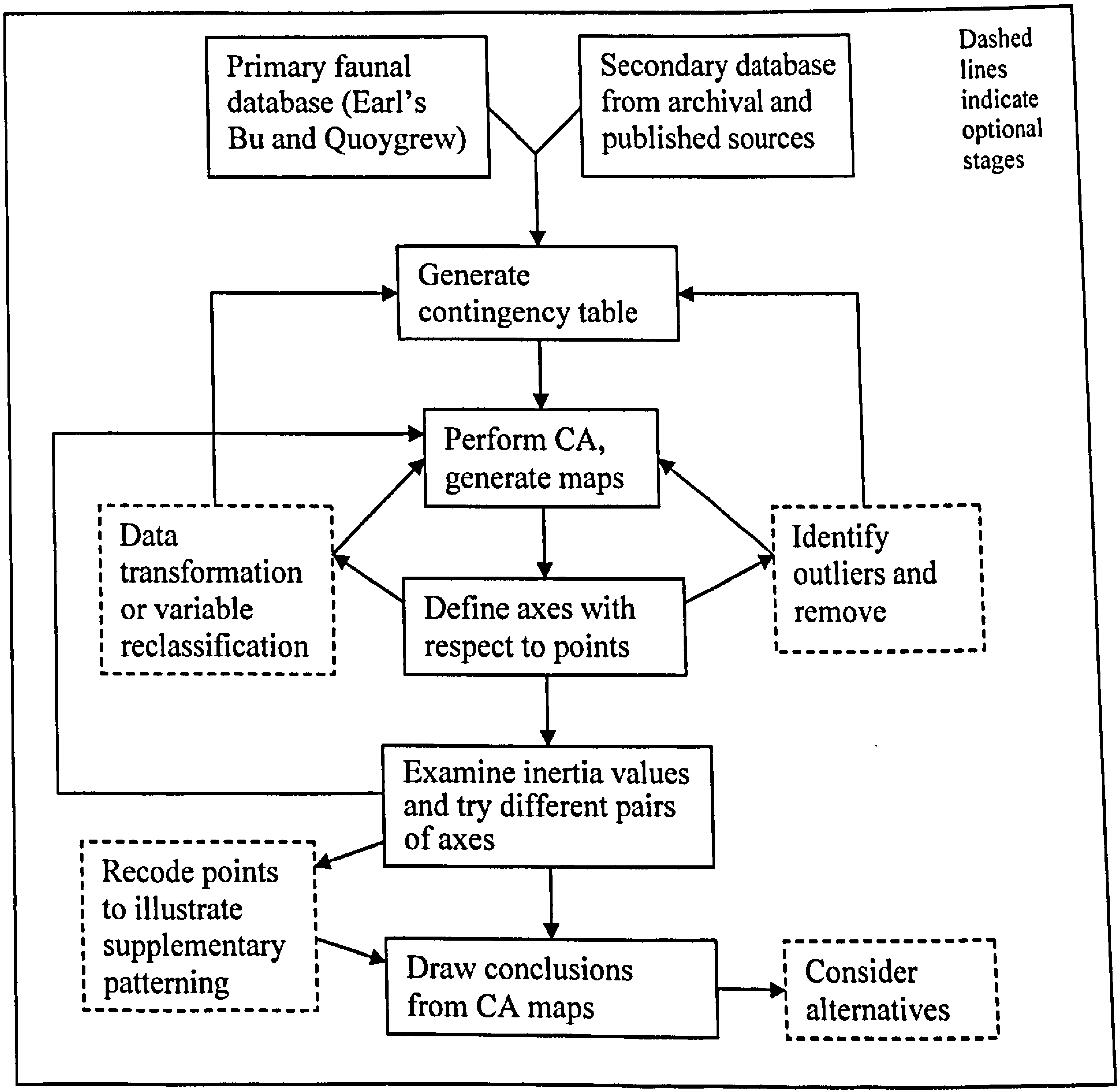


Figure 2.3: Theoretical process of creating and using CA plots

2.4 *Written sources*

A number of written sources were consulted for information regarding animals in the Northern Isles. The focus of this thesis is primarily on the zooarchaeological data, bu consultation of ethnohistorical and historical sources can contribute solutions t questions otherwise unanswerable by zooarchaeological data. Although most of thes date to recent centuries, they often describe the unimproved economic systems of fishin and farming that had been in place for hundreds of years, and are therefore a suitabl analogy with which to augment the zooarchaeological record. However, from the mi 18th century, Orkney's agricultural and economic patterns were altered by th introduction of kelp making (Fenton 1978; Thomson 2001); great care must be tak when using sources from this time period.

A number of sagas are contemporary with the archaeological settlements discussed in this thesis, particularly *Orkneyinga Saga* (Pálsson and Edwards 1978), which includes descriptions of Orphir, the estate now known as Earl's Bu. This saga was written around AD 1200 in Iceland and describes a number of historical events during the Earldom of Orkney. Its reliability for earlier centuries is now questioned, but it is generally considered to be dependable for the medieval period (Graham-Campbell and Batey 1998, 46). Other historical sources include descriptions of late Viking Age and medieval Orkney, but are of limited use; these are summarised in Thomson (2001).

Fenton's *The Northern Isles: Orkney and Shetland* (1978) is a major resource for physical descriptions of domestic stock and their role in the economy, fishing techniques, seasonality and uses, methods of capturing wild seabirds, and general descriptions of agriculture and 18th and 19th century life in the Northern Isles. This can be augmented by descriptions provided on a parish-by-parish basis in *The Statistical Account of Scotland* (e.g. Izat 1791-99) and *The New Statistical Account of Scotland* (e.g. Armit 1845) and by general publications about Northern Isles agriculture (e.g. Pringle 1874). Eighteenth and nineteenth century histories and travel guides to the Northern Isles and Scotland occasionally proved useful (e.g. Wallace 1700; Monteith 1845; Brand 1883[1701]; Low 1978 (1774)).

Descriptions of animals, their uses, and means of exploitation are provided in Low's *Fauna Orcadensis* (1813), and a number of other volumes of natural history (including Baikie and Heddle 1848; Pringle 1874; Buckley and Harvie-Brown 1891; Buckley and Evans 1899). Modern guides, including Barry's *Orkney Nature* (2000), *Fishes of the North-eastern Atlantic and the Mediterranean* (Whitehead *et al.* 1986a; 1986b; 1989) and *The Birds of the Western Palearctic* (Snow and Perrins 1997) were useful sources for natural history, particularly for information regarding habitats of birds, small mammals and fish.

2.5 Summary

The methods used throughout this thesis include primary zooarchaeological analysis, using a database for recording created by the author and based upon several well known recording methodologies, and analytical methods involving inferential statistics and graphical display methods. A summary of spatial analysis within archaeology and zooarchaeology was provided, together with a discussion of the multivariate statistics that can be used to assess spatial and chronological zooarchaeological patterning. Correspondence analysis was chosen as an ideal multivariate method of exploring faunal data. Inferential statistics were also used to determine the statistical significance of many aspects of patterning observed in the zooarchaeological data. Finally, written sources were used to augment the zooarchaeological record, particularly volumes of early natural history and ethnohistory. These have been applied in Chapter Nine to the spatial and temporal patterns identified using multivariate and statistical techniques in Chapter Eight.

Chapter Three: Introduction to Earl's Bu and Quoygrew

This short chapter will introduce the archaeological work undertaken at the two primary sites discussed in this thesis, namely Earl's Bu, Mainland Orkney and Quoygrew, Westray (see map in Chapter One, Figure 1.1). Excavation strategies will be discussed and compared, thus providing the methodological background to the following chapters which discuss the results of the zooarchaeological analysis. Particular emphasis will be placed upon the sampling strategies applied, as these have had a direct bearing on the ease (or otherwise) with which the zooarchaeology can be analysed.

3.1 Earl's Bu

Earl's Bu is located at HY 3346 0442 in the area of Orphir on mainland Orkney, near the large sheltered bay of Scapa Flow. The diverse site includes a Bronze Age burnt mound, the remains of a 12th century church, buildings of Norse date excavated by antiquarians and now under the Guardianship of Historic Scotland, a Norse horizontal mill built into and covered by extensive midden deposits, a graveyard and a modern working farm. The name 'bu' typically refers to a large farm with an associated church or chapel, on property belonging to the earls of Orkney (Graham-Campbell and Batey 1998, 192).

The site of Earl's Bu was mentioned several times in *Orkneyinga Saga*, a special occurrence among Northern Isles Viking and medieval archaeology as not only are textual references unusual, but ones that describe a site in any detail are extremely rare. *Orkneyinga Saga* was written in Iceland about 1200, and although its reliability for earlier centuries is now questioned, it is generally considered to be dependable for the medieval period (Graham-Campbell and Batey 1998, 46). The name used in the saga is Orphir, or Örfjara (as used by Johnston 1902), a term now used to refer to the general vicinity of the excavations, but which was originally used to denote the high status estate itself. The first quote of significance is in Chapter 55 of *Orkneyinga Saga*, where we are told that "during the reign of the brothers Harald and Paul, a Christmas feast was arranged on Earl Harald's estate at Orphir" (Pálsson and Edwards 1978, 99-100). Then in Chapter 66, under the year 1135, Orphir is described:

> "Earl Paul made preparations for a great Christmas feast at his estate called Orphir, and to it he invited a large number of important guests...The farmstead was a large one, standing on a hillside sloping down behind the farm

> buildings...There was a great drinking-hall at Orphir, with a door in the south wall near the eastern gable, and in front of the hall, just a few paces down from it, stood a fine church. On the left as you came into the hall was a large stone slab, with a lot of big ale vats behind it, and opposite the door was the living-room" (Pálsson and Edwards 1978, 124-25).

The church referred to in *Orkneyinga Saga* is the only known circular plan church in Scotland, the design of which was probably based on the church of the holy sepulchre in Jerusalem, visited by Earl Hakon during the crusades. The church was built around 1172 (Batey 1980, 17) and survived until the 18th century, although some remains are still standing, as illustrated in Figure 3.1 and Figure 3.2. Its unique design within the Northern Isles distinguishes the site of Earl's Bu as being of some importance and status, as do the textual references.

Figure 3.1: The round church, with Scapa Flow in the background (photo by the author)

Figure 3.2: The round church, looking towards the northeast (photo by the author)

3.1.1 Previous work

The first archaeological investigation of the site occurred in the mid 18th century, but little was recorded of that intervention. The site was investigated in detail by George Petrie about 1859 (Petrie 1861, as cited in Batey 1980), and again later by an antiquarian, Alfred Johnston, who published his account (Johnston 1902). Both of these excavations focused on the round church and fragments of walling visible in its vicinity, and finds included a comb of 12th century date (Johnston 1902, Fig. 2), similar to ones found in Sigtuna, Sweden (Batey 1980, 17). Midden material was described but not discussed in any detail except to state that "quantities of bones, ashes, and oyster shells" were found (Johnston 1902, 24). In the 1930s and '40s some excavation of the site continued while being prepared for Guardianship by J. Storer Clouston and W. Grant, but with even less documentation than the earlier investigations (Johnson and Batey 2003, 2). The area defined for Guardianship focused on walling near the round church as illustrated in Figure 3.3.

The structures uncovered during the antiquarian and Guardianship excavations probably included a combination of dates and functions, though most were probably of medieval date from the 11th to the 15th centuries (Batey and Morris 1992, 33; Batey 1993c, 20; Batey 1993a, 303). One of the aims of these early excavations was the excavation of the earl's drinking hall mentioned in the saga, but it has not been definitively identified (Batey 1993b, 453).

Figure 3.3: The antiquarian excavations, looking south towards the round church and Scapa Flow (photo by the author)

3.1.2 Recent excavations

In the 1950s, the local landowner discovered additional remains outside the Guardianship plot, when he attempted to dig foundations for a barn (re-sited elsewhere). Features found included a stone drain or passage. These were reopened in 1978 in the presence of archaeologists working at Birsay, revealing up to 6 courses of stone walling, capped with flagstones (Batey 1993a, 303; Batey 1980, 17). In 1979 a team from Durham led by Colleen Batey started excavations by opening up the feature and investigating the surrounding area using geophysics. This early investigation indicated that substantial quantities of environmental remains were located at the site, including undisturbed thick midden deposits that contained articulated fish remains, along with some finds of appropriate date for a medieval settlement (Batey 1980, 19, 20). Small scale excavations followed over the next several years as funding allowed, uncovering what was then thought to be a souterrain (Batey 1993b, 453). Huge quantities of environmental material were found along the length of the stone lined passage, as well as in a chamber at one end. This included mammal, fish, bird and sea mammal bone and burnt grain, and was sampled extensively. From the first year of investigation, it was immediately recognised that this wealth of stratified environmental material was related to the Earl's Bu Guardianship structures and could prove invaluable (Batey 1993c, 20, 26; Batey 1993b, 453; Batey 1993a, 303).

In the 1989 season the function of the structure began to be questioned. The supposed "souterrain passage" was found to expand into a chamber, which was recognised as the remains of a horizontal mill (Batey 1993c, 20; Batey 1993a, 303; Batey 1993b, 454). More recognisable features of this were then found, including fragments of the upperhouse, head race, bearing or pivot stones, a possible sump, a quern stone fragment, and a water course leading to the mill identified through geophysics; Figure 3.4 illustrates the mill under excavation. The passage found in the 1950s and thought to be a souterrain was reassessed as the tail race, with the slabs covering it possibly serving to ensure the outfall was not blocked with snow and ice, because water pressure during winter was best for milling (Batey 1993c, 24). The chamber filled with midden was then identified as the underhouse. Quantities of industrial waste were found in the lower levels of the mill chamber, including slag, crucible fragments, fuel ash and a steatite bar mould (Batey 1989, 2). Similar mills have been found in Ireland, as well as Scandinavia (including one of mid 9th century AD date from Omgård, Denmark (Nielsen 1997 as cited in Batey 1993c, 25)), though all known early comparative structures were made of wood and not stone (Batey 1993a, 304; Batey 1993b, 454). Comparable mills were used into the early modern period in the Northern Isles and are known historically and ethnographically, an oft-cited example being the stone horizontal mill at Dounby, Orkney (Batey 1993c, 23). Earl's Bu remained the location of a mill – not necessarily horizontal – until the early modern period (Fenton 1978 as cited in Batey 1993c, 23). Various antiquarians were derisive about the efficiency of such mills (Batey 1993c, 24), which may suggest that lack of success was a contributing factor to the mill's short life span.

Figure 3.4: The mill under excavation (photo by J Barrett)

The midden material first excavated from the upper layers of the mill was found to date to the medieval 11th and 12th centuries (Batey and Morris 1992, 33; Batey 1993c, 20). Artefacts from this midden postdating the mill included whetstones, comb fragments, beads and a steatite line sinker, all of definite Norse style and probably of medieval date (Batey 1993c, 26). Excavations continuing underneath the mill features indicated its construction was probably in the Viking Age, and the mill itself probably operated for a fairly short time before falling into disuse and becoming a dumping ground for waste from the nearby settlement (Batey 1993c, 23). The additional deposits found below the mill and tail race contained definitively Norse artefacts, including beads, steatite fragments, copper alloy fragments and worked bone, possibly of earlier Viking Age date (Batey 1989, 2; Batey and Morris 1992, 38; Batey 1993c, 26). The active use of the midden-mill-midden complex probably only spanned two or three centuries (Batey 1989, 2).

Some remains from Area A, another intervention at Orphir, were included in the fish bone assemblage. This 15m by 1m trench was located to the south of the main focus of archaeological investigation and was placed with the aim of examining the potential relationship between the Earl's Bu Guardianship area and the excavations (Batey 1980, 19). As this area was not phased, the 16 identified fragments of bone will not be discussed further.

About 200m to the west of the Guardianship area is the field of Lavacroon, investigated in 1979 and 1980 by fieldwalking (Batey and Freeman 1986). Finds of possible Viking Age or medieval date included a glass bead similar to ones from Ribe dating to c. 800, a steatite fragment, and evidence of "considerable industrial activity", comprising putative furnace lining and crucible fragments, a steatite ingot mould fragment probably for silver working, iron slag, vitrified fuel ash, copper alloy working evidence and metallic slag (Batey and Freeman 1986, 298; Batey 1980, 20-21). The only find of definite date broadly contemporary with the mill is the ingot mould, making it difficult to tie Lavacroon to Earl's Bu with any certainty. Although a few bone fragments were recovered during fieldwalking (Batey and Freeman 1986, 298), they will not be discussed below because they were not accurately dated or found in quantity.

The excavation was completed in 1993, with that season's aim being to finish up each area and consolidate the standing remains for eventual presentation of the site, now owned by Orkney Islands Council (Batey *et al.* 1993, 1). The earlier Viking Age midden deposits under the mill were of great interest, but were never fully investigated because the remains of the mill were left standing.

3.1.3 Phasing and dating

The bone from Earl's Bu was derived from 19 phases as defined by the excavators (Table 3.1), with each phase restricted to a particular function in space or time. The early period included middens beneath the mill dating to 880-1060 (see Table 3.2 for radiocarbon dates), walling from an unknown building, and redeposited midden used later during the construction of the mill. The middle period comprised phases contemporary with the use of the mill, including construction, walling, and later adaptations, dated to 970-1220. The later period included collapse and levelling events, with midden infilling the structure in three phases. The second of these midden phases dated to 990-1190, and the third of these to 890-1160. These 19 phases have been grouped by the author into three broad periods by a numeric code representing early, middle and late periods, and a letter representing the feature type (Table 3.3).

Each context was provided with a cursory description of its contents by the excavators. These have been summarised on the basis of the predominant contents, including midden, ash, clay, sand and gravel, rubble, etc. (Table 3.4; only preliminary descriptions were available for area B/D/D-extension). Deposit types could have been selected based on these descriptions, but as many contexts were not described as 'midden' yet contained substantial quantities of bone, it was decided to separate deposit types at the phase level.

Phase H: natural clays below underhouse and to east of tail race

Phase I: features below burnt mound, including a crushed and almost complete ceramic vessel of late Bronze Age date

Phase J: burnt mound consisting of burnt stones and very little else, truncated by the mill

Phase K: dumps of natural clays over the burnt mound and found south of the mill, unknown function

Phase L: early walling and clay 'backing', found to the south of the underhouse aligned north-south and therefore at right angles to the excavated mill building, not fully excavated

Phase M: middens pre-dating the mill, to the south and east of the mill, found behind walls and underneath the tail race at its eastern end, and of a rich nature containing artefacts of Viking Age date

Phase N: the mill structure, including the tail race, the underhouse, and the first head race or lade complex that supplied the water

Phase O: walling and 'tank', found next to the mill at the location of the burnt mound, poorly defined; the tank was covered with clays making stratigraphic comparisons with the rest of the site difficult

Phase P: redeposited clay, midden and burnt mound material over and behind (outside) the mill walls, used to infill the underhouse and tail race area, probably to support it

Phase Q: later adaptations of the mill structure, after the mill had been in use; the head race or lade that fed the water into the mill was narrowed and reduced to one, while at the same time the tail race was covered over

Phase R: features contemporary with the use of the mill, including silts and sands that accumulated in the underhouse and lades, and the spindle socket for the horizontal water wheel in the bottom of the underhouse

Phase S: collapse of the mill structure including some slabs that covered the very start of the tail race

Phase T: lower middens infilling the underhouse (post mill infilling stage I)

Phase U: clay levelling of the area around the underhouse and upper tail race

Phase V: upper middens and dumps infilling the underhouse and leat (post mill infilling stage II), bringing this area to the same height as the area around the leat

Phase W: truncated walling, to the north of the mill, probably representing later buildings though possibly contemporary with the mill, but of unknown date

Phase X: disturbed middens covering the area (post mill infilling stage III), spread over the entire site that was now flat; only some were disturbed by later modern activity

Phase Y: modern events associated with the barn, pig sty and general agriculture, including field walls, drains and a driveway, the construction of which resulted in some midden redeposition

Phase Z: Turf and topsoil

Table 3.1: Original phase descriptions as summarised from the site archive

New phase group (excavators' original phases)	Uncalibrated (bp)	1 sigma calibration (AD)	2 sigma calibration (AD)
M1 (M)	1050±50	890-920 and 950-1030	880-1050 and 1080-1160
F2 (R)	970±60	1000-1160	970-1220
M3b (V)	960±40	1020-1070 and 1080-1160	990-1190
M3c (X)	1020±50	900-920 and 970-1040 and 1090-1120 and 1140-1160	890-1160

Source: Final phasing document, recalibrated following Bronk Ramsey (2001; 2003)

Table 3.2: Radiocarbon dates at Earl's Bu

Period	Midden	Redeposited Midden	Construction/ Collapse	Features in use (mainly accumulated silts)
Early, beneath mill	M1 (M)	R1 (P)	C1 (L*)	
Construction and use			C2 (N, O*, Q)	F2 (R)
Later	M3 (U, V/X, T/X), M3a (T), M3b (V), M3c (X)	R3 (Y)	C3 (S, W*)	
Not used	(H, I, J, K, Z)			

*No fish bone, but mammal or bird

Table 3.3: New phase group classifications (excavators' original phasing in brackets)

Excavators' original phasing	Description of phase	Quantity of each type of context, per phase											
		Ash	Charcoal	Clay	Flagstones	Gravel	Midden	Rubble	Sand	Shell dump	Silt	Soil	Stones
L	Early walling			2									
M	Early midden	3		9		3	5	1	5			1	
N	Mill construction				1		1	1					
O	Walling and 'tank'			2									
P	Early redeposited midden	1		28			11	2	4	1	1	2	1
Q	Mill alterations			11	1		1	4			2	2	
R	Contemporary mill features			3	2	6		2	1				
S	Collapse			5	2			5	2			1	1
T	Later midden I	1		11			13		1			2	
U	Clay levelling			1			3						
V	Later midden II		1	13			24	2				4	
V/X	Mixed						1						
T/X	Mixed						1						
X	Later midden III	3		11	1		35		3			11	1
Y	Later redeposited midden			9	2	3	3	3				18	1

Table 3.4: Frequency of context types in each phase

3.1.4 Environmental Processing

The sampling program at Earl's Bu aimed to be 'total' for contexts with ecofactual remains, with a minimum of about 14 or 15L of soil processed from each context. Each sample was processed through a modified Siraf flotation tank to 1mm, with a flot resolution of 500 microns (Mainland 1995, 1; Batey *et al.* 1993, 10; Batey and Morris 1992, 38). Sample processing was initially by Andrea Bullock and Ingrid Mainland (Batey and Morris 1989, 49), and later by James Barrett (Batey and Morris 1991, 49), with a number of people involved at the sorting stage when each residue was sorted into >4mm, 2-4mm and <2mm (with some variations, including additional sorting at the 3mm and 6mm level, later standardised to the three main categories as best possible).

The hand collected and sampled mammal and bird bones from Earl's Bu are being analysed by Ingrid Mainland of the University of Bradford (1993; 1994; 1995). She has kindly made her unpublished dataset available for comparative purposes; interim mammal and bird bone results are summarised in Chapter Eight. Some of the fish bone assemblage was identified and analysed by James Barrett during the course of his PhD (approximately 26,000 fragments) (Barrett 1995; 1997), though at that time context phasing was not fully completed, nor were radiocarbon dates available. Barrett subsequently identified an additional portion of the assemblage, comprising approximately 6,000 fragments. The remainder was then identified and analysed by the author (approximately 34,000 fragments).

Earl's Bu has been a research excavation and as such has had to rely on student excavators and short excavation seasons, and an extremely long post-excavation period – as well as a shortage of funding. Sampling strategies and recording were not always as comprehensive as could be desired, although they did improve over time. During the few years of excavation in the 1990s, at least one bucket from each context was sieved, and if the results indicated environmental potential, the entire context was sieved. In the mid and late 1980s some contexts were partly sieved, and others presumably not sieved at all. Hand collected bone was taken from *both* sieved and unsieved deposits, making it difficult to correlate with the sampling results. This potential bias became a considerable problem when trying to analyse and correlate data recorded during sampling, post excavation processing and then identification. Initial weights and volumes of samples do not necessarily match weights recorded after sorting of sample residues, and again these are not always logical when compared to the final identified quantities. Furthermore, if a deposit was partly sieved, but first had hand collected bone removed from both the sieved material and from the rest of the deposit, what biases would be present? Would larger fish and larger elements be over-represented? It was possible to create a sub-set of contexts and samples that were completely sieved, because there was no accompanying hand collected bone and the sampling records confirmed this: these provided an unbiased baseline. However, there are also seven samples that were marked as fully sieved, but which also had accompanying hand collected bone (samples 353, 355, 485, 518, 538, 545, 646). These could have been used as an indicator of the typical proportions of hand collected to sieved fish bone, but the number of fragments derived from hand collection ranges from under 1% to 60% compared to the number of sieved fragments. This means that *even when a context was entirely sieved, a variable quantity of fish bone was first removed by hand by the excavators.* For most contexts, we know some portion of the matrix was sieved, and some or all bone spotted by eye was removed. The problem lies in correlating these two results. The subset of samples without hand collected bone - where probably everything was sieved – will have to be used to check against the results from the entire dataset. The analysis of Earl's Bu fishbone in Chapter Four starts by establishing the pattern of these biases, together with taphonomic patterning.

3.2 Quoygrew

Quoygrew is a coastal settlement site on the northwest of Westray, one of the more northerly islands in the Orkney archipelago (Figure 3.5). Coastal erosion of midden material and structures led to the discovery of the site in 1977 by Rosemary Hope and Caroline Wickham-Jones (Hope and Wickham-Jones 1977). It was investigated by Sarah Colley, who dated it to the Viking Age or medieval period, sampled a small area, and included it in her PhD thesis (Colley 1983c). Excavations began in 1997 under the direction of James Barrett, then of the University of Toronto and now of the University of York, and continue to the present day (see www.york.ac.uk/depts/arch/quoygrew/). The site includes modern ruins, a substantial farm mound or midden about 2m high and 50m across, a coastal mound containing fish-rich middens, and a series of structures (Barrett *et al.* 2000c; Barrett and Moore 2001; Barrett 2005; Simpson *et al.* 2005).

3.2.1 Previous work

Sarah Colley was the first person to excavate and analyse Quoygrew, albeit at a small scale. During her PhD, undertaken between 1978 and 1983, Colley examined a number of sites from Orkney, placing particular emphasis on the fish bone remains (Colley 1983c). She also analysed ethno-historical evidence for fishing in the Northern Isles in more recent centuries, and focused extensively on methodological issues involved in fish bone analysis and interpretation. She investigated three eroding coastal midden sites on Westray – Quoygrew, Evertaft and Cleat – and she was also involved with analysis of the fish remains from Tuquoy, Westray (Colley 1983c, 187).

In the late 1970s, the midden at Quoygrew was visible as a 20m stripe of dark material in the eroding coastal section, up to 1.5m thick, and containing structural remains (Colley 1983c, 209). Colley excavated a small area towards the southern end of this strip, 2m wide, 1m deep, and 1.1m down from the upper surface of the midden, therefore leaving some of the earliest deposits intact (Colley 1983c, 209). Norse period bone pins and toggles provided a date for the lowest levels of the excavation (Colley 1983c, 209, Fig. 7.2). Colley's results from layers 3 to 16 are approximately contemporary with Barrett's phase 2, and Colley's layers 1 and 2 with Barrett's phase 7.

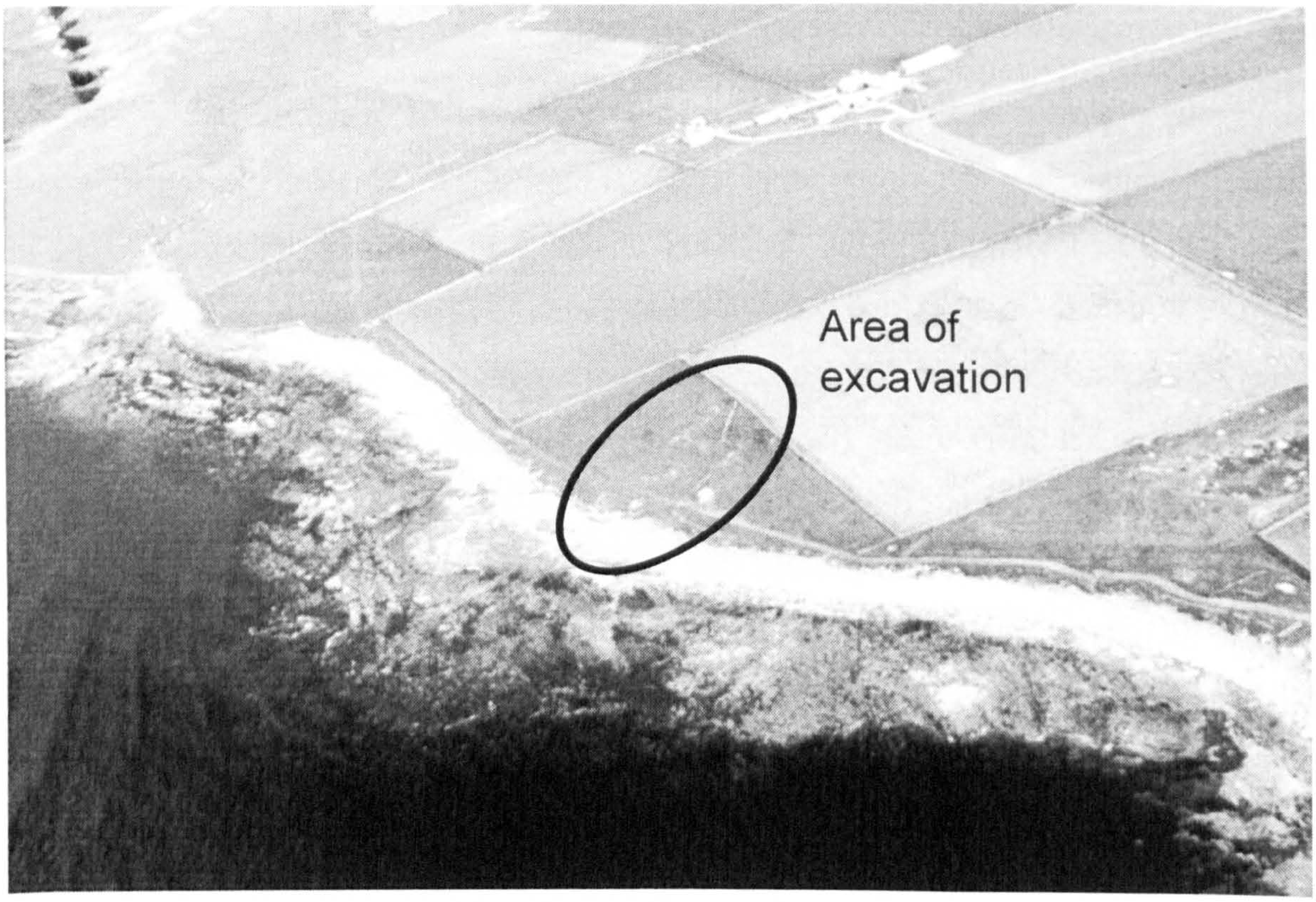


Figure 3.5: Quoygrew and area from the air (photo by J. Barrett)

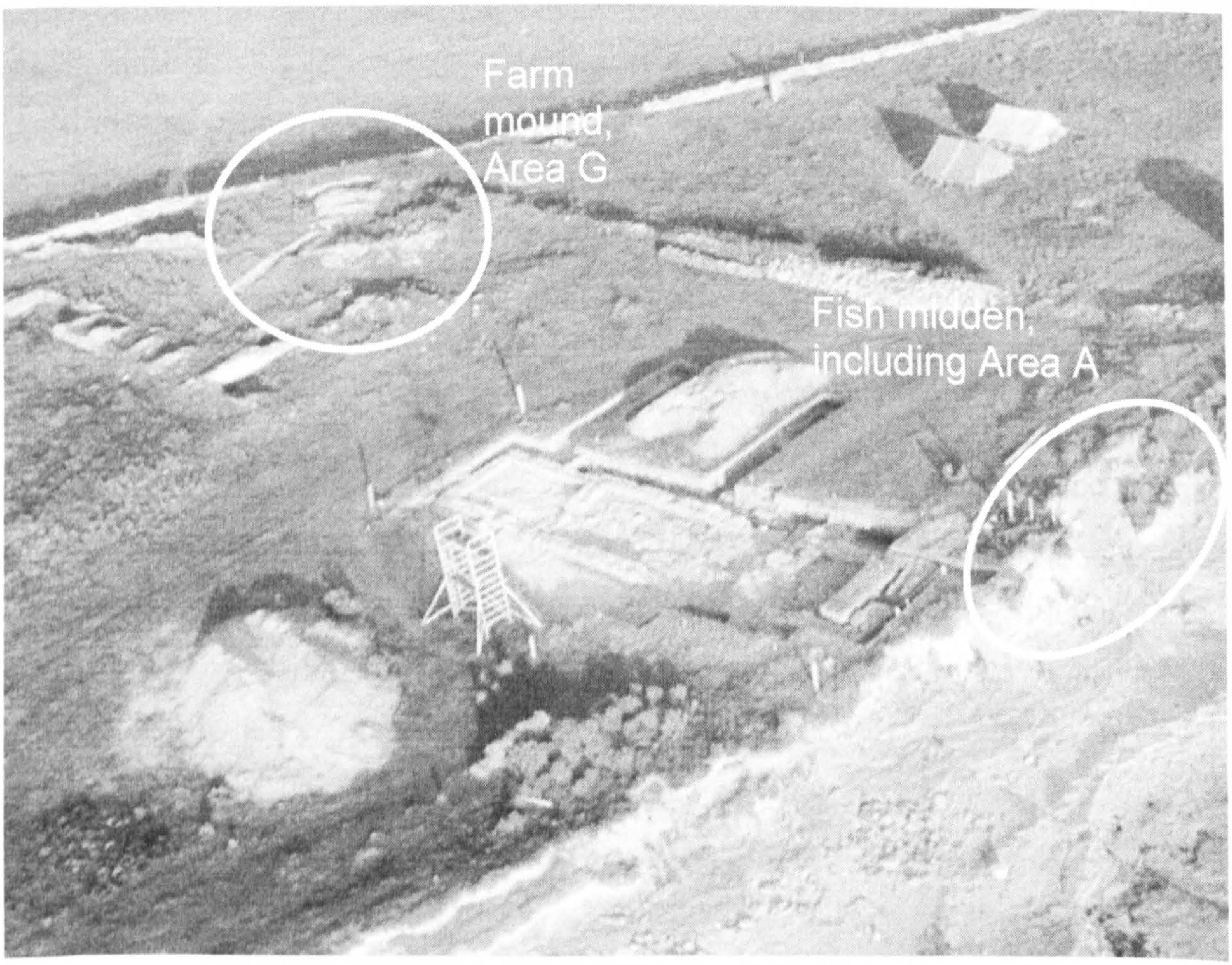


Figure 3.6: Quoygrew from the air, showing locations of the farm mound and fish midden (photo by J. Barrett)

3.2.2 Current excavations

The zooarchaeological analysis has focused on two areas from the ongoing excavations, the coastal fish midden (Area A), and the inland farm mound (Area G) (Figure 3.6). Environmental supervision has been under the direction of the author from the 2000 season onwards, with much of the on-site sample processing, bone washing, drying and recording actually done by the author. Most of the post-excavation sorting of samples and bone has been done under the direction of the author, or at least with her input.

Area A is part of the eroding fish-midden, which is exposed at the cliff edge and extends over 40m along the shoreline (Figure 3.7). Four sample columns have been excavated along the fish midden face (Areas A, B, C and E), and each contains approximately similar stratigraphy. However, Area A was selected for detailed zooarchaeological investigation because it has been investigated in greater detail than the others: its micromorphology has been assessed, it has been analysed for geoarchaeological data (Simpson *et al.* 2005), and it has been the subject of a detailed stratigraphic analysis (Andrews 2005). This area was also thicker and appeared to be less disturbed than any of the other eroding midden (Simpson *et al.* 2005, 360). The fact that it was small and was entirely sampled made it an ideal comparison for Area G, as was its dating (see Table 3.6).

Area A consisted of a column 1.5m deep and 50 by 50cm, which was excavated in 1997 and entirely sampled for flotation. Phase 1.2, the interface between natural and midden, is approximately contemporary with the deposition of Area G phase ii and dates to the 7th to mid 10th centuries (see Table 3.6), while the radiocarbon dates from the base of phase 2 are approximately contemporary with Area G phase iii and date to the mid 11th to mid 13th centuries. Dates from the top of the phase 2 deposits comprise early to late 13th century. The finds from the fish midden are consistent with the radiocarbon dates and include antler and bone objects, all of which date from the 10th to the 12th centuries (Barrett 2005, 269).

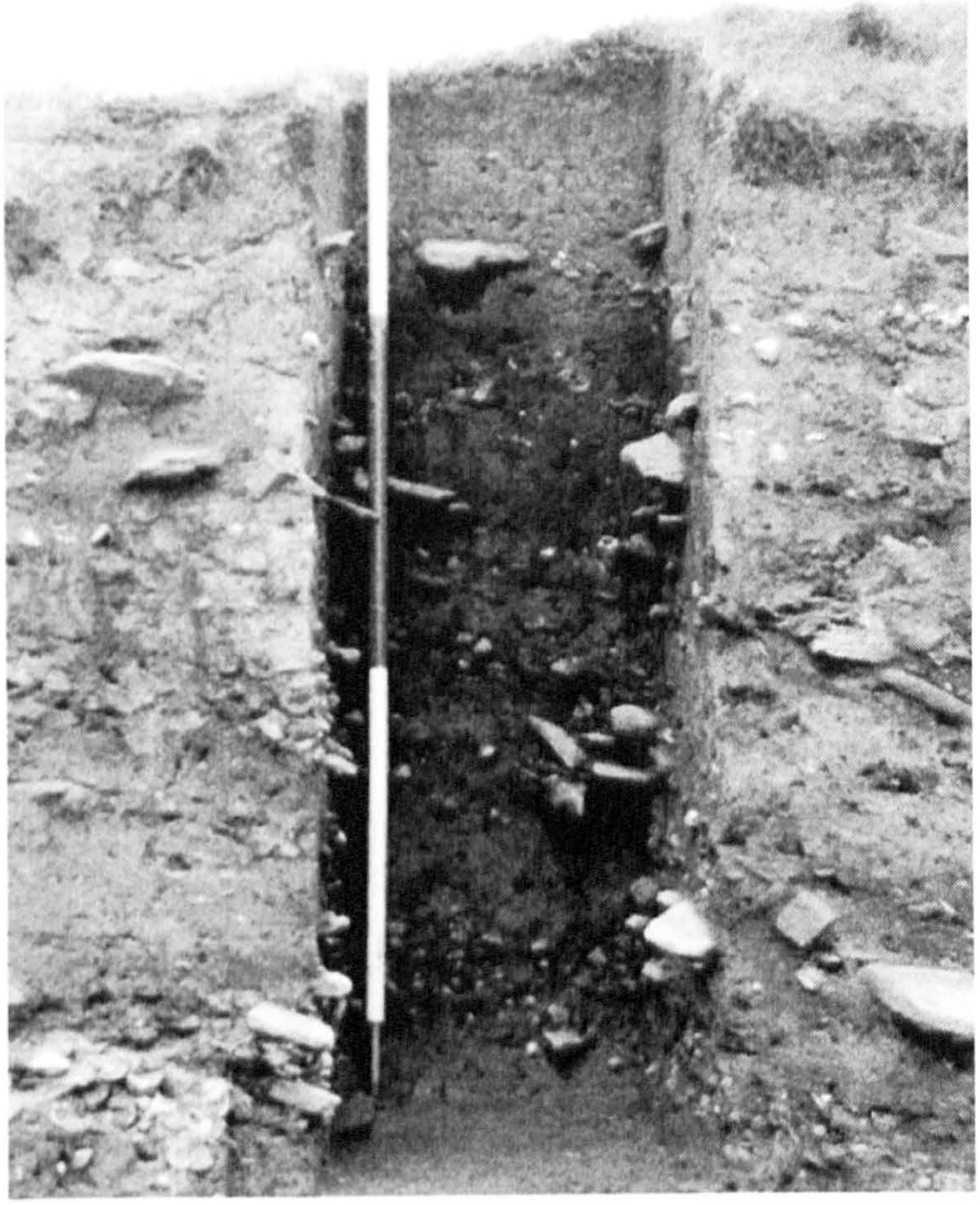


Figure 3.7: Area A (photo from the Quoygrew archive)

Area G, the farm mound, is located towards the eastern edge of the settlement, away from the shore, and was first excavated in the 1999 season when an area 4.6m by 5m was excavated. In 2000 this was expanded to 7.6m by 6m, and a further extension by 3m in 2001 took the final area to about 68m^2. Excavation in this main Area G trench was completed that year, although further interventions in 2004 and 2005 were opened up to the north to relate the stratigraphy of Area G to the rest of the site. Previously in 1999, a small trench (Area G2) was opened extending south from the main Area G with the aim of exploring the stratigraphic relationship between the farm mound and the plaggen field to the south (Barrett *et al.* 2000d, 15). The uppermost layer of Area G was garden soil, under which lay the undisturbed midden material (Table 3.5). During excavation two layers or blocks were noted containing visibly different inclusions: the upper midden block was about 0.5m thick and contained large quantities of shell and fish bone, termed the 'marine zone' in Figure 3.8, while the lower block was about 0.3m thick and contained higher quantities of mammal bone. Bone was very well preserved throughout, and rabbit disturbance was minimal. A flagstone path or drain was found within phase iii, the only structural element to the midden (Barrett 2005). Finds from the midden are consistent with a late Viking Age and early medieval date (bone or antler combs and pins, steatite sherds and spindle whorls). A pottery sherd from phase iii was likely of 12th century date (Barrett and Moore 2001), while a radiocarbon date from the same phase indicates an 11th to mid 13th century date (Table 3.6). Phase ii was dated to the 9th to10th centuries, with the lower extreme of the calibrated radiocarbon date just in the 8th century. However, given the artefactual evidence, a date this early is probably unlikely, but it must be considered until more radiocarbon dates are calculated. The garden soil over the Area G middens was dated by luminescence to the mid 15th to mid 16th centuries, although pottery suggests a later 19th century origin (Barrett 2005).

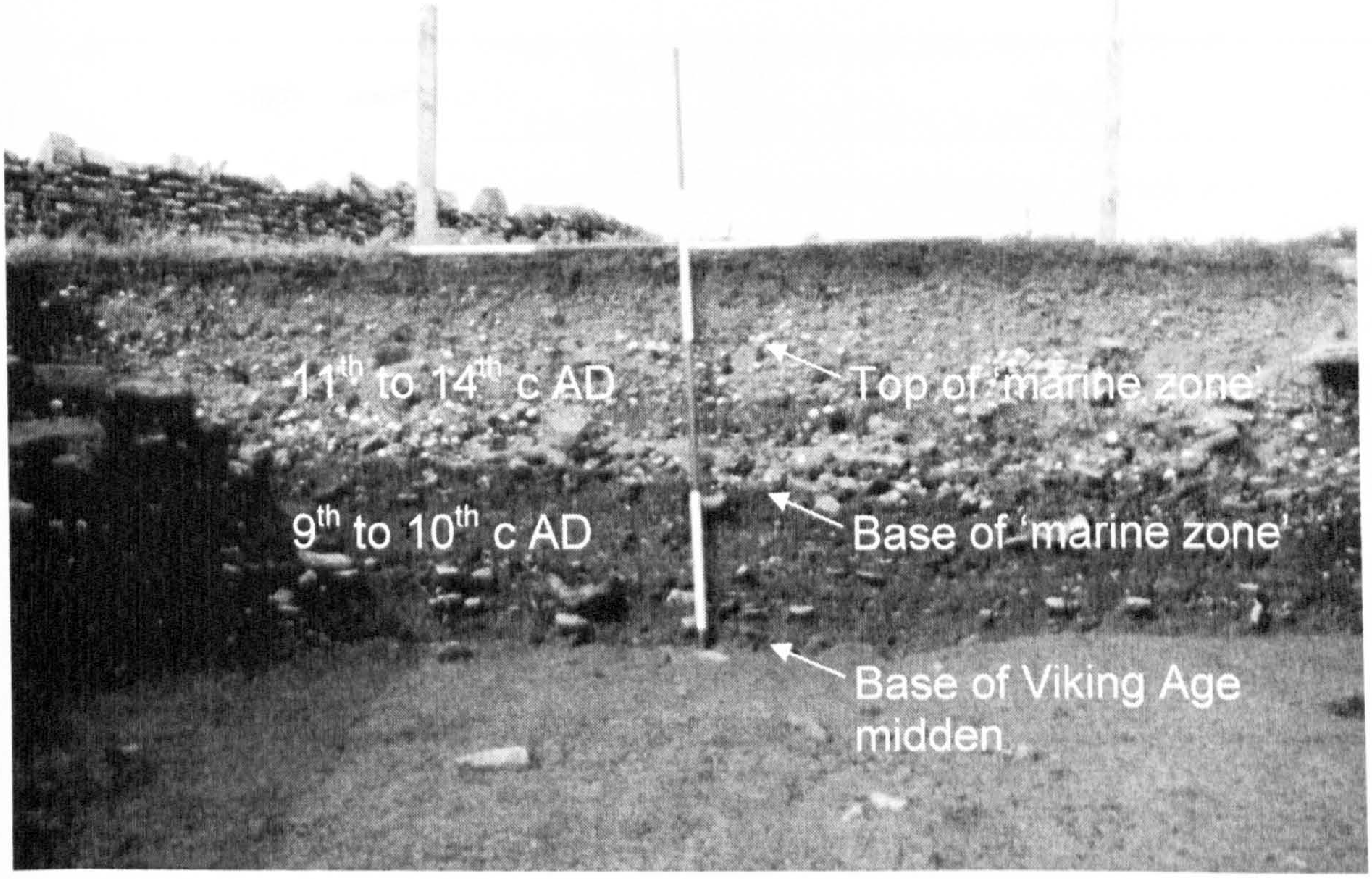


Figure 3.8: Area G, midden stratigraphy (photo by J. Barrett)

Area	Phase	Description	Contexts
A, fish midden	1.2	Transition of natural to midden	A026
	2	Midden	A002-A025
	7	Natural topsoil and turf	A001
G, farm mound	i	Disturbed soil horizon	G023, G024, G061
	ii	Lower midden	Block G063
	iii	Upper midden	Block G026
	iv	Plaggen soil over midden	G025
	v.ii	Cultivation furrows and clean sand fill	

The final phasing became available as this thesis neared completion. The phases above have been superseded by a site-wide numbering system. Appendix Seven contains a table of concordance between the interim results used above and throughout this thesis, and the final results that will be used for publication.

Table 3.5: Phasing

Area	Phase	Uncalibrated (bp)	Calibrated 2 sigma (AD)
A, fish midden	1.2	1220±50	676-896
	2 near base of midden (combined)	865±24	1066-1223
	2 near top of midden (combined)	747±30	1217-1294
G, farm mound	ii	1130±35	779-981
	iii	905±60	1035-1261

Table 3.6: Radiocarbon dating, following Barrett 2005

3.2.3 Quoygrew recovery methods

Recovery of environmental material was by hand collection and systematic sampling. No hand collected bone was removed from sampled sediments, thus ensuring the integrity of the sampled subset and making subsequent analysis straightforward, in contrast to Earl's Bu. Samples were taken for flotation and 4mm coarse sieving, mostly undertaken by the author or under her supervision. Both sample types followed a similar trajectory through post-excavation processing and sorting, again mostly under the supervision of the author. Flotation samples were processed through a 1mm screen for the heavy fraction, and a 500micron sieve for the flot. Samples were dried in the on-site laboratory and shipped to York, where the residue was sieved to 2mm and 4mm for flotation samples and 4mm for coarse samples. The >4mm fraction was sorted for all inclusions, while a subset of materials was sorted from the 2-4mm fraction. Samples were initially weighed and volumes were taken prior to processing on site (to nearest 0.1kg and 1L) and again following sieving into >4mm, 2-4mm and <2mm. After sorting the >4mm fraction, the weight of each inclusion was then recorded (to nearest 0.1g).

Larger stones were removed during flotation or coarse sieving and weighed (to nearest 0.1kg).

Hand collection of bone was carried out at all times in Area G, and because bone preservation and texture was of sufficient quality, bone was easily recognisable to the excavators in the sediment of all phases of this area. Hand collected bone was washed on site over a 4mm mesh and dried in the on-site laboratory, and then sent to York for sorting into mammal, fish and bird, weighing, taking volumes – again mostly under the supervision of the author – before final identification. No hand collection of bone was undertaken in Area A, because all sediments were sampled.

A total of 270 flotation samples and 243 coarse samples were taken from Area G between 1999 and 2001, weighing approximately 4900kg in total on site. Area A was completely excavated in 1997, producing 70 flotation samples weighing approximately 540kg on site. A total of 162.8 kg of hand collected bone was recovered from Area G (mammal phase i 0.3kg, phase ii 11.1kg, phase iii 24.8kg and other phases or unphased 2.6kg; fish phase i 0kg, phase ii 7.3kg, phase iii 111.2kg and other phases or unphased 4.7kg; bird phase i 0kg, phase ii 0.1kg, phase iii 0.6kg and other phases or unphased 0.1kg). Bird bone from both Areas A and G was identified by Rebecca Briscoe, mammal and fish by the author.

All hand collected and sampled mammal bone from Areas A and G was identified, but given the order of magnitude difference between classes of bone, fish identification was limited to the sampled material. Even full identification of only the Area A and G flotation samples proved impossible, because of the huge quantities involved, but by weight about half of all fish flotation samples were analysed. Within Area A, at least half of all flotation samples from each context were analysed (42 samples out of a working total of 69*). All flotation samples from Area G phases i and ii were analysed, as were all coarse samples, in order to provide a suitable dataset (48 samples for phase i, 179 for phase ii). The samples in Area G phase iii were substantially larger than the earlier samples, so a maximum of 3 from each context was analysed (40 out of a working total of 146 samples). The 2-4mm fraction was analysed from the subset of flotation

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* The total number of samples taken onsite was often slightly higher, but following several years of storage and sorting, a few samples were mislaid, mislabelled or mixed.

samples used for identification of the fish (total of 193 samples). Records were kept only of the identified bone from the 2-4mm fraction because it was impractical to count and weigh all unidentified fragments from this fraction. Both mammal and fish were identified, though the main emphasis of the 2-4mm fraction was the recovery of small fish species and elements.

Several hundred fish bone articulations were identified and separately bagged to ensure integrity, while fully recording any associated sample numbers. These commonly included vertebrae, as well as cranial elements and fin rays, typically from cod and saithe of a variety of sizes. Unfortunately few articulations were from the samples that were fully identified, but these will be discussed in the text. The hand collected articulations may be analysed at a later date to ascertain species and element patterns in greater detail.

All of the bird bone identifications were made by Rebecca Briscoe, mostly for the purposes of her undergraduate dissertation, "An analysis of the bird bone assemblage from the G1 midden at Quoygrew Orkney, with particular reference to economic changes c.1000AD", submitted in 2005. All queries were checked by Terry O'Connor. Her raw data was used by the author, checked for consistency, and reanalysed without reference to her written dissertation unless to clarify certain points or comments contained in the database. Because there was very little bird bone compared to mammal and fish, all hand collected and >4mm fractions from Areas A, B, C, D, E and G were analysed. No attempt was made to analyse the bird bone from the 2-4mm samples, though from qualitative observation, they would be unlikely to contribute meaningfully to the assemblage.

3.2.4 Midden densities and phasing

Using data recorded during sample processing, the densities of the Quoygrew middens can be calculated in grams of bone per litre of sample. The densities for fish, shell, mammal and bird are displayed in Figure 3.9, and they confirm the patterning observed visually (Figure 3.8). Phases i and ii have much lower densities of fish and shell than phase iii. Phase 2 is generally like phase iii for fish and shell, but it has higher densities of bird and lower densities of mammal. Phases ii and iii have higher densities of mammal than phase 2, the fish midden, thus confirming the separation of the two middens into the general, multi-purpose farm mound and the more specific fish midden. This spatial separation will be maintained throughout the analysis of the Quoygrew bone.

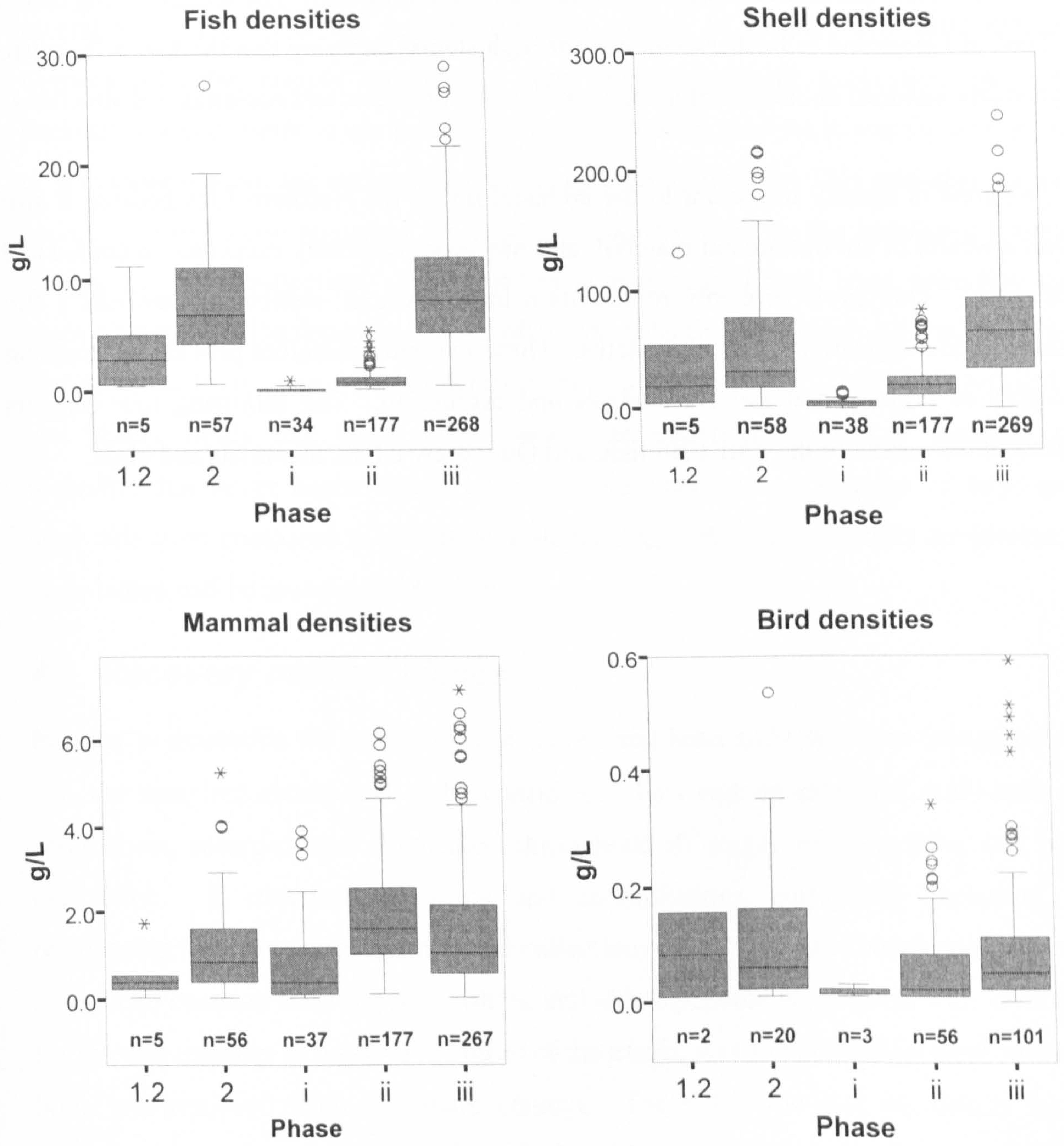

Figure 3.9: Quoygrew midden densities, variation by phase for shell, fish, mammal and bird

3.3 Summary

The importance of Earl's Bu is three-fold. Firstly, its stone horizontal mill is a very rare feature in the Viking world. Secondly, the wealth of environmental material associated with it is rare and valuable; the middens found under, in and around the mill probably represent both domestic and industrial rubbish from the settlement at Earl's Bu previously excavated. Thirdly, the settlement was probably a high status Norse Orcadian settlement suggested by the round church, the Guardianship structures, important textual references, and the possible presence of an Earl's drinking hall. The metalworking debris found at Lavacroon is further evidence for high status, implying that the Earl's Bu estate probably included an industrial area, as well as the domestic and ecclesiastical structures.

Quoygrew is equally important to the archaeology of the Northern Isles because it also has a wealth of environmental material, and has been rigorously excavated, recorded and analysed. Quoygrew probably represents a more 'normal' settlement than Earl's Bu; there is no suggestion it was high status. These two sites therefore provide an excellent supply of primary material for analysis and discussion. The following four chapters present the results of the Earl's Bu fish, and Quoygrew's fish, mammals and birds.

Chapter Four: Earl's Bu Results

The background to the excavations at Earl's Bu was discussed in the previous chapter. This included a discussion of the environmental processing, which took place over several years and under the supervision of a variety of people, with little funding. Consequently, the sample record that was produced during excavation and post-excavation was difficult to use because of inconsistencies, and yet it was the only source of information about the various classes of material identified. This was also the only source of clarification regarding the recovery biases caused by the imbalance between sieving and hand collection. This problem is summarised thus: hand collection took place over most of the deposits, but sampling was selective; and hand collected bone was first removed from *some* sampled deposits, but probably not all. This likely resulted in two biases, firstly that larger bones would be under-represented in samples, and secondly, that larger bones would be over-represented overall because of large-scale hand collection compared to moderate-scale sieving. Before the results are presented, these biases will be investigated further.

4.1 Recovery method biases

In order to determine the proportions of sieved and hand collected bone throughout the site, the sampling record had to be consulted. This was an extensive multi-authored spreadsheet, recorded and augmented throughout all stages of excavation and post-excavation. It contained problems and contradictions, particularly regarding the relationship between sampling and hand collection of bone. It was immediately apparent that not all contexts were sieved to 100%, and although some proportions were recorded, for the vast majority of contexts, a subset of the matrix was sampled while hand collected bone was retrieved from the entire context. Table 4.1 provides the details for all contexts, where the proportion of deposit sieved has been estimated. Bone counts from the >4mm sieved contexts were then 'corrected' (multiplied by the reciprocal of the portion sieved) to determine an equivalent value at 100%. For example, if 50% of the deposit was sieved, the >4mm sieved counts were doubled to correct to 100%. The results were graphically displayed to explore correlations between sieved and hand collected counts (TNB, Figure 4.1 and NISP, Figure 4.2). Theoretically, if a correlation was observed, the potential biases caused by unbalanced hand collection and sampling could have been factored into all results. Unfortunately, because no correlation was observed in Figure 4.1, Figure 4.2, or even in Figure 4.3 (the 'uncorrected' hand collected and sieved counts), further exploration of this bias was required.

Using the data from Table 4.1 again, 114 fragments were identified from the hand collected material out of a total NISP corrected to 3384. Thus, when sampling was 100%, 3.3% of the identified material was derived from hand collection. In other words 3.3% is a baseline value at which no bias is present. Any higher proportions of identified hand collected bone would suggest an over-representation of large, easily recognisable fish bone. Looking then at all contexts with both hand collected and sieved portions, 995 specimens were identified from the hand collected material, out of a total NISP of 10123. Thus, 9.8% of the identified assemblage was derived from hand collection. This would indicate that overall, the bias caused by unequal hand collection and sieving is only an inflation of about 6.5%; or, 6.5% of the identified assemblage was derived from hand collection without any equivalent sampling – about as precise as it is reasonable to get given the problems with the sampling records. Some phase groups had a higher quantity of hand collection than others (Figure 4.4). Of the QC1 fragments identified from phase group M3[*], 20% were derived from hand collection, while all other midden phase groups ranged from 4% to 7% with an overall average of 8% for the entire site (Table 4.2). Phase groups C3 and R3 both had much higher proportions of hand collected material than other phase groups (55% and 37%). This needed to be quantified further to determine if the bias has a particular pattern that could be identified; therefore both fish sizes and element percent completeness were examined.

Figure 4.5 displays all gadid QC1 element data by size for hand collected versus >4mm specimens, indicating that some elements are more biased by differential recovery than others (gadid fish were the most commonly occurring taxonomic group and are therefore ideally suited to this analysis, as discussed below in section 4.4). As expected, fewer 300-500mm total length and no <300mm total length fragments were recovered by hand. The cleithrum, dentary and posttemporal 500-800mm and 800-1000mm total length hand collected specimens followed the proportions of the sieved material; the articular, maxilla, quadrate and premaxilla were all subject to greater proportions of 500-800mm

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[*] Here and throughout, "M3" is used to refer to the midden material loosely dated to the later period, that could not be attributed to phase groups M3a, M3b or M3c. Occasionally all later period midden material will be combined, but this will be made explicit as "M3 all" or "M3 total".

and 800-1000mm total length bones in the hand collected assemblage; the proportions of parasphenoid 500-800mm, 800-1000mm and >1000mm total length specimens were all increased by the hand collected assemblage compared to sieved, and vomers were almost entirely recovered by sieving.

Figure 4.6 shows the varying proportions of gadid QC1 element percent completeness between the hand collected and sieved assemblages. As expected, the 1-20% category is under-represented by the hand collected assemblage for most elements, particularly the articular, cleithrum, parasphenoid, posttemporal, premaxilla and quadrate. Dentary and maxilla percent completeness values are similar between the two recovery methods. Vomers are rarely recovered by hand. Percent completeness values above 20% are quite similar for all elements, although particularly for the 81-99% and 'whole' categories the hand collected assemblage contributes a higher proportion than for the other categories.

As expected, the difference between recovery methods for all gadid QC1 total length estimates was statistically significant for all size categories (greatest difference 0.284, Kolmogorov-Smirnov Z value 4.512, significance 0.000)[*], between 300-500mm, 500-800mm, 800-1000mm and >1000mm total lengths (0.280; 4.462, 0.000), and even between 800-1000mm and >1000mm total lengths (0.138; 1.655; 0.008). There are no significant differences between recovery methods for ling (0.262; 0.867; 0.440) or haddock (0.084; 0.643; 0.803), but cod sizes remain significantly different between recovery methods (0.359; 4.340; 0.000) indicating that this species is most affected. As only three of the 58 saithe QC1 elements recorded were hand collected, no significance testing is possible for this species.

In conclusion, biases were caused by unequal sieving and hand collection, but these were not substantial. Only a very small quantity of the dataset was derived from hand collection without matching sampling, although this was more pronounced in phase group M3, and the small phase groups C3 and R3. Because hand collection obviously favours larger fragment sizes, that bias is found in those species with a range of fish sizes that includes smaller fish; statistical tests and fish total length estimates (see section 4.6 below) confirm that a size bias caused by recovery methods is only significant for cod.

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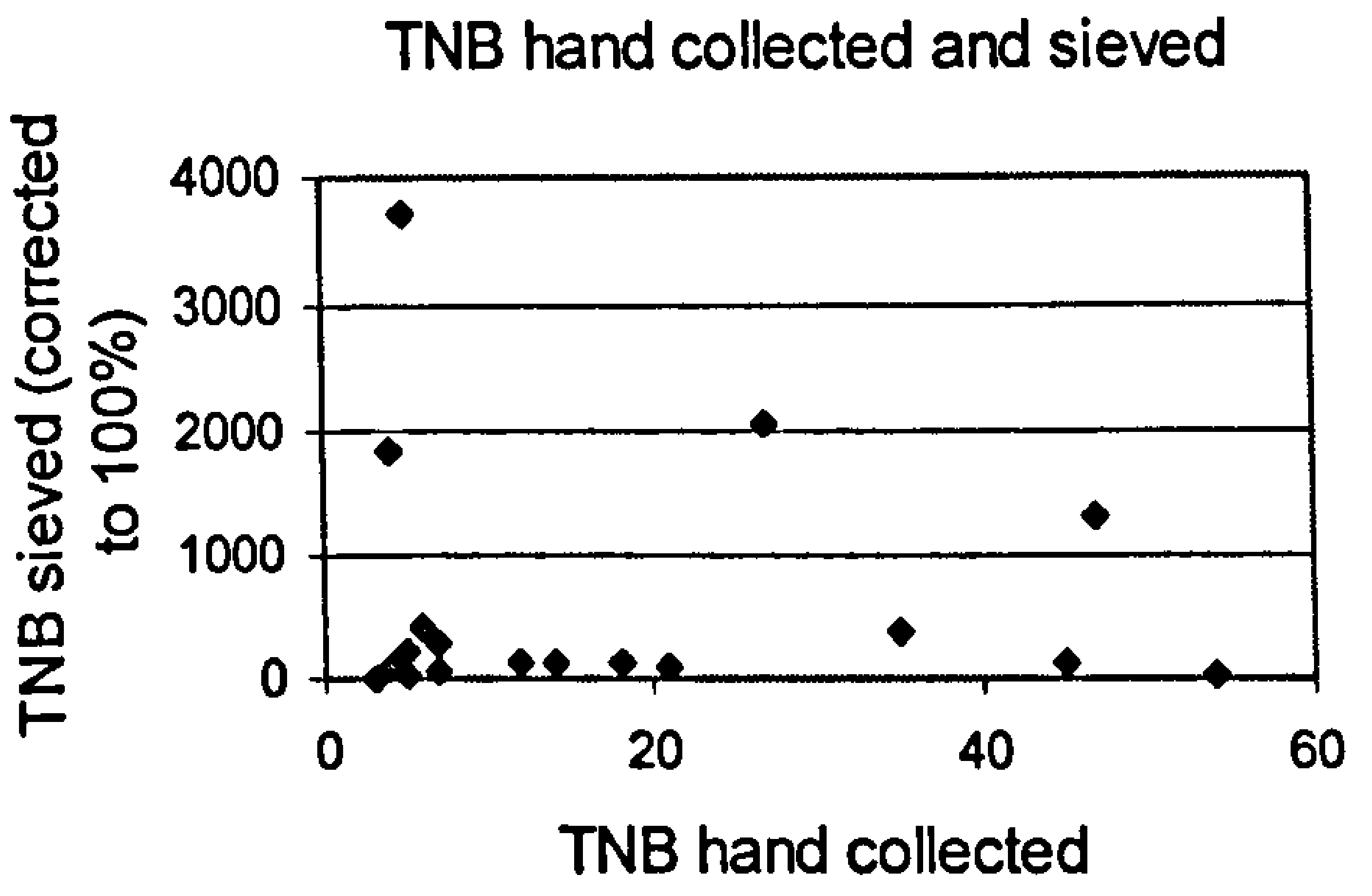
[*] For an explanation of this and other statistical techniques used in this chapter, refer to Appendix Two.

The cod elements most affected by recovery biases are the articular, maxilla, premaxilla and quadrate (displaying an increase of 800-1000mm and >1000mm total length categories). The size distribution of cod vomers is the least affected because virtually all specimens were recovered by sieving. The fragmentation percent completeness is also affected by hand collection, with under-representation of the 1-20% completeness category for the articular, cleithrum, parasphenoid, posttemporal, premaxilla and quadrate, while the vomer is least affected. Together, this indicates cod articulars, premaxillae and quadrates, particularly from phase group M3, are most affected by recovery biases. These observations must be kept in mind during the analyses throughout this chapter. The following section will investigate preservation and fragmentation in greater detail, followed by a section on further taphonomic alterations.

Context Number	Quantity of Samples	Proportion Sieved	Hand Collected		Sieved >4mm		Sieved >4mm "corrected" to equal 100%	
			TNB	NISP	TNB	NISP	TNB	NISP
300	1	12.50%	54	11	4	2	32	16
301	1	100%	6	2	408	24	408	24
306	1	100%			4	0	4	0
324	1	100%			25	8	25	8
326	1	25%	88	30				
332	3	100%	27	6	2073	632	2073	632
334	2	100%	5	3	3726	1162	3726	1162
337	1	25%			62	21	248	84
338	2	100%	47	2	1307	410	1307	410
359	1	100%	8	0				
388	1	100%	14	8	112	33	112	33
402	1	100%			289	71	289	71
406	1	25%	5	1	6	1	24	4
409	1	100%			17	5	17	5
410	1	50%	7	1	38	12	76	24
414	1	100%	5	2	208	48	208	48
436	1	100%			3	1	3	1
437	1	50%	18	4	65	14	130	28
438	1	5%	35	10	19	1	380	20
442	1	16.60%	12	6	23	11	138	66
443	1	12.50%	45	2	17	3	136	24
445	1	75%	4	3	64	25	85	33
447	1	100%			10	3	10	3
449	1	10%	8	2				
450	1	10%			35	4	350	40
501	2	12.50%	4	4	230	65	1840	520
503	1	25%	21	11	24	6	96	24
511	1	100%	3	3	5	0	5	0
563	2	100%	7	3	296	104	296	104
		Totals	423	114			12018	3384

Table 4.1: TNB and NISP from all contexts with both hand collected and sampled material, where the proportion sampled is known



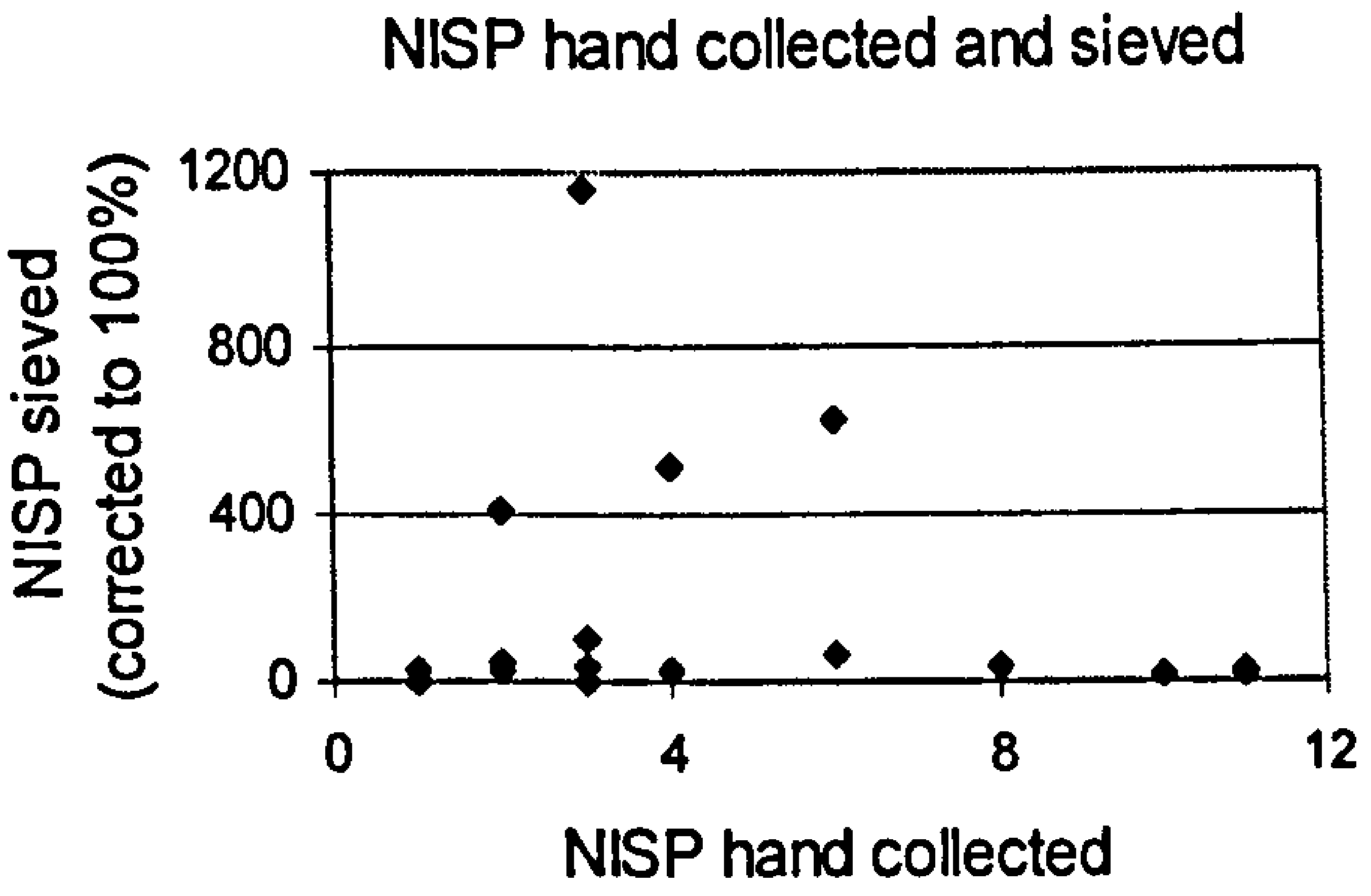


Figure 4.1 (left): Correlation of TNB for hand collected and sieved (>4mm) contexts with known proportions of sieving

Figure 4.2 (right): Correlations of NISP for hand collected and sieved (>4mm) contexts with known proportions of sieving

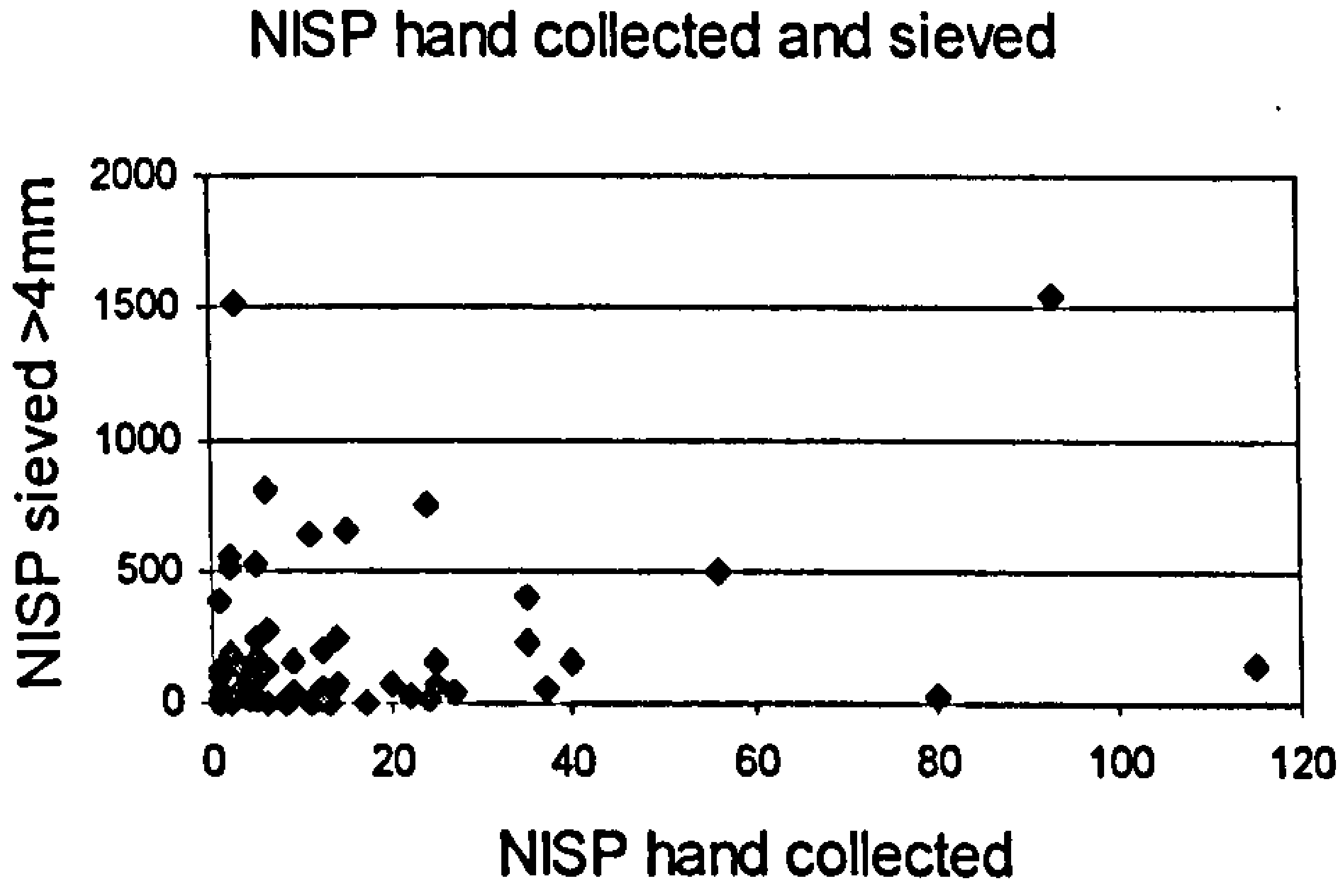


Figure 4.3: NISP for all hand collected and sieved (>4mm) contexts, regardless of proportion sieved

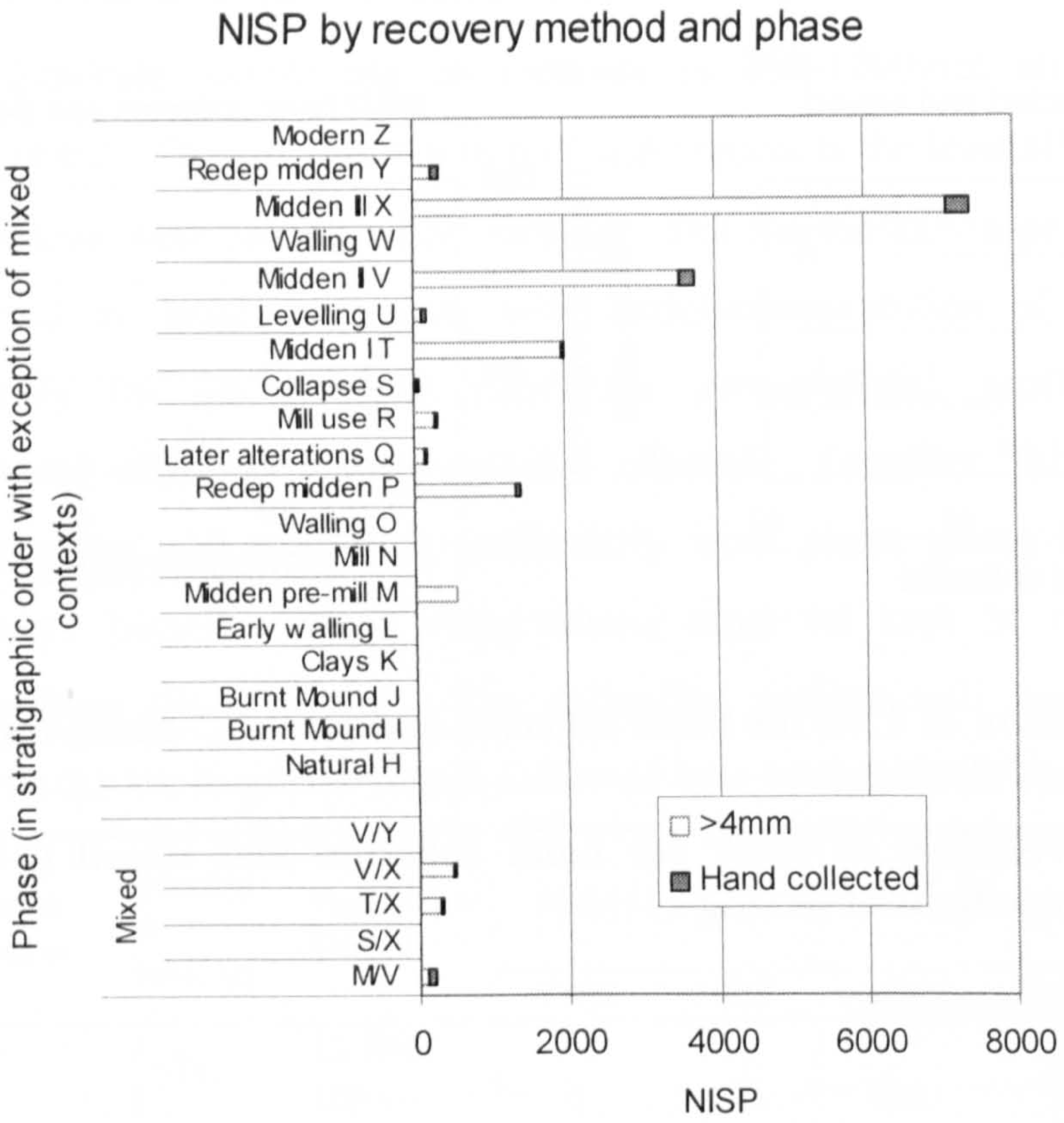


Figure 4.4: NISP by recovery method and phase

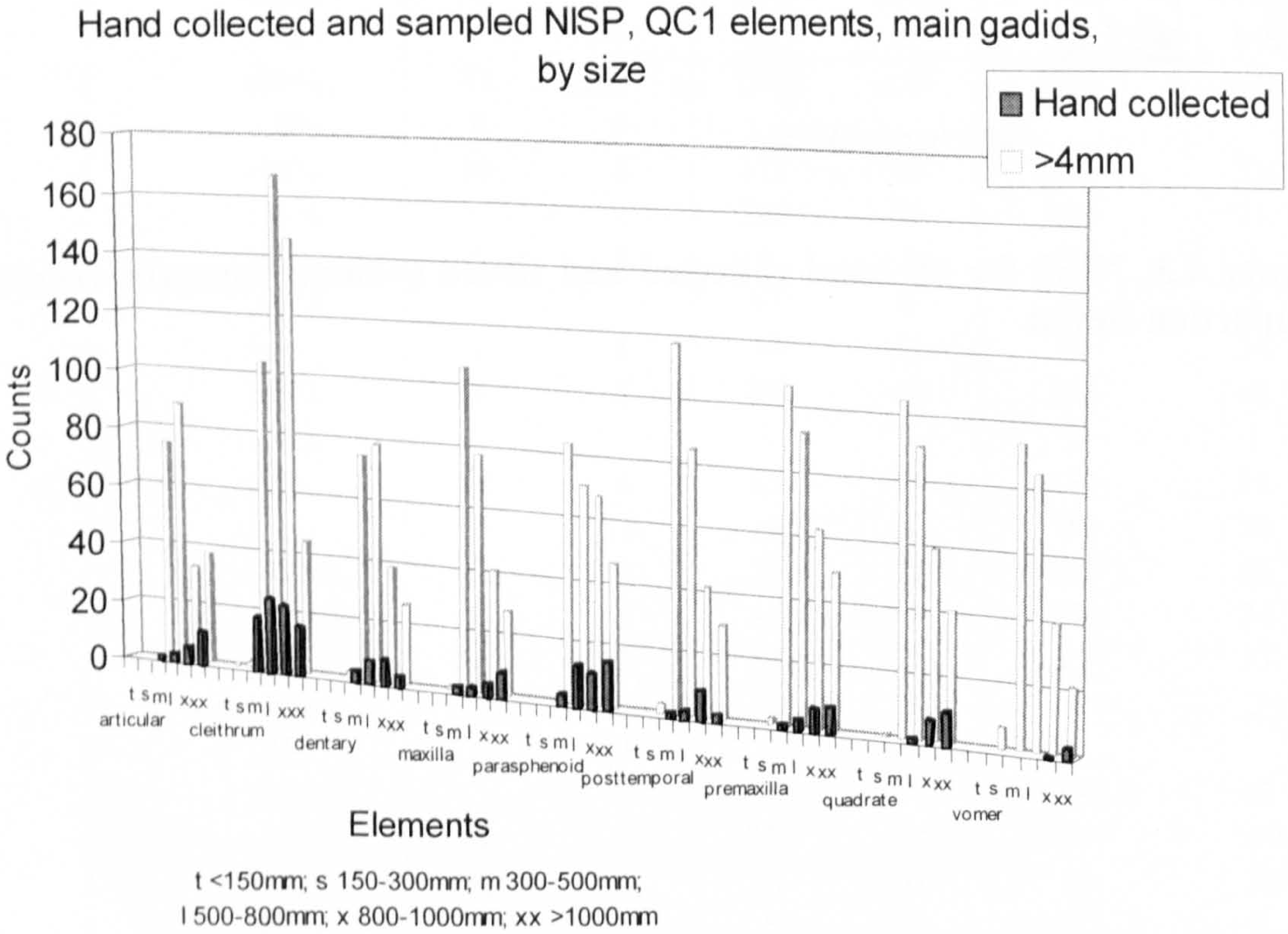


Figure 4.5: Hand collected and sampled NISP for gadid fish sizes (includes definite and probable cod, haddock, ling, saithe, *Gadus/Pollachius* and undifferentiated gadids), main QC1 elements only

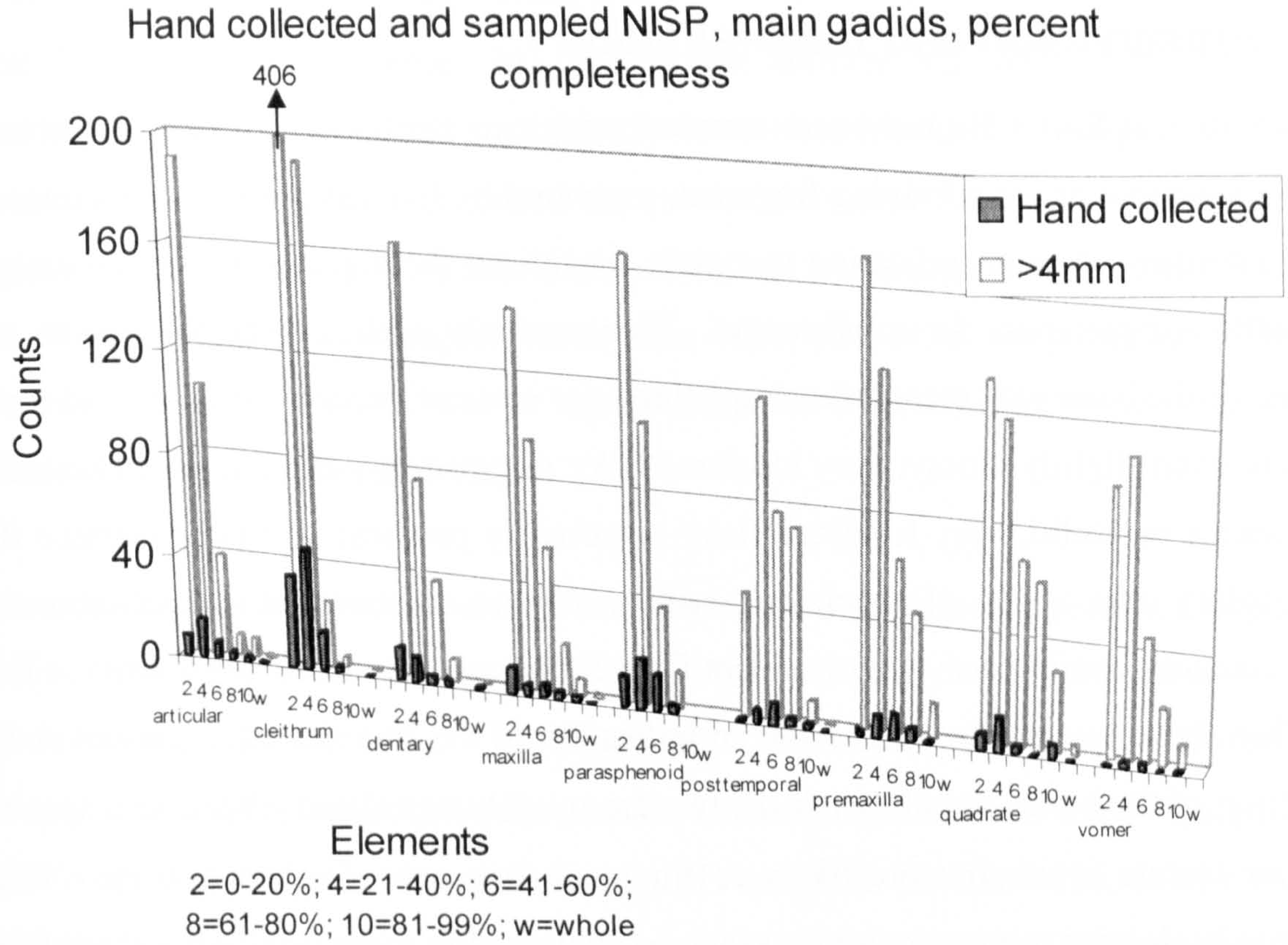


Figure 4.6: Hand collected and sampled NISP for gadid fish percent completeness (includes definite and probable cod, haddock, ling, saithe, *Gadus/Pollachius* and undifferentiated gadids), main QC1 elements only

Phase groups	>4mm QC1 NISP (% of total)	Hand Collected QC1 NISP (% of total)	Total QC1 NISP
C2	54 (95%)	3 (5%)	57
C3	9 (45%)	11 (55%)	20
F2	106 (95%)	6 (5%)	112
M1	128 (93%)	9 (7%)	137
M3	160 (80%)	39 (20%)	199
M3a	450 (96%)	17 (4%)	467
M3b	726 (93%)	52 (7%)	778
M3c	1381 (94%)	90 (6%)	1471
R1	273 (93%)	19 (7%)	292
R3	59 (63%)	34 (37%)	93
Total	3346 (92%)	280 (8%)	3626

Table 4.2: QC1 NISP by recovery method and phase group

4.2 Preservation and fragmentation

Preservation at Earl's Bu has been recorded using two attributes. Percent completeness is an assessment of the surviving fragment, measured by five categories in 20% intervals, with a further category indicating complete specimens (here grouped with the category 80-100% completeness for consistency). This was only applied to QC1 elements. The texture of the bone was recorded using a three tier scale of excellent (majority of surface fresh or even slightly glossy; very localized flaky or powdery patches), good (lacks fresh appearance but solid; very localized flaky or powdery patches), and poor (surface flaky or powdery over >50% of specimen), with a number of comparative specimens from each category available during the identification process to ensure consistency. Taken together, these two attributes provide an indication of the fragmentation present and the condition of the bone, and although the two are roughly correlated – because a specimen of poor texture is much more likely to fragment than one of robust texture – further patterns in element representation can then be examined in more detail after these factors are considered. Percent completeness and textures by phase group for cod and haddock QC1 elements are presented graphically in Figure 4.7, Figure 4.8, Figure 4.9 and Figure 4.10, indicating the variation found throughout space and time. No otoliths were found at Earl's Bu, indicating soil conditions were less conducive to survival than at other comparative sites.

Significant differences were found within the combined hand collected and >4mm dataset when considering bone texture. Figure 4.11 illustrates the relationships between texture and phase using a triangular graph, using data from Table 4.3 and Table 4.4. Most variation is between proportions of 'good' and 'poor', while 'excellent' remained at a low level throughout all phases. Kruskal-Wallis tests on these data indicate a significant difference between phase groups for cod textures (Chi-Sq 183.396, nine degrees of freedom, significance 0.000) and haddock textures (86.110, nine, 0.000). Having determined the existence of significant differences, these were then investigated further using Kolmogorov-Smirnov tests to narrow down which phase groups differed significantly. Using all elements derived from hand collection and >4mm sieving, cod texture tests of significance produced the results shown in Table 4.5 (each phase group tested against every other phase group, with significant results marked in bold). F2 was significantly poorer than eight other phase groups, C3 was significantly poorer than seven others, and R1 was significantly better than seven others. The midden contexts were found at neither extreme. M1, the earliest midden, was only significantly better than M3c, the latest. M3a was significantly better than all other M3 deposits. Haddock texture tests of significance produced the results shown in Table 4.6. Phase group F2 again was significantly poorer than eight others. R1 was significantly better than M3b and M3c, while M3a was again better than M3b and M3c, very similar to the cod textures. To summarise, F2 was in significantly worse condition than all others, while M3a and R1 were better preserved.

Some significant differences were also observed when considering percent completeness counts. Using the entire dataset for all QC1 elements with percent completeness scores (as for Table 4.3 and Table 4.4), significant differences were found between phase groups F2 and R3 (greatest difference 0.220, Kolmogorov-Smirnov Z 1.570, significance 0.014); M1 and M3b (0.149, 1.611, 0.011); M1 and M3c (0.162, 1.816, 0.003); M3a and M3b (0.086, 1.474, 0.026); M3a and M3c (0.099, 1.867, 0.002); M3b and R1 (0.106, 1.545, 0.017); M3b and R3 (0.212, 1.936, 0.001); M3c and R1 (0.119, 1.856, 0.002); M3c and R3 (0.225, 2.107, 0.000). These results can be used to identify a spectrum of percent completeness, from significantly highly fragmented (M3b, M3c) to significantly more intact (M3a, M1, R3), thus providing a statistical confirmation of the trends observed when examining Table 4.3 and Table 4.4. This issue was further investigated using correspondence analysis for the larger phases (for an explanation of this technique, see Chapter Two, Methods) as shown in Figure 4.12 (data provided in Table 4.8). The horizontal axis illustrates differences between phase groups where 1-20% and 21-40% are the most prominent completeness levels, while the vertical axis separates out those with higher quantities of 81-100% completeness. The results corroborate the significance testing. Phase group M1 is furthest from the average (the centre of the axes), indicating its better preservation than other phases, while M3a is in turn better preserved than M3c and M3b, both of which tend to correspond more with the 1-20% completeness category.

The percentage of bone that could be identified in each phase group was surprisingly variable (Table 4.7), but this may be a factor of the amount of time the bones were kept in storage, transported and handled. Some bags identified by JFH had counts of the total unidentified fragments written on them from earlier processing, and in many cases these values severely underestimated the numbers of unidentified fragments that JFH could record. Generally, JFH identified a few percentage points less than JHB at every phase group where both analysts identified a part of the dataset. This discrepancy is probably attributable to random variation, post-excavation wear and fragmentation, and a degree of inter-analyst variation.

In conclusion, proximity to the surface, rather than length of burial, was found to negatively affect the preservation and texture of fish bones, while bone from features contemporary with the mill's use were in poorer condition than that from middens. The redeposition of midden material did not have a detrimental affect on preservation. Hand collection under-estimated the proportion of the smaller percent completeness scores (see section 4.1), so the phases with higher than average hand collection may be expected to show better preservation, but of these, only R3 fits the pattern, indicating this is unlikely to be a significant bias. Results suggested texture and preservation was significantly worse for F2, M3b and M3c, while R3, M1 and M3a were significantly better preserved. These results will be used during all discussions of species and element variation to ensure any conclusions drawn are not simply a reflection of these biases, rather than underlying economic patterning.

Phase groups	Percent Completeness (applied to QC1 elements) 1-20%	21-40%	41-60%	61-80%	81-100%	Total
Unphased	21 (30%)	**26 (38%)**	15 (22%)	5 (7%)	2 (3%)	69
C2	**25 (43%)**	**25 (43%)**	5 (9%)	3 (5%)	0 (0%)	58
C3	5 (25%)	**7 (35%)**	3 (15%)	2 (10%)	3 (15%)	20
F2	**54 (48%)**	31 (28%)	19 (17%)	5 (4%)	3 (3%)	112
M1	44 (32%)	**61 (45%)**	17 (12%)	8 (6%)	7 (5%)	137
M3	**82 (41%)**	60 (30%)	28 (14%)	21 (11%)	7 (4%)	198
M3a	179 (38%)	**181 (39%)**	66 (14%)	31 (7%)	9 (2%)	466
M3b	**366 (47%)**	212 (27%)	117 (15%)	61 (8%)	28 (4%)	784
M3c	**717 (48%)**	425 (28%)	189 (13%)	121 (8%)	40 (3%)	1492
R1	106 (36%)	**107 (37%)**	51 (18%)	20 (7%)	7 (2%)	291
R3	24 (26%)	**50 (53%)**	10 (11%)	6 (6%)	4 (4%)	94

Table 4.3: Percent completeness counts and percentages by phase group, combined hand collected and >4mm (highest values in bold)

Phase groups	Texture (applied to QC1 elements)				Texture (applied to QC1, 2, 3 and 4)			
	Poor	Good	Excellent	Total	Poor	Good	Excellent	Total
Un-phased	**36 (51%)**	33 (47%)	1 (1%)	70	94 (39%)	**147 (61%)**	1 (0.4%)	242
C2	19 (33%)	**39 (67%)**	(0%)	58	47 (23%)	**154 (76%)**	2 (1%)	203
C3	**10 (50%)**	**10 (50%)**	(0%)	20	**29 (53%)**	26 (47%)	(0%)	55
F2	**83 (80%)**	21 (20%)	(0%)	104	**112 (62%)**	68 (37%)	2 (1%)	182
M1	38 (27%)	**98 (71%)**	3 (2%)	139	77 (11%)	**641 (89%)**	3 (0.4%)	721
M3	70 (35%)	**111 (56%)**	19 (10%)	200	98 (23%)	**301 (72%)**	19 (5%)	418
M3a	97 (20%)	**379 (79%)**	3 (1%)	479	186 (8%)	**2140 (92%)**	3 (0.1%)	2329
M3b	296 (38%)	**456 (59%)**	21 (3%)	773	487 (20%)	**1892 (78%)**	34 (1%)	2413
M3c	515 (36%)	**834 (59%)**	67 (5%)	1416	613 (26%)	**1662 (70%)**	105 (4%)	2380
R1	68 (23%)	**224 (76%)**	1 (0%)	293	148 (12%)	**1061 (88%)**	1 (0.1%)	1210
R3	35 (37%)	**59 (63%)**	(0%)	94	81 (25%)	**245 (75%)**	(0%)	326

Table 4.4: Texture counts and percentages by phase group, combined hand collected and >4mm (highest values in bold)

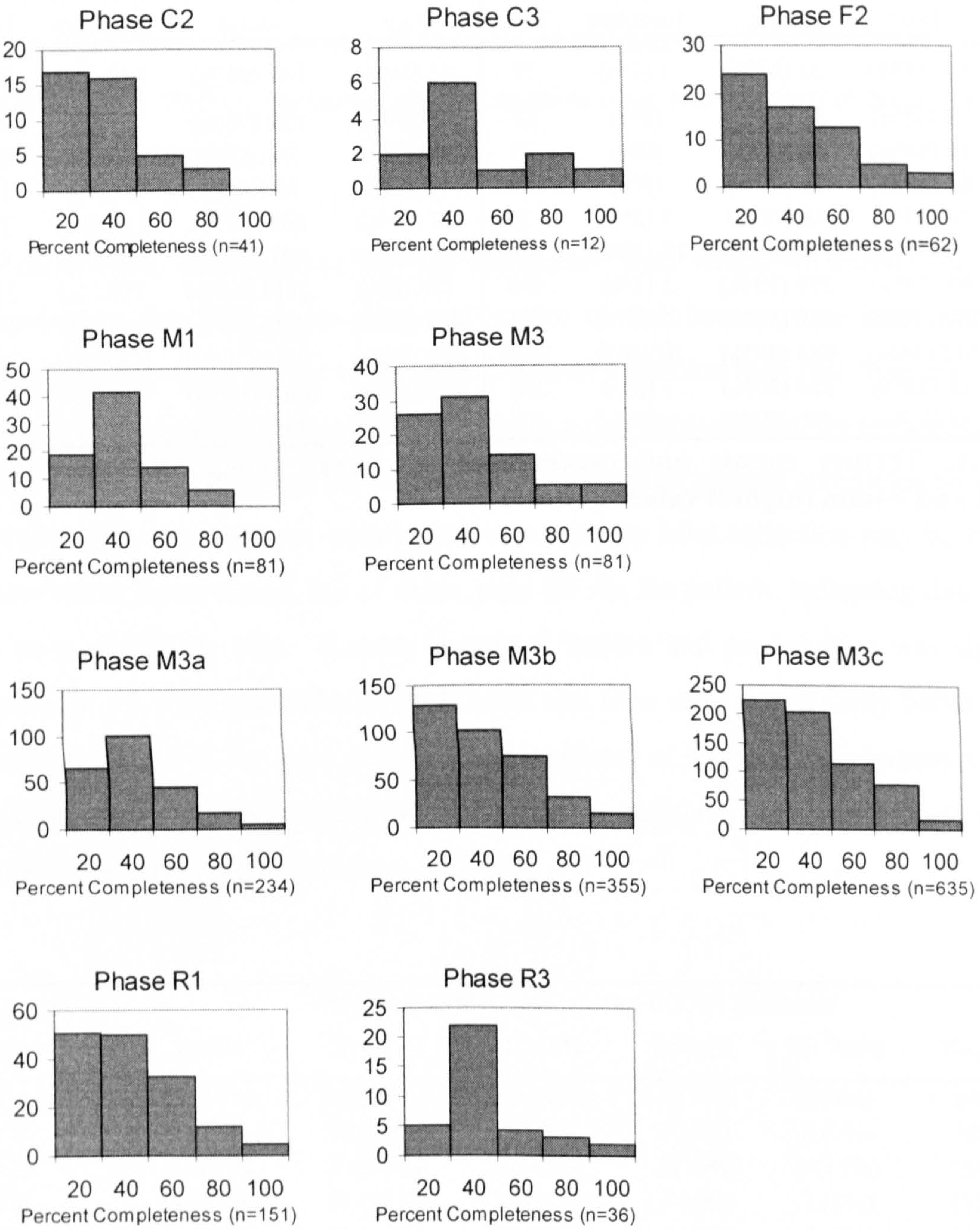


Figure 4.7: Cod percent completeness categories by phase group, hand collected and >4mm QC1 elements

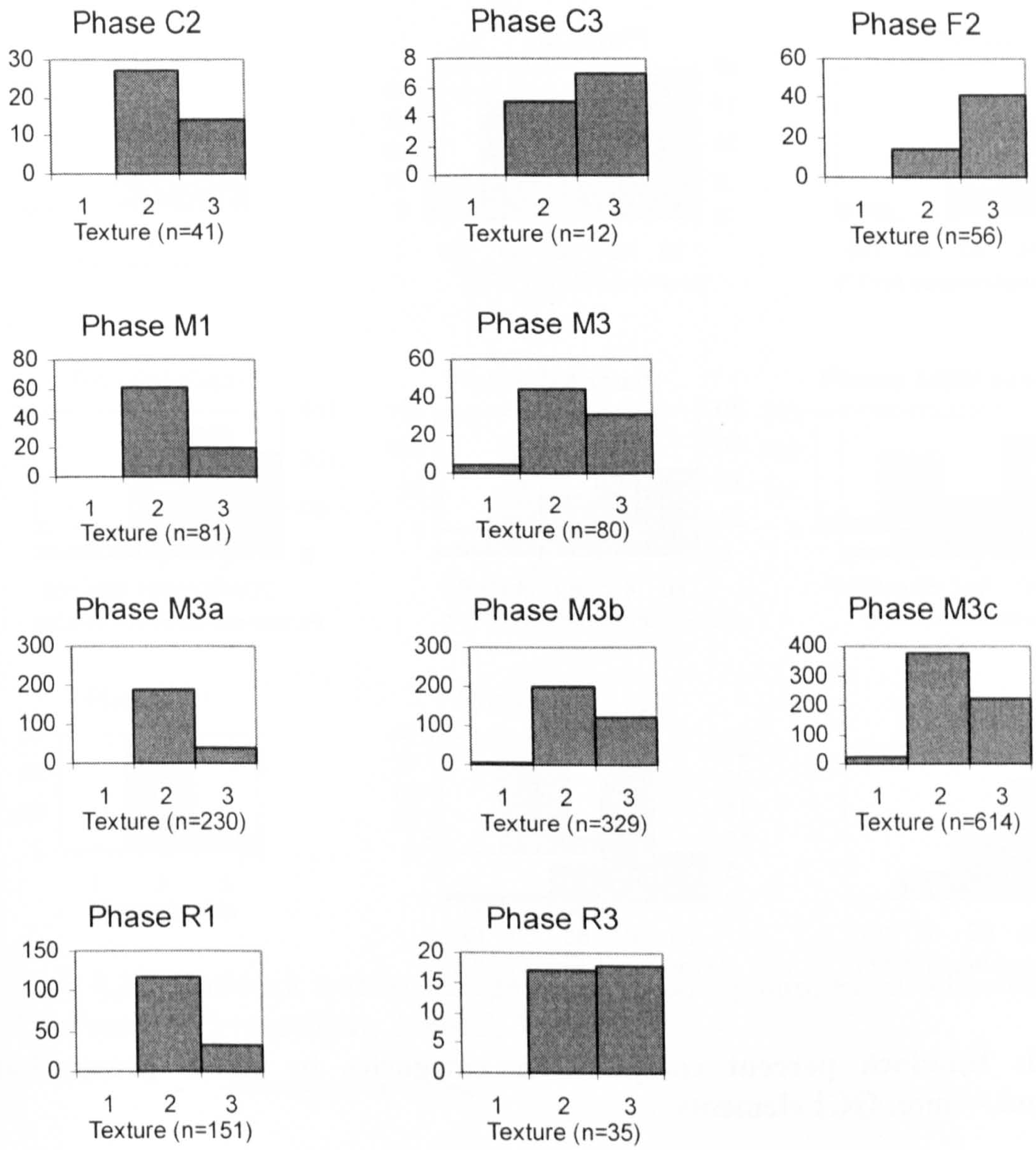


Figure 4.8: Cod texture categories by phase group, hand collected and >4mm QC1 elements (1=excellent, 2=good, 3=poor)

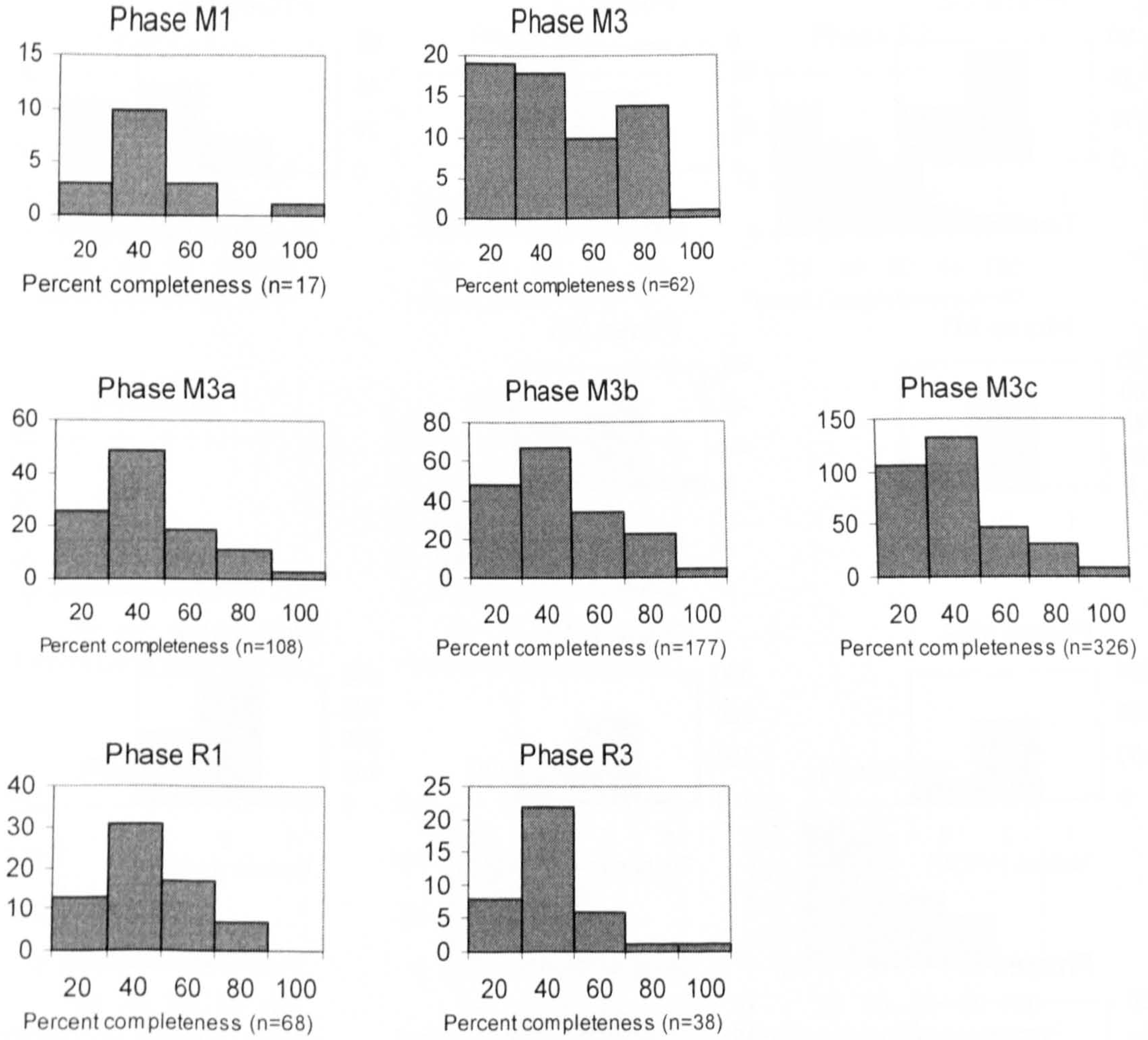


Figure 4.9: Haddock percent completeness categories by phase group, hand collected and >4mm, QC1 elements

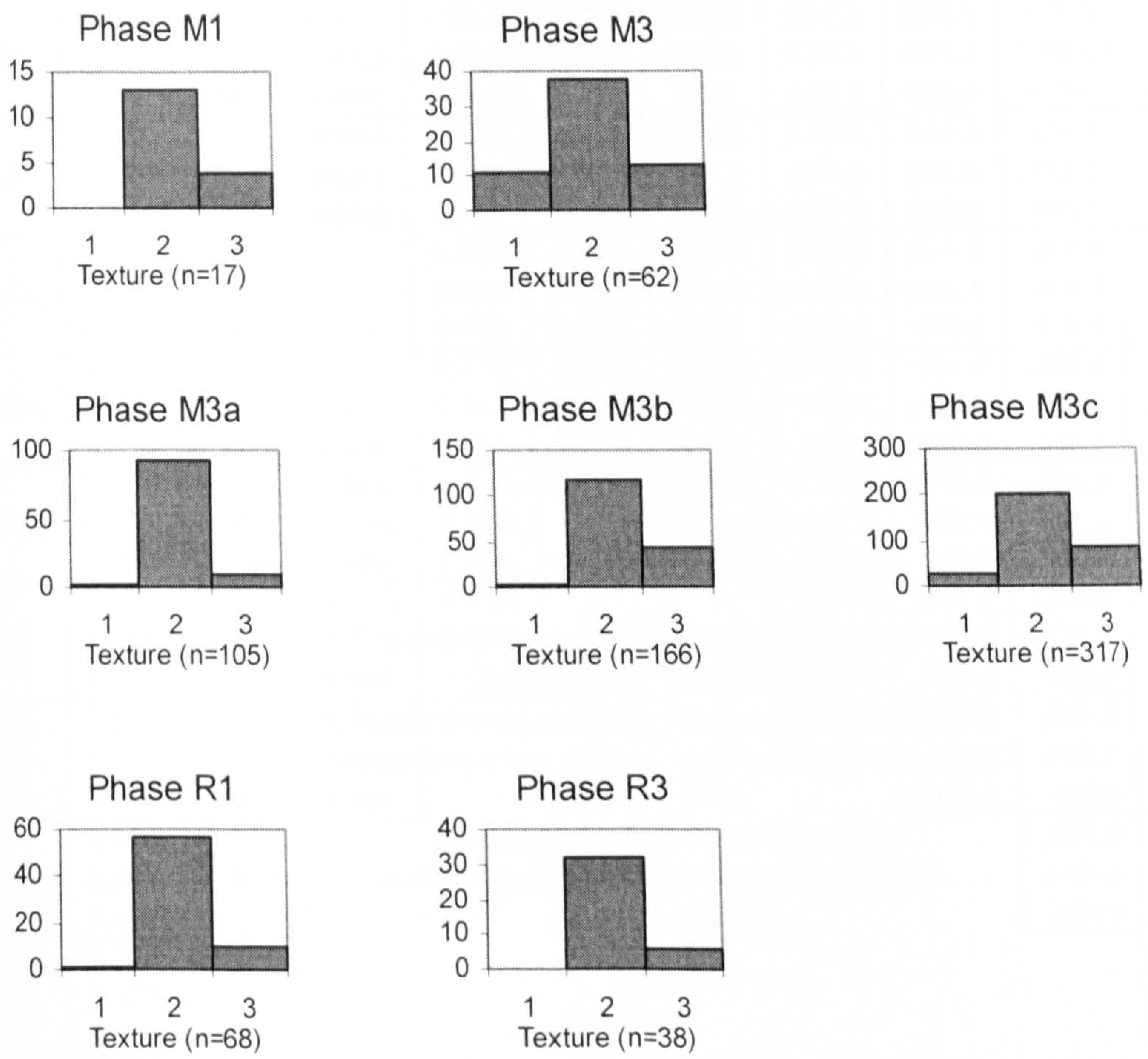


Figure 4.10: Haddock texture categories by phase group, hand collected and >4mm QC1 elements (1=excellent, 2=good, 3=poor)

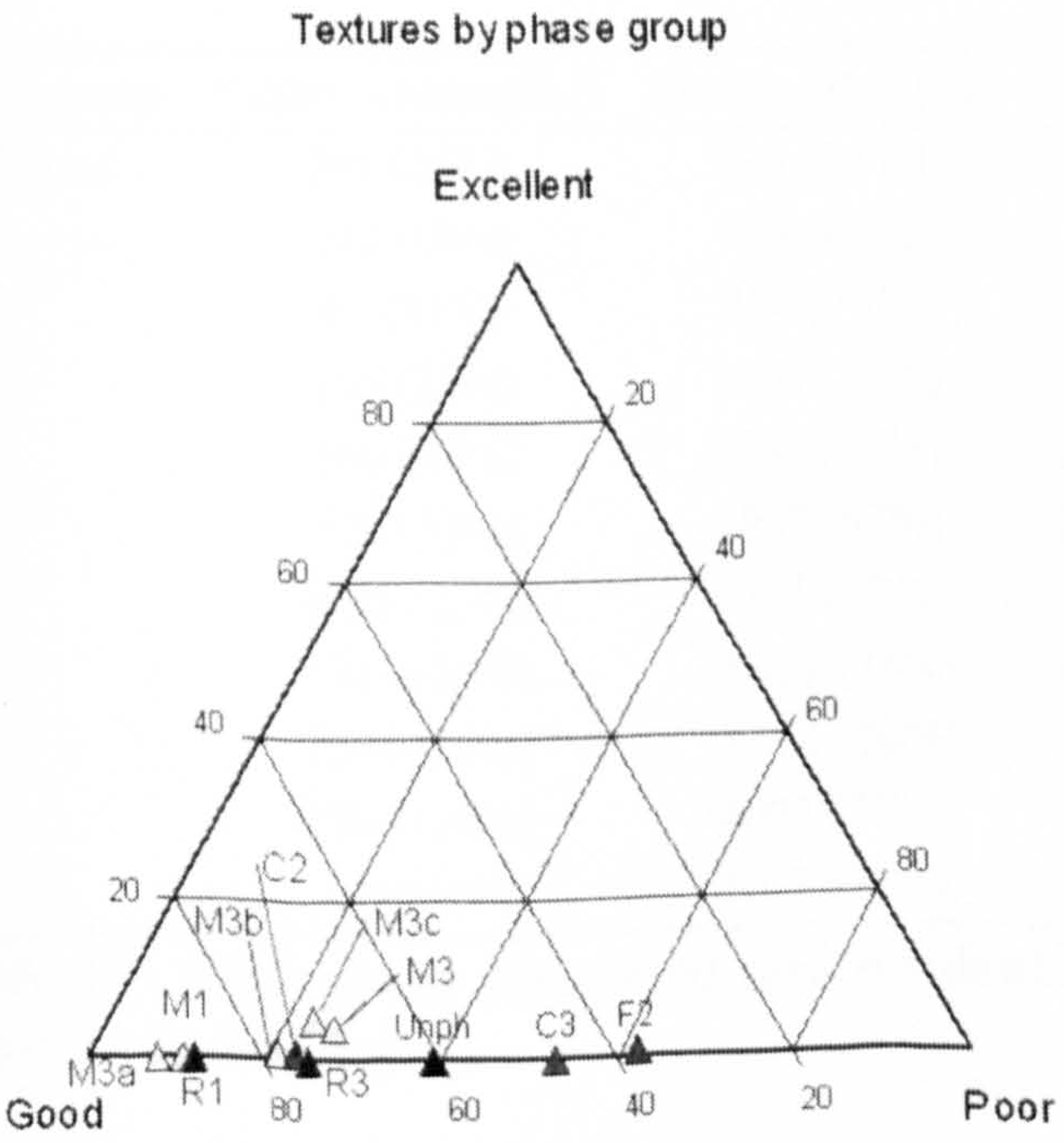


Figure 4.11: Triangular plot of numbers of each type of texture for each phase group, combined hand collected and >4mm QC1

	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1
R3	0.055; 0.364; 0.999	0.259; 1.185; 0.120	**0.368; 2.394; 0.000**	0.159; 1.337; 0.056	0.031; 0.240; 1.000	**0.202; 1.929; 0.001**	0.091; 0.880; 0.421	0.047; 0.455; 0.986	**0.196; 1.827; 0.003**
R1	0.142; 1.143; 0.146	**0.456; 2.259; 0.000**	**0.564; 4.394; 0.000**	0.037; 0.445; 0.989	**0.170; 1.692; 0.007**	0.005; 0.087; 1.000	**0.106; 1.790; 0.003**	**0.150; 2.569; 0.000**	
M3c	0.021; 0.179; 1.000	**0.306; 1.536; 0.018**	**0.415; 3.333; 0.000**	**0.112; 1.452; 0.029**	0.020; 0.213; 1.000	**0.155; 2.941; 0.000**	0.044; 0.888; 0.410		
M3b	0.036; 0.301; 1.000	**0.350; 1.755; 0.004**	**0.459; 3.677; 0.000**	0.068; 0.877; 0.426	0.064; 0.672; 0.757	**0.111; 2.073; 0.000**			
M3a	0.147; 1.211; 0.106	**0.461; 2.303; 0.000**	**0.570; 4.521; 0.000**	0.043; 0.533; 0.939	**0.175; 1.802; 0.003**				
M3	0.031; 0.217; 1.000	**0.286; 1.327; 0.059**	**0.394; 2.649; 0.000**	0.133; 1.178; 0.124					
M1	0.105; 0.780; 0.578	**0.418; 2.011; 0.001**	**0.527; 3.814; 0.000**						
F2	**0.423; 2.551; 0.000**	0.109; 0.474; 0.978							
C3	**0.314; 1.381; 0.044**								

Cells show greatest difference, Kolmogorov-Smirnov Z value, and significance level
Bold formatting indicates significant pairing

Table 4.5: Kolmogorov-Smirnov test results for cod textures against phase groups, hand collected and >4mm, all specimens with textures

	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1
R3	0.075; 0.383; 0.999	0.175; 0.343; 1.000	**0.771;** **2.623;** **0.000**	0.015; 0.098; 1.000	0.129; 0.889; 0.408	0.030; 0.270; 1.000	0.087; 0.802; 0.541	0.102; 0.953; 0.324	0.035; 0.309; 1.000
R1	0.040; 0.221; 1.000	0.210; 0.417; 0.995	**0.806;** **2.840;** **0.000**	0.051; 0.370; 0.999	0.126; 1.013; 0.256	0.005; 0.067; 1.000	**0.123;** **1.576;** **0.014**	**0.137;** **1.826;** **0.003**	
M3c	0.177; 1.000; 0.270	0.073; 0.145; 1.000	**0.669;** **2.381;** **0.000**	0.086; 0.660; 0.777	0.062; 0.526; 0.945	**0.132;** **1.893;** **0.002**	0.056; 0.842; 0.477		
M3b	0.163; 0.912; 0.376	0.087; 0.174; 1.000	**0.683;** **2.427;** **0.000**	0.072; 0.542; 0.931	0.117; 0.987; 0.284	**0.117;** **1.617;** **0.011**			
M3a	0.046; 0.254; 1.000	0.204; 0.407; 0.996	**0.801;** **2.834;** **0.000**	0.045; 0.338; 1.000	0.124; 1.023; 0.246				
M3	0.153; 0.754; 0.621	0.129; 0.253; 1.000	**0.693;** **2.328;** **0.000**	0.129; 0.789; 0.562					
M1	0.091; 0.431; 0.992	0.159; 0.309; 1.000	**0.755;** **2.489;** **0.000**						
F2	**0.846;** **2.595;** **0.000**	0.596; 1.043; 0.227							
C3	0.250; 0.473; 0.979								

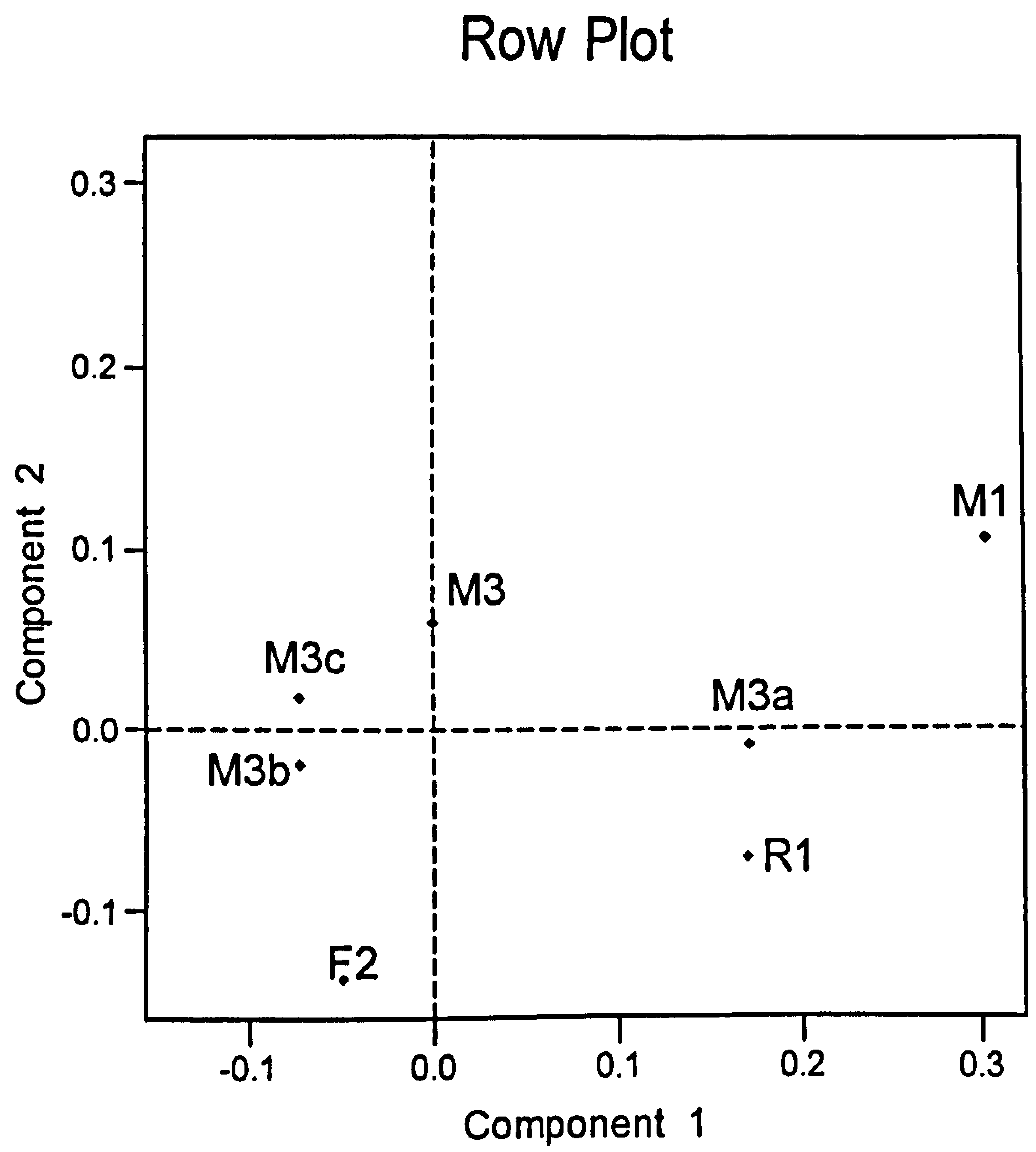
Cells show greatest difference, Kolmogorov-Smirnov Z value, and significance level

Bold formatting indicates significant pairing

Table 4.6: Kolmogorov-Smirnov test results for haddock textures against phase groups, hand collected and >4mm, all specimens with textures

Phase group	NISP (% identified)	Unidentified (%)	Total
Unphased	291 (25%)	883 (75%)	1175
C2	206 (18%)	930 (82%)	1136
C3	61 (21%)	230 (79%)	291
F2	295 (23%)	1004 (77%)	1299
M1	566 (23%)	1895 (77%)	2461
M3	978 (33%)	1967 (67%)	2945
M3a	1995 (23%)	6516 (77%)	8511
M3b	3744 (26%)	10452 (74%)	14196
M3c	7396 (30%)	16961 (70%)	24357
R1	1395 (26%)	4003 (74%)	5398
R3	355 (25%)	1057 (75%)	1412

Table 4.7: Percentage identified and unidentified fragments by phase group, hand collected and >4mm



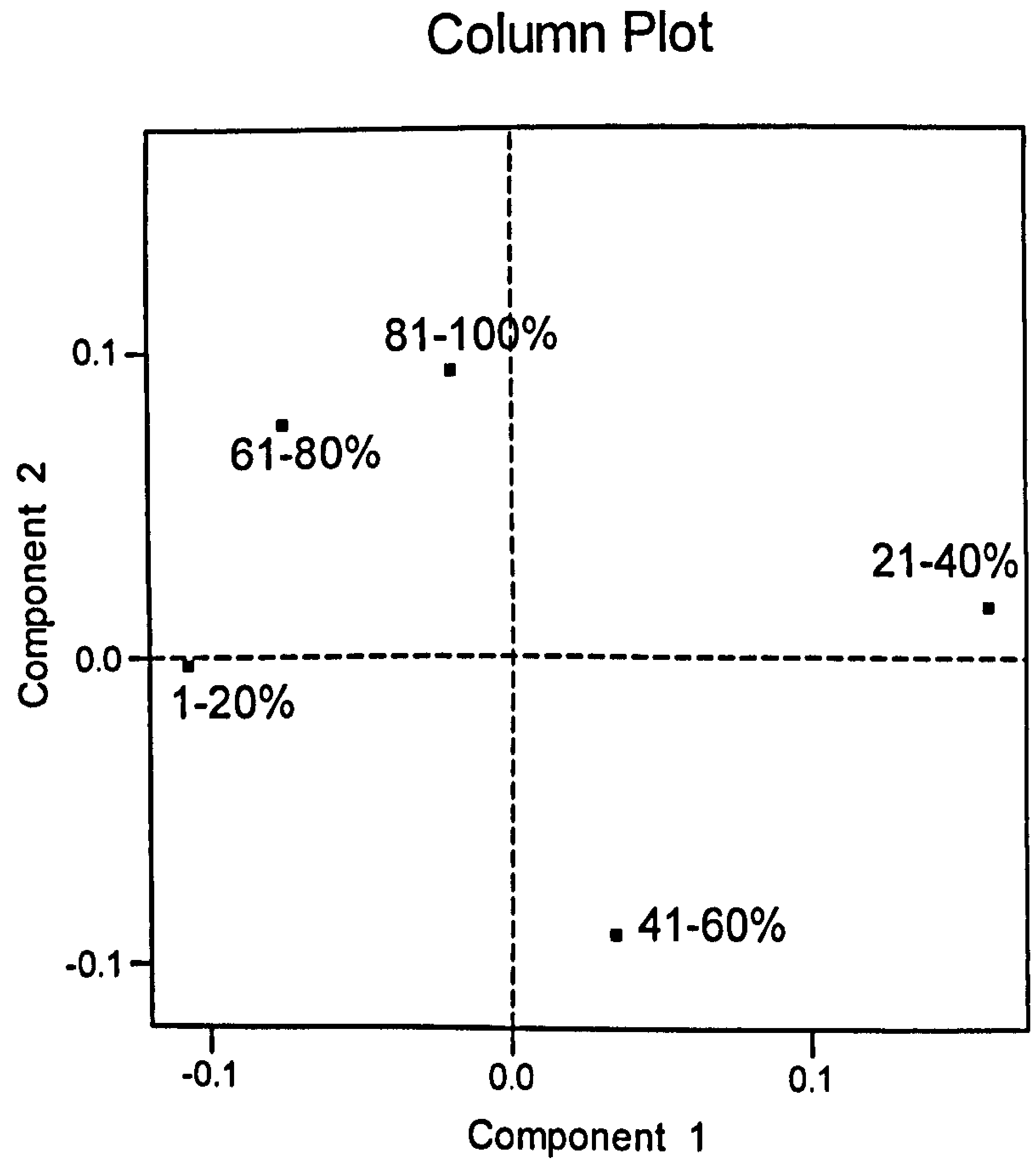


Figure 4.12: Correspondence analysis plots of percent completeness for QC1 elements, major phases

Rows:				Component 1			Component 2		
Phase groups	Quality	Mass	Inertia	Co-ordinate	Contribution to row inertia	Contribution of row to axis inertia	Co-ordinate	Contribution to row inertia	Contribution of row to axis inertia
F2	0.79	0.03	0.04	-0.04	0.091	0.006	-0.136	0.700	0.313
M1	0.87	0.03	0.25	0.30	0.783	0.266	0.106	0.097	0.233
M3	0.25	0.05	0.04	-0.00	0.000	0.000	0.061	0.252	0.112
M3a	0.90	0.13	0.24	0.17	0.901	0.294	-0.009	0.002	0.005
M3b	0.68	0.22	0.10	-0.07	0.645	0.088	-0.019	0.043	0.042
M3c	0.87	0.42	0.15	-0.07	0.818	0.168	0.019	0.054	0.078
R1	0.93	0.08	0.16	0.17	0.803	0.179	-0.070	0.137	0.217

Columns:				Component 1			Component 2		
Percent compl-eteness	Quality	Mass	Inertia	Co-ordinate	Contribution to row inertia	Contribution of row to axis inertia	Co-ordinate	Contribution to row inertia	Contribution of row to axis inertia
1-20%	0.95	0.44	0.29	-0.10	0.95	0.378	-0.003	0.001	0.002
21-40%	0.98	0.30	0.43	0.15	0.97	0.577	0.016	0.010	0.044
41-60%	0.75	0.14	0.09	0.03	0.10	0.013	-0.089	0.658	0.587
61-80%	0.54	0.07	0.08	-0.07	0.27	0.032	0.076	0.278	0.234
81-100%	0.16	0.02	0.09	-0.02	0.00	0.001	0.094	0.152	0.134

Table 4.8: Data table for Figure 4.12

4.3 Other taphonomic alterations

A small number of specimens had further alterations, including evidence of burning, butchery (see section 4.7), digestion, tooth marks and pathological alterations (included here because there were insufficient examples to present separately). Table 4.9 quantifies these by phase group for all data, and provides an indication of the prevalence of each type of alteration. By far the most common was evidence of burning, recorded here by colour as calcined (white-grey) or charred (black). About 7.3% of all fragments exhibited some evidence of burning, but because of the small fragment size and distortions caused during the burning process, most of these fragments were unidentifiable to species or element (839 of the calcined specimens and 2025 of the charred specimens were unidentified). The construction and collapse phase groups showed the highest proportions of burnt remains. The M1 deposits had a higher than usual percentage of charred bone (9.8%) without any increase in calcined material, compared to the other midden deposits. This could indicate a real change in activities at the site, or could reflect differential preservation, but given that phase groups M3a and R3 were also well preserved (see section 4.2), the former is more likely. Among those elements that could be identified, some were more burnt than others (Table 4.10), particularly the premaxilla and the dentary (possibly because these elements retain the distinctive tooth sockets that permit identification even when burnt). The fish bone evidence is in marked contrast to the mammal bone, as 24% of the early midden and 42% of the later midden was burnt (Mainland 1995, 3). No conclusions were drawn regarding the mammal bone, but these substantial quantities of burnt bone could reflect refuse disposal patterns, the remains of meals being burnt to reduce the final quantity of waste. If so, it appears different types of bone were disposed of in different ways.

Evidence of carnivore gnawing and digestion was found throughout most phase groups with any quantity of bone, indicating that carnivore activity may have adversely affected the assemblage. However, quantities were extremely low at less than 0.1% overall; any bias will therefore not be significant. Other scavenging activity may have left less evidence in the zooarchaeological record, including that of seabirds (Barrett and Oltmann 2000, 5).

In summary, evidence of burning was found throughout all levels and was the most frequently occurring alteration to bone. Burning was most common in the construction and collapse phase groups, a consistent result given that texture and preservation were poor in these layers (see section 4.2), suggesting greater alterations had occurred to this phase group than any other. The tendency towards increased burning of dentaries and premaxillae, compared to other elements, may be a real pattern, or may reflect their ease of identification even when burnt.

Phase group	Calcined	Charred	Cut & Chop mark	Path-ology	Dig-estion	Tooth marks	Crushed	Calcined/ crushed	Digestion/ crushed
Unphased	15 (1.2%)	37 (3.0%)		1		2		1	
C2	62 (4.5%)	183 (13.3%)	1						
C3	14 (4.8%)	34 (11.7%)							
F2	48 (3.7%)	87 (6.6%)	1						
M1	52 (2.0%)	249 (9.8%)	2	2	2				
M3	67 (2.2%)	77 (2.6%)	3		2	4		1	
M3a	238 (2.6%)	516 (5.6%)	13	11	6	3			1
M3b	423 (2.9%)	713 (4.8%)	20	8	7	4			
M3c	572 (2.3%)	899 (3.6%)	29	19	45	9	9	1	2
R1	121 (2.2%)	330 (5.9%)	1	5	1				
R3	24 (1.7%)	21 (1.5%)	5	3	2				
Grand Total	1636 (2.5%)	3146 (4.8%)	75	49	65	22	9	3	3

Table 4.9: Taphonomic counts per phase group, all data (percentages indicate proportion of altered out of total fragment count for that phase group)

Element	Calcined	Charred
Articular	3 (0.8%)	14 (3.6%)
Cleithrum	8 (1.1%)	12 (1.6%)
Dentary	15 (4.4%)	24 (7%)
Maxilla	4 (1.2%)	13 (3.8%)
Parasphenoid	8 (2.1%)	11 (2.9%)
Posttemporal	10 (2.9%)	12 (3.5%)
Premaxilla	31 (6.6%)	37 (7.9%)
Quadrate	11 (2.4%)	12 (2.7%)
Vomer	5 (1.7%)	8 (2.8%)
Total all gadid QC1 elements	95 (2.5%)	143 (3.8%)

Table 4.10: Count of all gadid QC1 elements with burning, percentages indicating proportion out of total gadid NISP for each element

4.4 Species

As is typical of Viking Age and medieval sites in the Northern Isles (see Chapter One for an introduction to the zooarchaeology of the region), the fish assemblage was dominated by cod family (Gadid) fish (Table 4.11, Table 4.12, Table 4.13, and Table 4.14). For the entire site, 98.1% of the identified specimens by NISP were derived from gadids (hand collected and >4mm only); proportions for each phase group ranged from a minimum of 94.2% (M1) to 100% (C3). A total of 34 separate taxa were identified from the hand collected and >4mm assemblage, and a further six taxa were identified in the <4mm fraction, although the vast majority of the assemblage was comprised of cod, haddock, gadid or *Gadus/Pollachius* (a term used to include cod, saithe and undifferentiated specimens).

As only a select subset of elements was fully identified to species (QC1 and QC2) or to family (QC3), any comparison must take these differences into consideration. Furthermore, for the <4mm fraction of the assemblage, only vertebrae, dentaries and premaxillae were identified.

Different results were obtained by examining the NISP of QC1 elements (Figure 4.13), QC3 elements (Figure 4.14) or QC1 element weight (Figure 4.15). The NISP of QC1 elements indicated a decrease in cod from M1 (about 62%) to M3c (about 44%). Haddock increased from the M1 to the M3 deposits, but not through the three sequential M3 phase groups. The 'gadid' QC1 elements were those that could not be identified directly to species, and this value was highest in phase group F2, consistent with the poor preservation and high fragmentation occurring in this phase group (see Table 4.3 and Table 4.4). One ling fragment was found in the early midden M1 phase group (and only 20 from phase group R1), indicating that this species was only caught and consumed in any quantity (albeit low) in the phase groups that post-dated the mill. The weights of QC1 elements place much greater emphasis on cod and ling. Given that no ling of <500mm total length were recorded (Figure 4.46), the higher rank of ling by weight as opposed to by count is to be expected. The fragments only identified to 'gadid' represent a much lower percentage by weight than they do by NISP, reflecting the correlation between more complete fragment size and ease of identification at species level. The QC2 elements have a much higher proportion of *Gadus/Pollachius* identifications, likely to represent cod given the low proportion of saithe and the overall lack of pollack in the assemblage. Haddock are present in higher proportions when considering the vertebrae as compared to the QC1 elements, probably because of their easier identification compared to cod and saithe vertebrae and compared to the QC1 elements. However, haddock vertebrae still increase from M1 to the M3 phase groups. The substantial quantities of robust haddock cleithra and posttemporals (as discussed below, section 4.5) are therefore not a taphonomic bias, because quantification by vertebrae alone indicates that the substantial quantity of haddock at Earl's Bu is a real phenomenon.

The non-gadid species contributed very little to the assemblage by either count or weight, although a considerable number of species were represented as detailed in Table 4.11 (hand collected and >4mm), Table 4.12 (<4mm) and Table 4.11 (<4mm vertebrae, dentaries and premaxillae). Eels were particularly prevalent in the <4mm assemblage compared to the hand collected and >4mm fractions. Relatively few cod were represented in the <4mm assemblage, suggesting that most cod were not of <150mm or 150-300mm total length (confirmed by the metrical data, see Figure 4.31), but in contrast, saithe were present in much higher quantities suggesting that <150mm and 150-300mm total length saithe were caught in some quantity compared to similarly sized cod, particularly in phase group M3a (see Figure 4.44).

Correspondence analysis can be used to illustrate some of the patterning noted above. Figure 4.16 shows the row and column plots using the NISP of QC1 elements (hand collected and >4mm fractions combined) for the main species as used in Figure 4.13. The variation in the dataset accounted for only 2% inertia, but patterns are visible. Phase group M3 tends more towards ling than do M1 or F2, while M3c has relatively more saithe than any other phase with these recovery methods. Phase groups M1 and F2 also tend away from haddock as they contain less of that species. Figure 4.17 shows similar plots for all QC2 elements, plus the premaxilla and dentary counts, for the entire dataset (thus incorporating even the smaller fish that were only found in the <4mm subset). This plot represents 10% of the variation in the dataset. The pattern is not as clear here, but in general the earlier deposits are less associated with haddock and ling than the later phases. F2 is fairly peripheral, indicating its different nature compared to the main midden phase groups. Further variation between species will be investigated using the results of individual elements in the following section.

While the vast majority of fish caught at Earl's Bu were large gadids, some other species may represent deliberate capture and some of the smaller fish may represent stomach contents from the larger gadids (Barrett 1997, 365). Other species, like the gurnards found in phase group M3c, may have been accidental catches while fishing for large gadids, or could have been stomach contents of the larger gadids (Barrett 1997, 368). The small quantities of rocklings may have been caught from the shore, but the low proportion at Earl's Bu corresponds to the unusually low proportion of small saithe, a species also caught from the shore (Low 1813, 193-94), and common at many other sites in the Northern Isles, including Quoygrew. Small quantities of fish from the dogfish families were found throughout, particularly in phase group M3b (34 identifications). This species is known to have been of moderate importance in early modern Orkney, both as food and for their oil, used for light (Low 1813, 170). A fishery was recorded in the late 18th century in the Orphir region, when the dogfish were exploited throughout the summer months because small saithe were not available (Liddel 1791-99, 398), but given the absence of small saithe at Earl's Bu, this fishery was unlikely exploited as a substitute. The dogfish could also represents accidental catches while fishing for large gadids (Low 1813, 170; Barrett 1997, 368). Small quantities of herring were found in M3b (17 identifications), but were otherwise absent; these may have been gut contents and there is certainly no evidence to suggest herring were of any economic importance at this time, despite the contemporary importance of this species in England and the Western Isles, and its later importance to early modern Scotland (Barrett *et al.* 2004b; Cerón-Carrasco 2005; Sharples 2005). Salmon and trout were found at trace levels throughout, with slightly elevated quantities found in phase group M3a (28 identifications), M3b (28 identifications) and M3c (24 identifications); these probably represented deliberate fishing of freshwater lakes or streams, or from the shore or at sea. A wide range of sizes was represented, from <300mm to over 800mm total length. Given the absence of large rivers on Orkney, the larger individuals probably were caught at sea. Some quantities of eels were recovered from the later midden deposits, particularly from the <4mm fraction (M3a, 77 identifications; M3b, 147 identifications; M3c, 118 identifications); these probably represented deliberate catches from streams (Barrett 1997, 367).

To place the fish assemblage in its comparative context, the overall relationship between fish and mammal bone at Earl's Bu can be investigated using weights and NISP data (summarised in Table 4.17). Weight data were available for QC1 fish bones and for most mammal bone fragments from the later seasons of excavation (Mainland 1995, 2). A simple scatter plot of phase-level weights illustrates the positive correlation between mammal and fish (Figure 4.20). Earlier phase groups, particularly M1 and R1, tend to contain more mammal by weight than do the later phase groups M3a, M3b and M3c. The proportion of fish increases through time from M3a to M3c, suggesting that fish became increasingly significant to diet and economy through time. A similar scatter plot indicating the relationship between fish and mammal NISP complements the results of weights (Figure 4.21); TNB could have been investigated but the variation in unidentified counts makes this a poor choice (see section 4.2). Results indicate a linear relationship, with the early phase groups R1 and M1 containing proportionally more mammal fragments than the later M3a, M3b and M3c phase groups.

The relationship between the mammal and fish assemblages can be assessed using correspondence analysis to get an overall idea of variation present. Figure 4.18 and Figure 4.19 are the row and column plots of all species with at least 20 recorded specimens, representing a total inertia of 9.3%. The main gadid species are all located on the right hand side of the plot, and the main domestic mammal categories are to the left. The four M3 phase groups are all located to the right of the plot, in the general vicinity of the main gadid species, and away from the domestic mammals, while the M1 point is the reverse, located in the direction of the domestics and away from the gadids. The lack of mammal bone attributed to phase group M3 requires future investigation. The Earl's Bu mammal and bird bone will be discussed further in Chapter Eight.

In conclusion, the exploitation of fish increases proportionally through time when compared to mammal. Haddock also increased through time, as less were found in the early phase groups that pre-dated the mill than in the later phase groups, while cod decreased proportionally. Phase group R1 displayed similar trends to the phase 3 deposits, but given that this phase has not (yet) been directly dated (see Chapter Three), this need not be problematic. This has no influence on the trend towards increasing proportions of fish through time, as shown in Figure 4.18 and Figure 4.19. Ling was only exploited in low quantities mainly in the later phase groups. Recovery biases were unlikely to affect haddock; although the later deposits (M3a to M3c) exhibit increasing fragmentation and poorer textures, the increase in haddock vertebrae through time suggests that this pattern isn't solely taphonomic (as would be expected if only the robust QC1 cleithra and posttemporals were increasingly recovered in the later phase groups). Further investigation at the element level will explore these patterns in detail.

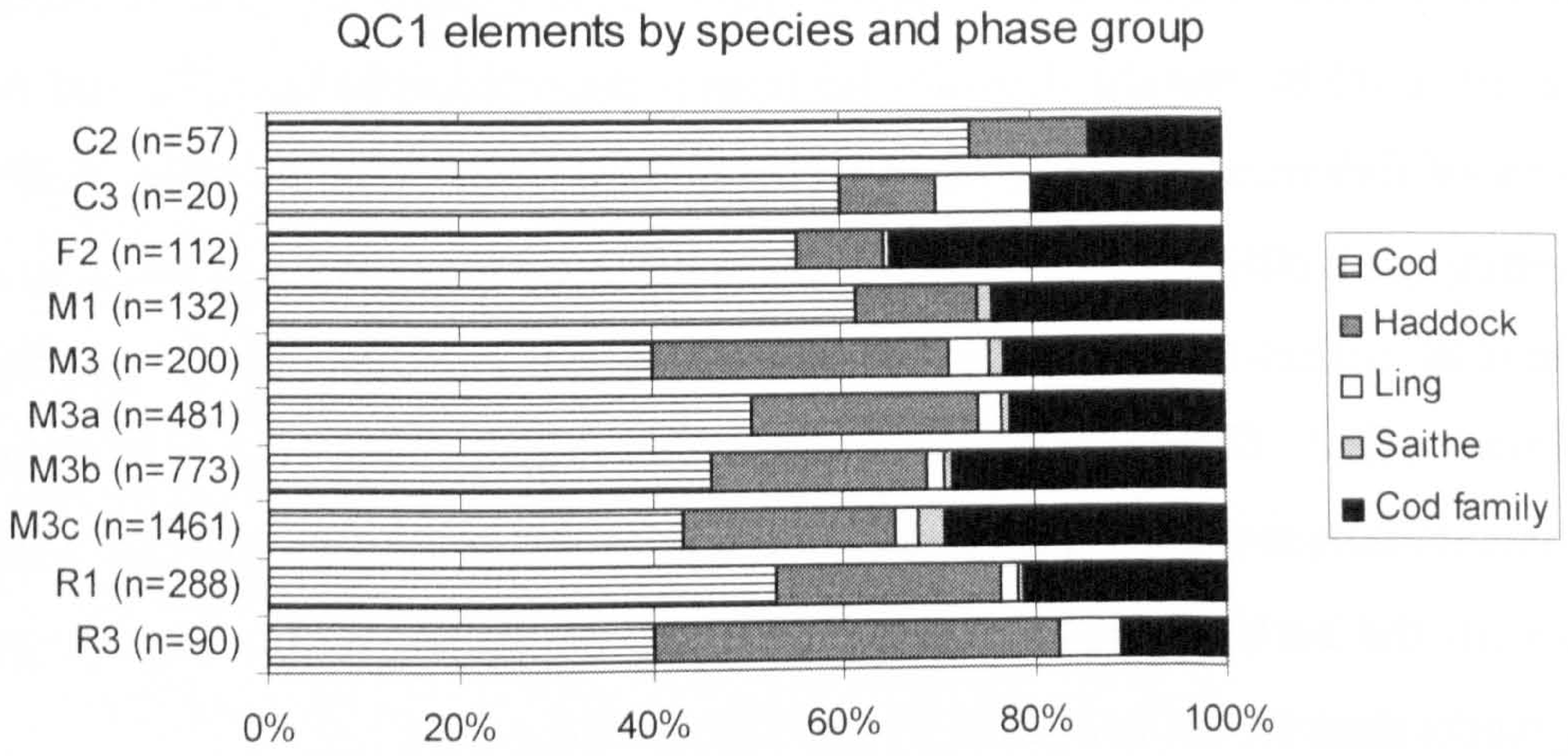


Figure 4.13: Percentage of QC1 elements by NISP, by species and phase group, all recovery levels (main species only representing 99% of the QC1 dataset with phasing)

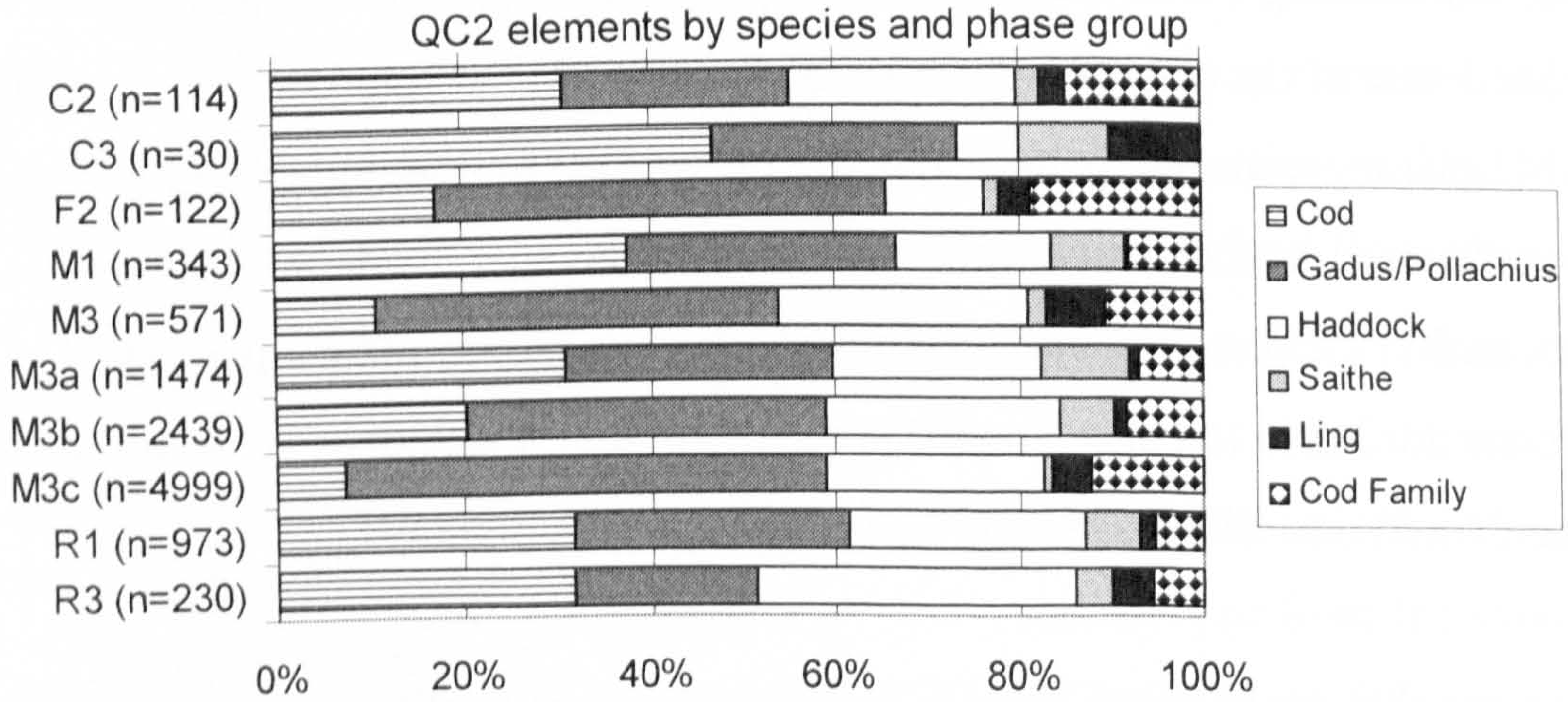


Figure 4.14: Percentage of QC2 elements by NISP, by species and phase group, all recovery levels (main species only representing 93% of the QC2 dataset with phasing)

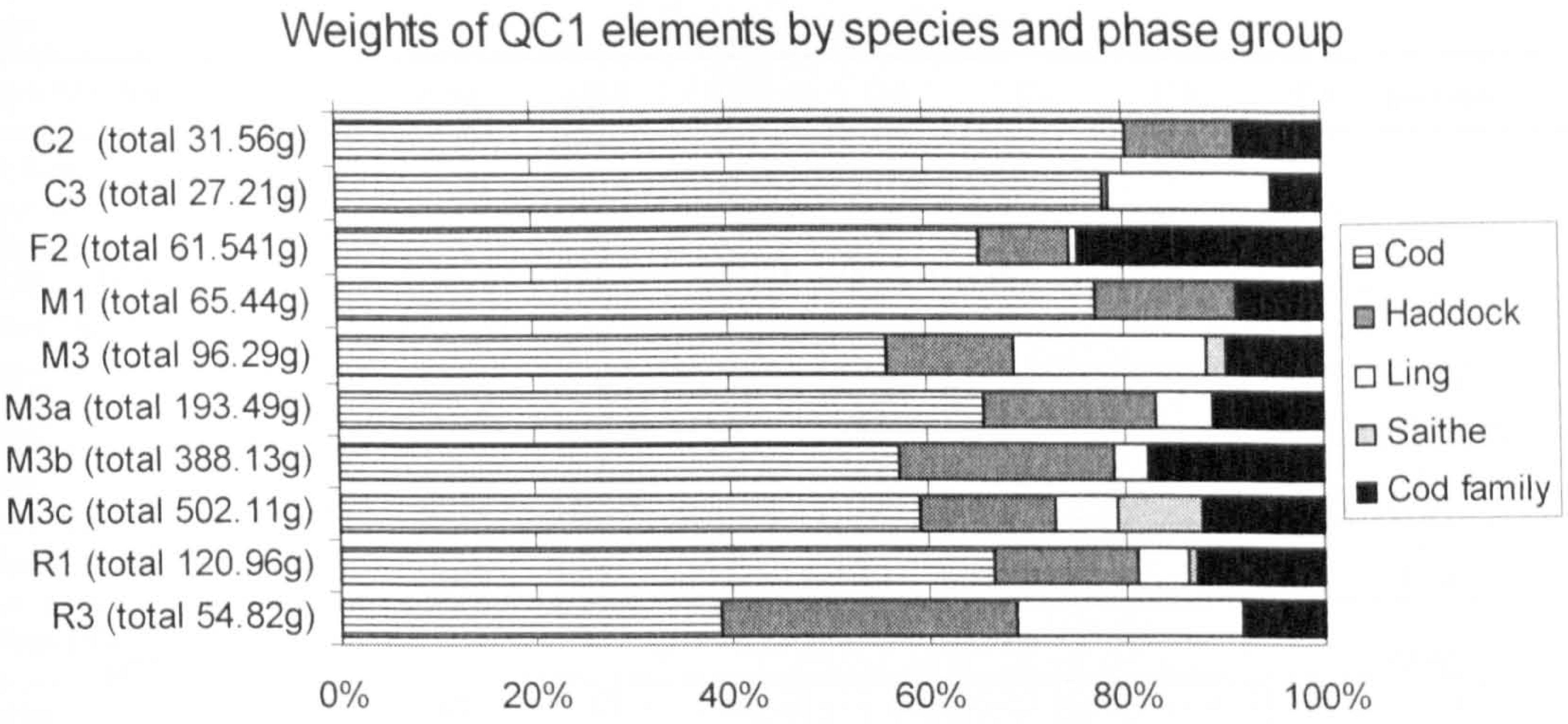


Figure 4.15: Percentages of weights of QC1 elements by species and phase group, all recovery levels (main species only representing 99% of the QC1 dataset with phasing)

Species	Unphased	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3
Shark/Ray									1 (0%)		
Dogfish Families				2 (0.7%)	5 (0.9%)	1 (0.1%)	3 (0.2%)	15 (0.4%)		1 (0.1%)	2 (0.6%)
Spurdog?									1 (0%)		
Ray Family	1 (0.3%)				1 (0.2%)		5 (0.3%)	3 (0.1%)			
Thornback Ray		2 (1%)					3 (0.2%)	1 (0%)	1 (0%)		
Herring								1 (0%)			
Allis Shad/Twaite										1 (0.1%)	
Salmon And Trout Family	1 (0.3%)	1 (0.5%			6 (1%)	1 (0.1%)	13 (0.7%)	20 (0.5%)	16 (0.2%)	16 (1%)	
Trout					1 (0.2%)		2 (0.1%)				
Eel					12 (2%)		3 (0.2%)	20 (0.5%)	20 (0.3%)	2 (0.1%)	
Conger Eel								2 (0.1%)			
Hake					1 (0.2%)		3 (0.2%)	17 (0.5%)	11 (0.1%)	1 (0.1%)	5 (1%)
Cod Family	106 (36%)	62 (30%)	15 (25%)	127 (43%)	154 (27%)	331 (34%)	515 (26%)	1133 (30%)	2355 (32%)	308 (22%)	70 (20%)
Gadus/ Pollachius	45 (15%)	27 (13%)	8 (13%)	54 (18%)	76 (13%)	240 (25%)	349 (17%)	844 (23%)	2268 (31%)	242 (17%)	39 (11%)
Cod	77 (26%)	76 (37%)	26 (43%)	75 (25%)	208 (37%)	127 (13%)	641 (32%)	793 (21%)	869 (12%)	453 (32%)	107 (30%)
Cod?	2 (0.7%)			9 (3%)		12 (1%)	9 (0.5%)	30 (0.8%)	112 (2%)	2 (0.1%)	
Haddock	50 (17%)	34 (17%)	4 (7%)	22 (7%)	70 (12%)	205 (21%)	381 (19%)	725 (19%)	1390 (19%)	302 (22%)	111 (31%)
Haddock?	2 (0.7%)			1 (0.3%)		4 (0.4%)		7 (0.2%)	27 (0.4%)	2 (0.1%)	
Whiting									3 (0%)		
Whiting?									7 (0.1%)		
Pollack	1 (0.3%)							10 (0.3%)			
Saithe	5 (1.7%)	1 (0.5%)	3 (5%)		24 (4%)	5 (0.5%)	39 (2%)	71 (2%)	55 (0.7%)	37 (3%)	4 (1%)
Saithe?								1 (0%)	5 (0.1%)		
Norway Pout/ Bib/ Poor-Cod		1 (0.5%)									
Rockling							1 (0.1%)	1 (0%)			
Five Bearded Rockling							1 (0.1%)		1 (0%)		
Three Bearded Rockling									1 (0%)		
Greater Fork Beard?						1 (0.1%)					
Ling	1 (0.3%)	2 (1%)	5 (8%)	5 (2%)	1 (0.2%)	47 (5%)	25 (1%)	43 (1%)	218 (3%)	20 (1%)	16 (5%)
Ling?							2 (0.1%)	3 (0.1%)	11 (0.1%)		
Atlantic Mackerel										1 (0.1%)	
Wrasse Family					1 (0.2%)	1 (0.1%)				3 (0.2%)	
Ballan Wrasse					3 (0.5%)						
Ballan Wrasse?					3 (0.5%)						
Gurnard Family						1 (0.1%)		1 (0%)	12 (0.1%)	3 (0.2%)	

Sea Scorpion Family						1 (0.1%)					
Sea Scorpion									1 (0%)		
Bull Rout?										1 (0.1%)	
Flatfish									1 (0%)		
Turbot Family								1 (0%)			
Halibut Family						1 (0.1%)		1 (0%)	5 (0.1%)		1 (0.3%)
Plaice									2 (0%)		
Plaice?									2 (0%)		
Lemon Sole									1 (0%)		
Angler								1 (0%)			
Total identified (as % of total)	291 (25%)	206 (18%)	61 (21%)	295 (23%)	566 (23%)	978 (33%)	1995 (23%)	3744 (26%)	7396 (30%)	1395 (26%)	355 (25%)
Unidentified (as % of total)	883 (75%)	930 (82%)	230 (79%)	1004 (77%)	1895 (77%)	1967 (67%)	6516 (77%)	10452 (74%)	16961 (70%)	4003 (74%)	1057 (75%)
Grand Total (% of total for site)	1175 (2%)	1136 (2%)	291 (0.5%)	1299 (2%)	2461 (4%)	2945 (5%)	8511 (14%)	14196 (23%)	24357 (39%)	5398 (9%)	1412 (2%)
	Unphased	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3

Table 4.11: NISP count and percent, all species, by phase group, for hand collected and >4mm

Species	Unphased	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3
Dogfish Families		1 (0.4%)			3 (4.1%)		7 (1.7%)	18 (3.3%)	4 (0.5%)	3 (2%)	
Spurdog								1 (0.2%)	11 (1.4%)		
Ray Family		219 (92.4%)		1 (9.1%)			2 (0.5%)	3 (0.6%)	1 (0.1%)		
Thornback Ray									6 (0.8%)		
Atlantic Herring					2 (2.7%)		2 (0.5%)	14 (2.4%)	3 (0.4%)		
Atlantic Herring?								2 (0.4%)			
Salmon And Trout Family		1 (0.4%)			2 (2.7%)		13 (3.2%)	7 (1.3%)	7 (0.9%)	4 (2.7%)	1 (4%)
Salmon And Trout Family?								1 (0.2%)	1 (0.1%)		
Eel	5 (8.6%)	1 (0.4%)		2 (18.2%)	11 (15.1%)	1 (2.8%)	74 (18%)	127 (23.4%)	98 (12.5%)	19 (12.8%)	1 (4%)
Hake										1 (0.7%)	
Cod Family		7 (2.5%)		1 (9.1%)	15 (20.5%)	5 (13.9%)	56 (13.4%)	64 (11.8%)	159 (20.2%)	22 (14.8%)	3 (12%)
Gadus/ Pollachius	9 (15.5%)	2 (0.8%)		5 (45.5%)	24 (32.9%)	6 (16.7%)	68 (16.5%)	94 (17.3%)	306 (39%)	48 (32.2%)	6 (24%)
Cod	2 (3.4%)	2 (0.8%)			2 (2.7%)	4 (11.1%)	28 (6.8%)	29 (5.4%)	11 (1.4%)	4 (2.7%)	2 (8%)
Cod?								2 (0.4%)	7 (0.9%)	1 (0.7%)	
Haddock	1 (1.7%)	1 (0.4%)			4 (5.5%)	9 (25%)	49 (11.9%)	68 (12.5%)	101 (12.9%)	13 (8.7%)	7 (28%)
Haddock?							1 (0.2%)	1 (0.2%)		2 (1.3%)	
Saithe	40 (69%)	2 (0.8%)		2 (18.2%)	6 (8.2%)	9 (25%)	104 (25.3%)	79 (14.6%)	32 (4.1%)	22 (14.8%)	5 (20%)
Saithe?								1 (0.2%)	1 (0.1%)		
Norway Pout/ Bib/Poor-Cod							1 (0.2%)	1 (0.2%)	1 (0.1%)		
Norway Pout									1 (0.1%)		
Rockling							2 (0.5%)	4 (0.7%)	5 (0.6%)	2 (1.3%)	
Five Bearded Rockling									2 (0.3%)		
Three Bearded Rockling						1 (2.8%)					
Ling		1 (0.4%)						3 (0.6%)	6 (0.8%)	1 (0.7%)	
Ling?							1 (0.2%)				
Atlantic Horse-mackerel									1 (0.1%)		
Atlantic Mackerel								1 (0.2%)			
Atlantic Mackerel?							1 (0.2%)				
Butterfish	1 (1.7%)				1 (1.4%)			15 (2.8%)	4 (0.5%)	1 (0.7%)	
Butterfish?									5 (0.6%)		
Sea Breams								1 (0.2%)			
Dragonet									1 (0.1%)		
Halibut					1			3	5	3 (2%)	

Family					(1.4%)			(0.6%)	(0.6%)		
Wrasse Family					2 (2.7%)			1 (0.2%)	1 (0.1%)	3 (2%)	
Wrasse Family?						1 (2.8%)		1 (0.2%)			
Sea Scorpion Family?							1 (0.2%)		1 (0.1%)		
Gurnard Family									1 (0.1%)		
Megrim							1 (0.2%)				
Flatfish									2 (0.3%)		
Viv. Eel Pout								1 (0.2%)			
Grand Total	58	237		11	73	36	411	542	784	149	25
	Unphased	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3

Table 4.12: NISP count of QC2, premaxillae and dentaries by phase group, for <4mm

Species	Vertebrae								Total vertebrae & % Total vertebrae	
	1-2 mm	% 1-2mm	2-4 mm	%2-4mm	<4 mm	%<4 mm	>4 mm	%>4 mm		
Shark/Ray							1	0.0	1	0.0
Dogfish Fam					35	1.7	29	0.3	64	0.5
Spurdog					12	0.6			12	0.1
Spurdog?							1	0.0	1	0.0
Ray Fam					3	0.1	3	0.0	6	0.1
Thornback Ray					6	0.3			6	0.1
Herring Fam			1	3.1	15	0.7			16	0.1
Herring Fam?					1	0.0			1	0.0
Atlantic Herring					4				4	0.0
Atlantic Herring?					2	0.1			2	0.0
Salmon And Trout Fam					35	1.7	67	0.7	102	0.9
Salmon And Trout Fam?					2	0.1	1	0.0	3	0.0
Allis Shad/Twaite Shad							1	0.0	1	0.0
Eel	1	33.3	3	9.4	333	16.3	46	0.5	383	3.3
Conger Eel							2	0.0	2	0.0
Hake					1	0.0	19	0.2	20	0.2
Cod Fam	1	33.3	7	21.9	316	15.4	787	8.1	1111	9.5
Cod Fam?					3	0.1	2	0.0	5	0.0
Cod/Saithe/ Pollack	1	33.3	6	18.8	562	27.4	3993	41.3	4562	38.8
Cod			3	9.4	74	3.6	1704	17.6	1781	15.2
Cod?			1	3.1	8	0.4	30	0.3	39	0.3
Haddock			3	9.4	247	12.1	2436	25.2	2686	22.9
Haddock?					4	0.2	16	0.2	20	0.2
Whiting?							6	0.1	6	0.1
Pollack							11	0.1	11	0.1
Saithe			8	25.0	287	14.0	183	1.9	478	4.1
Saithe?					2	0.1	2	0.0	4	0.0
Norway Pout/Bib/Poor-Cod					3	0.1	1	0.0	4	0.0
Norway Pout					1	0.0			1	0.0
Rockling					13	0.6	2	0.0	15	0.1
5 Bearded Rockling					2	0.1	1	0.0	3	0.0
3 Bearded Rockling					1	0.0	1	0.0	2	0.0
Ling					11	0.5	249	2.6	260	2.2
Ling?					1	0.0	10	0.1	11	0.1
Sea Breams					1	0.0			1	0.0
Wrasse Fam					7	0.3	3	0.0	10	0.1
Wrasse Fam?					2	0.1			2	0.0
Ballan Wrasse							1	0.0	1	0.0
Atlantic Horse-mackerel					1	0.0			1	0.0
Atlantic Mackerel					1	0.0	1	0.0	2	0.0
Atlantic Mackerel?					1	0.0			1	0.0
Dragonet					1	0.0			1	0.0
Butterfish					22	1.1			22	0.2
Butterfish?					5	0.2			5	0.0
Gurnard Fam					1	0.0	9	0.1	10	0.1
Red Gurnard							1	0.0	1	0.0
Red Gurnard?							1	0.0	1	0.0
Sea Scorpion Fam?					2	0.1			2	0.0
Flatfish					2	0.1			2	0.0
Turbot Fam							1	0.0	1	0.0
Megrim					1	0.0			1	0.0
Halibut Fam					12	0.6	7	0.1	19	0.2
Lemon Sole							1	0.0	1	0.0
Plaice							1	0.0	1	0.0

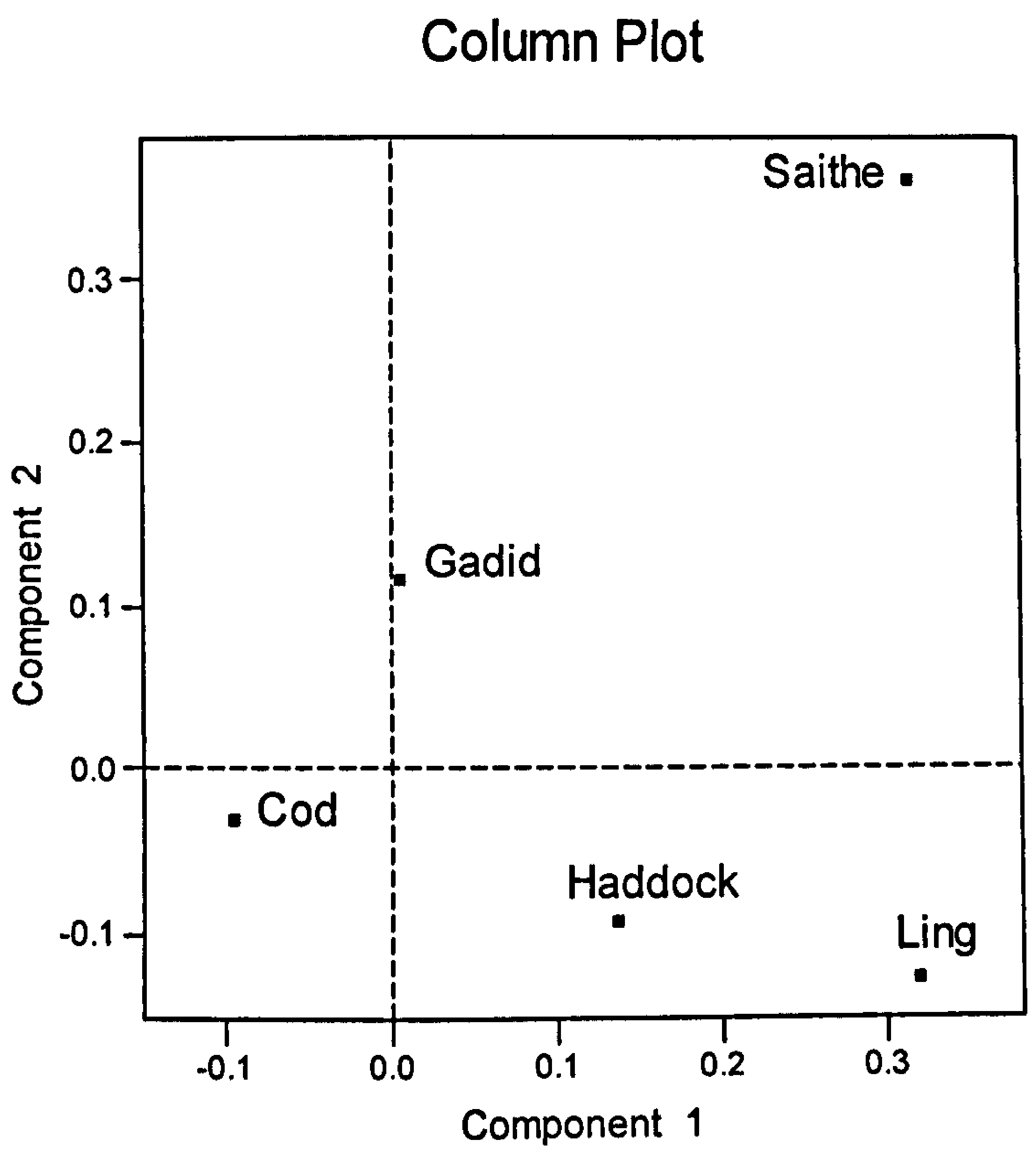
Plaice?							2	0.0	2	0.0
Viv. Eel Pout					1	0.0			1	0.0
Unidentified					5	0.2	29	0.3	34	0.3
Grand Total	3	100	32	100	2049	100	9661	100	11745	100

Table 4.13: Vertebrae recovered from <4mm and >4mm fractions by species NISP and percent

Species	Dentaries				Total dentaries & % Total dentaries		Premaxillae				Total premaxillae & % Total premaxillae	
	<4 mm	%<4 mm	>4 mm	%>4 mm			<4 mm	%<4 mm	>4 mm	%>4 mm		
Shark/Ray												
Dogfish Fam												
Spurdog												
Spurdog?												
Ray Fam												
Thornback Ray												
Herring Fam												
Herring Fam?												
Atlantic Herring												
Atlantic Herring?												
Salmon And Trout Fam			1	0.3	1	0.3						
Salmon And Trout Fam?												
Allis Shad/Twaite Shad												
Eel	2	13.3	2	0.7	4	1.3						
Conger Eel												
Hake									4	0.9	4	0.9
Cod Fam	5	33.3	91	31.2	96	31.3	1	10.0	145	33.6	146	33.1
Cod Fam?												
Cod/Saithe/ Pollack												
Cod	4	26.7	122	41.8	126	41.0	3	30.0	177	41.1	180	40.8
Cod?			14	4.8	14	4.6	1	10.0	29	6.7	30	6.8
Haddock	3	20.0	42	14.4	45	14.7			45	10.4	45	10.2
Haddock?			1	0.3	1	0.3			5	1.2	5	1.1
Whiting			1	0.3	1	0.3			1	0.2	1	0.2
Whiting?												
Pollack												
Saithe	1	6.7	11	3.8	12	3.9	5	50.0	9	2.1	14	3.2
Saithe?									2	0.5	2	0.5
Norway Pout/Bib/Poor-Cod												
Norway Pout												
Rockling												
Five Bearded Rockling												
Three Bearded Rockling												
Greater Fork Beard?									1	0.2	1	0.2
Ling			5	1.7	5	1.6			11	2.6	11	2.5
Ling?									1	0.2	1	0.2
Sea Breams												
Wrasse Fam												
Wrasse Fam?												
Ballan Wrasse												
Atlantic Horse-mackerel												
Atlantic Mackerel												
Atlantic Mackerel?												
Dragonet												
Butterfish												

Butterfish?												
Gurnard Fam									1	0.2	1	0.2
Red Gurnard												
Red Gurnard?												
Sea Scorpion Fam?												
Sea Scorpion			1	0.3	1	0.3						
Flatfish												
Turbot Fam												
Megrim												
Halibut Fam												
Lemon Sole												
Plaice												
Plaice?												
Angler			1	0.3	1	0.3						
Viv. Eel Pout												
Unidentified												
Grand Total	15	100	292	100	307	100	10	100	431	100	441	100

Table 4.14: Dentaries and premaxillae recovered from <4mm and >4mm fractions by species NISP and percent



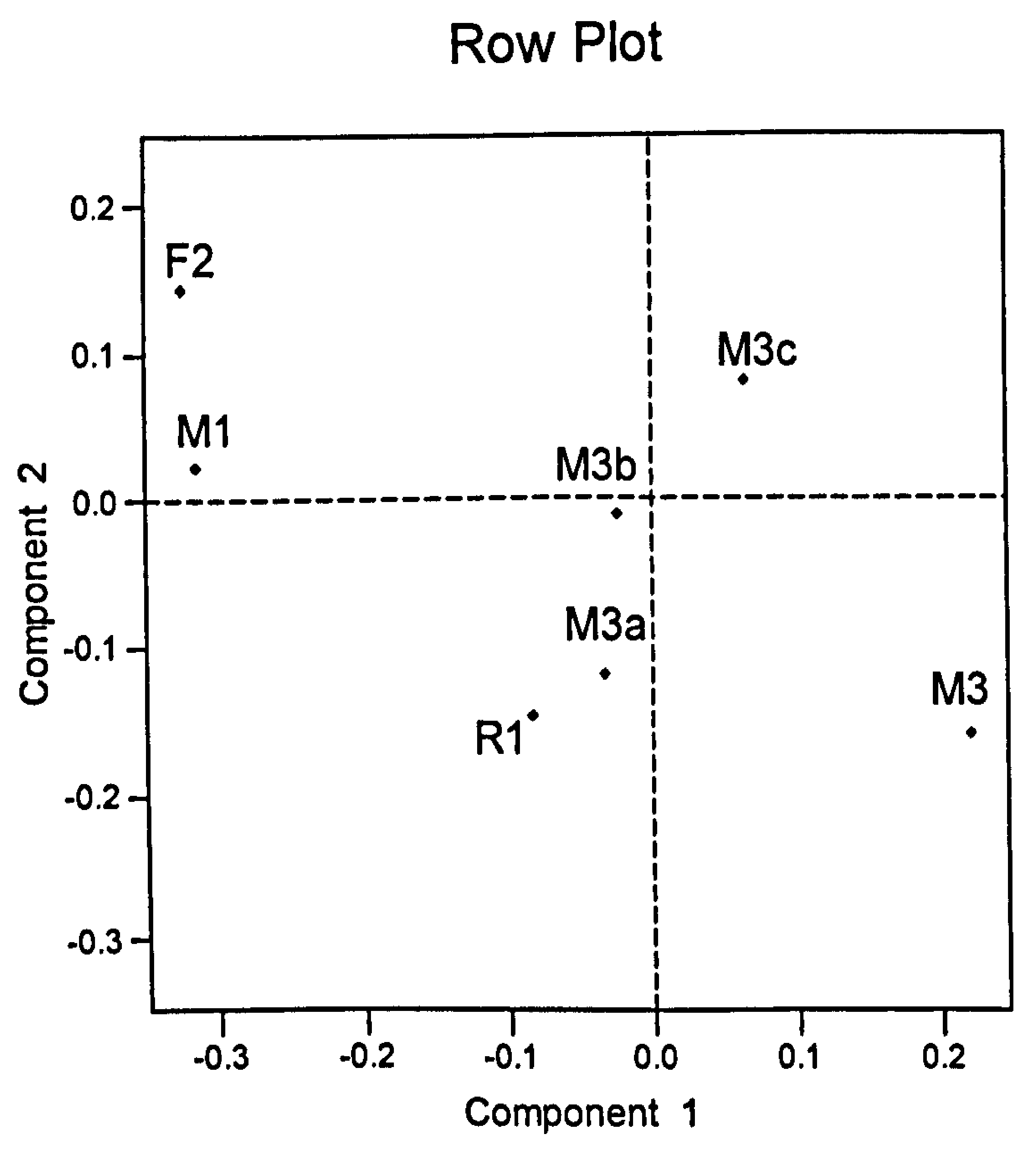
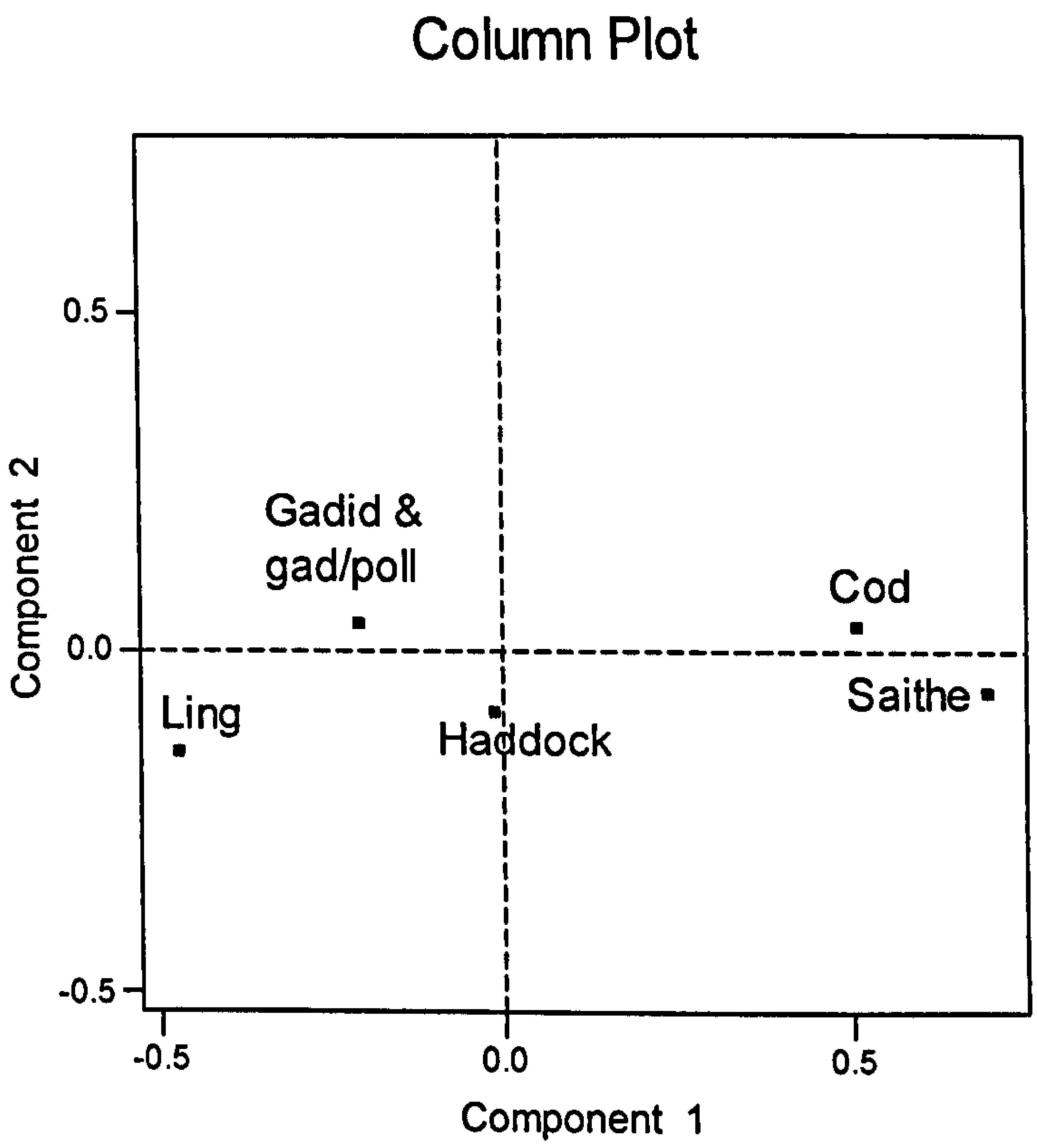


Figure 4.16: Row and column CA plots of QC1 element NISP counts for main gadid species and major phases (hand collected and >4mm) (see Table 4.15 for contributions)



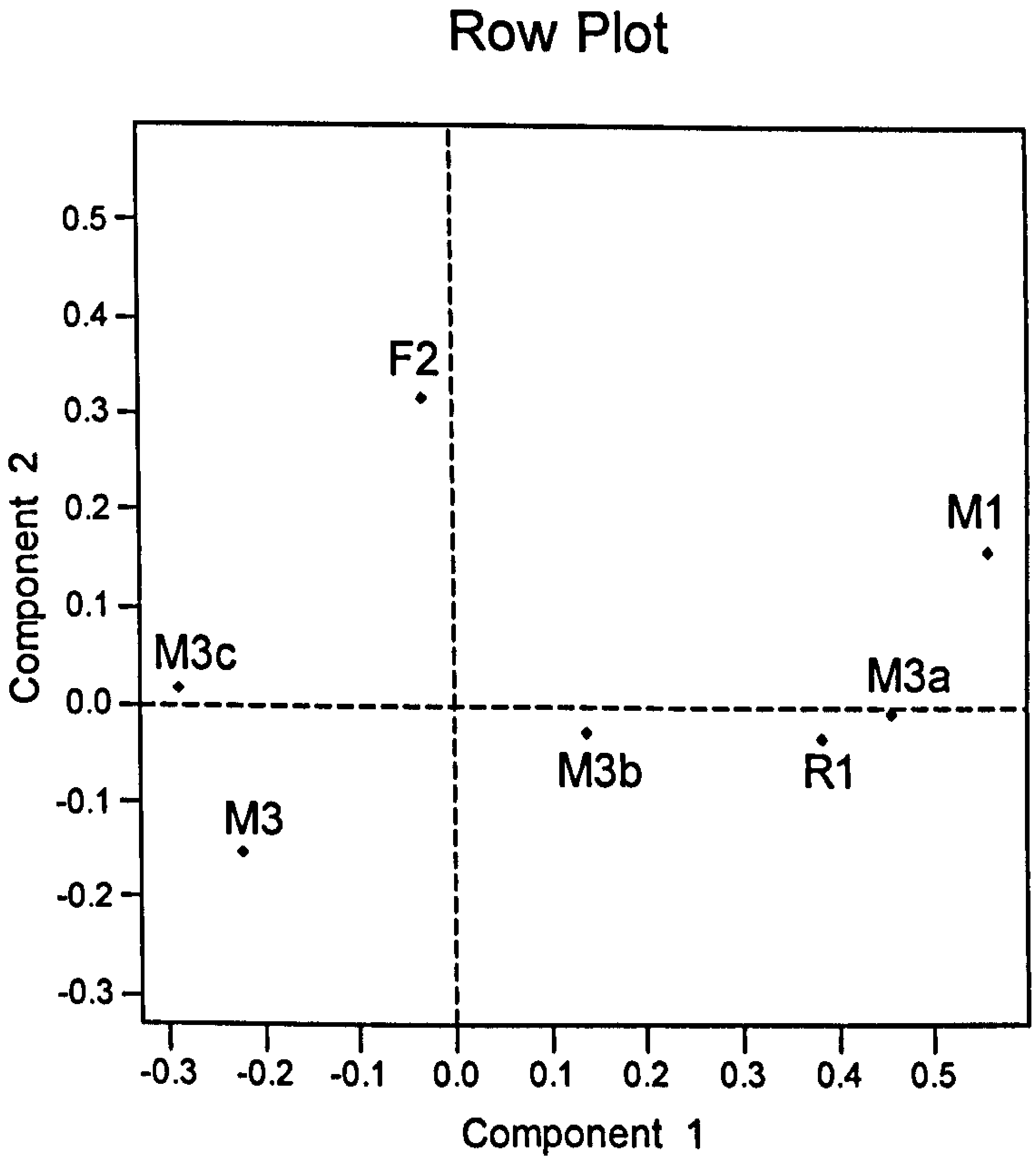


Figure 4.17: Row and column CA plot of QC2 elements and premaxilla and dentary NISP counts for main species, major phases, hand collected, >4mm and <4mm (see Table 4.16 for table of contributions)

Rows:				Component 1			Component 2		
Phase groups	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
F2	0.86	0.03	0.19	-0.32	0.722	0.270	0.144	0.144	0.077
M1	0.88	0.03	0.17	-0.31	0.883	0.301	0.023	0.005	0.002
M3	0.96	0.05	0.18	0.22	0.631	0.224	-0.159	0.330	0.167
M3a	0.94	0.14	0.09	-0.03	0.070	0.012	-0.118	0.874	0.223
M3b	0.13	0.22	0.04	-0.02	0.114	0.010	-0.010	0.021	0.003
M3c	0.96	0.42	0.19	0.06	0.359	0.135	0.082	0.601	0.324
R1	0.95	0.08	0.10	-0.08	0.234	0.046	-0.146	0.718	0.203
Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Gadid	0.85	0.27	0.18	0.00	0.002	0.001	0.116	0.850	0.420
Cod	0.94	0.46	0.21	-0.09	0.854	0.344	-0.032	0.095	0.055
Haddock	0.97	0.22	0.26	0.13	0.674	0.337	-0.092	0.302	0.216
Ling	0.83	0.02	0.12	0.32	0.724	0.173	-0.128	0.115	0.039
Saithe	0.78	0.01	0.22	0.31	0.339	0.145	0.360	0.441	0.270

Table 4.15: Contributions for CA plot Figure 4.16

Rows:				Component 1			Component 2		
Phase groups	Quality	Mass	Inertia	Co-ordinate	Contrib . to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
F2	0.84	0.01	0.01	-0.03	0.008	0.000	0.318	0.832	0.366
M1	0.98	0.03	0.10	0.55	0.911	0.104	0.159	0.074	0.218
M3	0.78	0.05	0.04	-0.22	0.539	0.027	-0.151	0.247	0.317
M3a	0.98	0.13	0.27	0.45	0.987	0.292	-0.006	0.000	0.001
M3b	0.85	0.22	0.04	0.13	0.825	0.044	-0.026	0.029	0.040
M3c	1.00	0.45	0.37	-0.29	0.996	0.398	0.017	0.003	0.035
R1	0.92	0.08	0.13	0.38	0.920	0.135	-0.031	0.006	0.023
Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib . to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Gadid & *Gadus/ Pollachius*	0.99	0.51	0.22	-0.20	0.961	0.231	0.040	0.035	0.217
Cod	0.98	0.18	0.47	0.51	0.982	0.506	0.038	0.006	0.074
Haddock	0.87	0.23	0.02	-0.01	0.016	0.000	-0.090	0.857	0.505
Ling	0.83	0.02	0.08	-0.47	0.755	0.065	-0.149	0.075	0.167
Saithe	0.93	0.03	0.19	0.69	0.932	0.198	-0.061	0.007	0.038

Table 4.16: Contributions for CA plot Figure 4.17

	Fish			Mammal		
Phase group	NISP	TNB	NISP QC1 weights (g)	NISP	TNB	NISP weights (g)
C2	443	1374	32.46	677	2543	3055.18
C3	61	291	27.21	533	1168	2053.26
F2	306	1311	63.86	918	2992	3941.26
M1	639	2540	67.83	2128	6594	9335.17
M3	1017	2984	108.30	59	206	165.03
M3a	2461	9234	207.71	2619	9090	8610.31
M3b	4296	14762	432.57	5691	19482	24403.46
M3c	8194	25162	753.88	10246	34161	27395.74
R1	1544	5552	127.13	2874	8986	10642.82
R3	380	1440	57.25	1319	2704	7099.67
Totals	19341	64650	1878.20	27064	87926	96701.9

Table 4.17: NISP, TNB and weight summary for fish and mammals

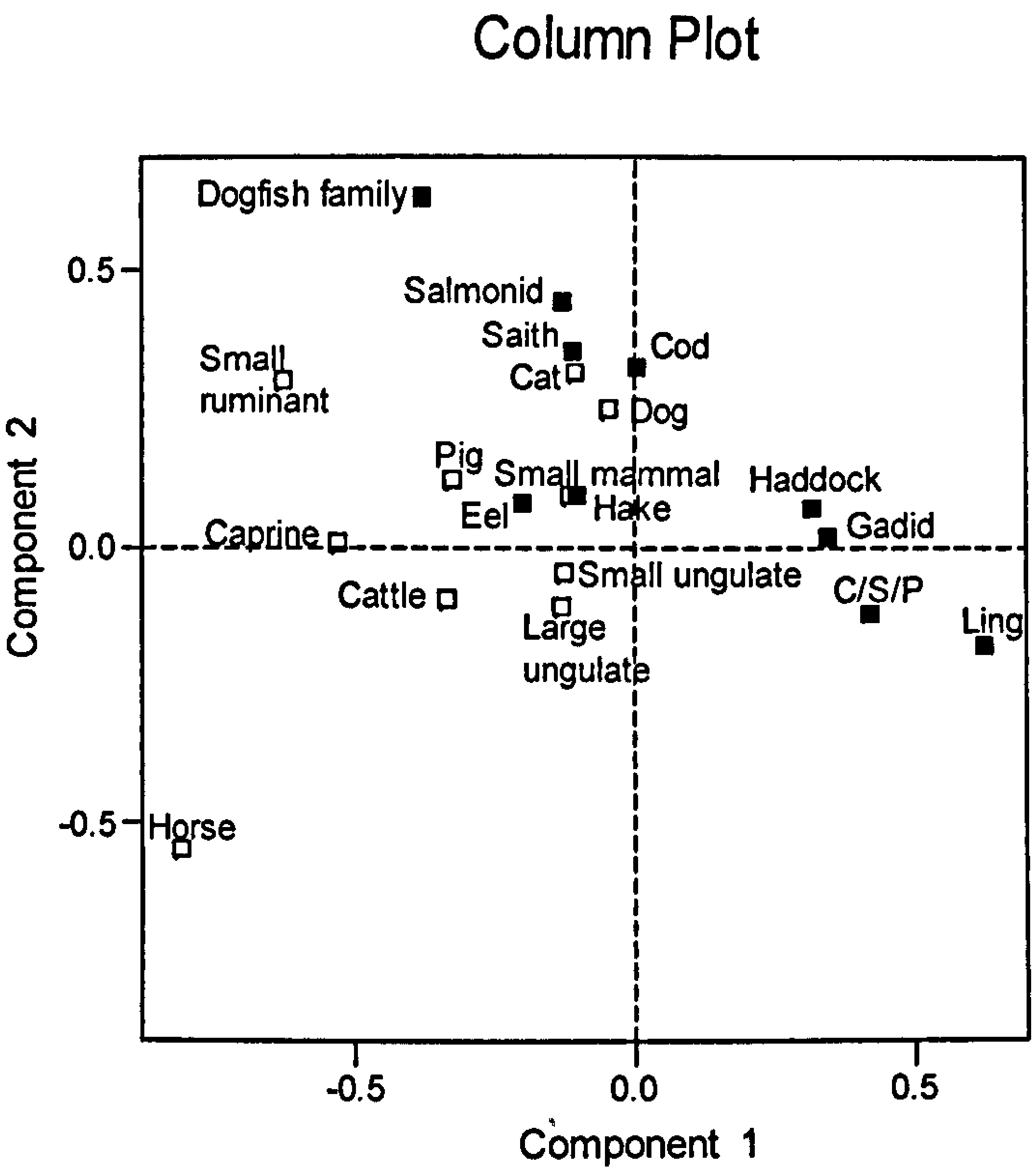


Figure 4.18: Column CA plot of all species with >20 NISP, fish QC1, 2, 3 and all mammals, hand collected and >4mm recovery (see Table 4.18 for contributions)

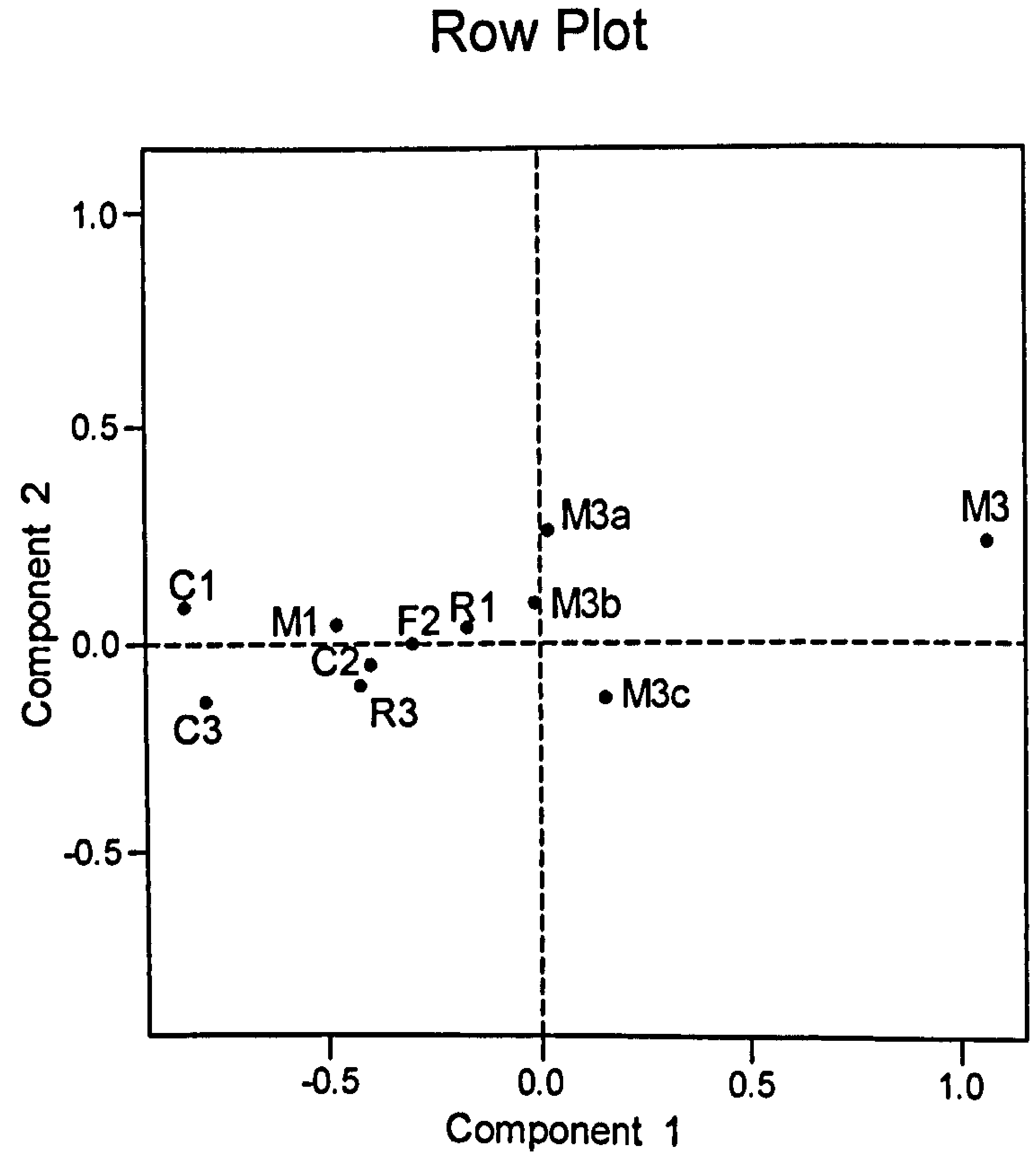
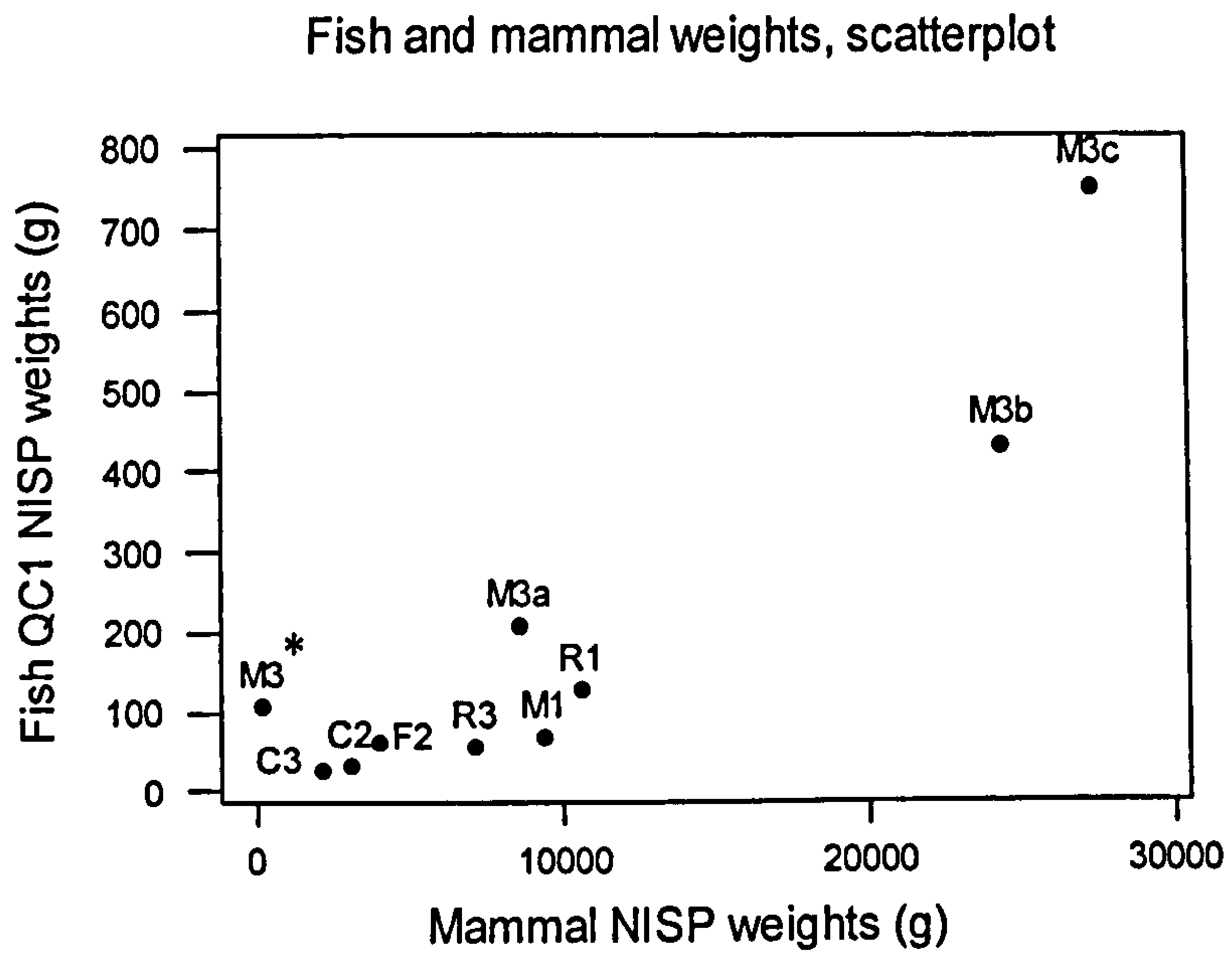


Figure 4.19: Row CA plot of phase groups, matching Figure 4.18 (see Table 4.18 for contributions)

Rows:				Component 1			Component 2		
Points	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
C1	0.097	0.000	0.003	-0.832	0.096	0.000	0.086	0.001	0.000
C2	0.817	0.020	0.030	-0.398	0.803	0.043	-0.051	0.013	0.003
C3	0.626	0.014	0.107	-0.786	0.608	0.115	-0.136	0.018	0.014
F2	0.308	0.026	0.059	-0.302	0.308	0.032	0.003	0.000	0.000
M1	0.808	0.059	0.126	-0.476	0.801	0.178	0.043	0.007	0.006
M3	0.862	0.025	0.256	1.061	0.822	0.370	0.234	0.040	0.075
M3a	0.750	0.104	0.071	0.022	0.005	0.001	0.258	0.745	0.389
M3b	0.300	0.216	0.047	-0.012	0.005	0.000	0.092	0.295	0.103
M3c	0.962	0.401	0.130	0.156	0.566	0.130	-0.130	0.396	0.380
R1	0.301	0.096	0.076	-0.173	0.287	0.039	0.039	0.014	0.008
R3	0.587	0.039	0.095	-0.425	0.556	0.093	-0.101	0.031	0.022

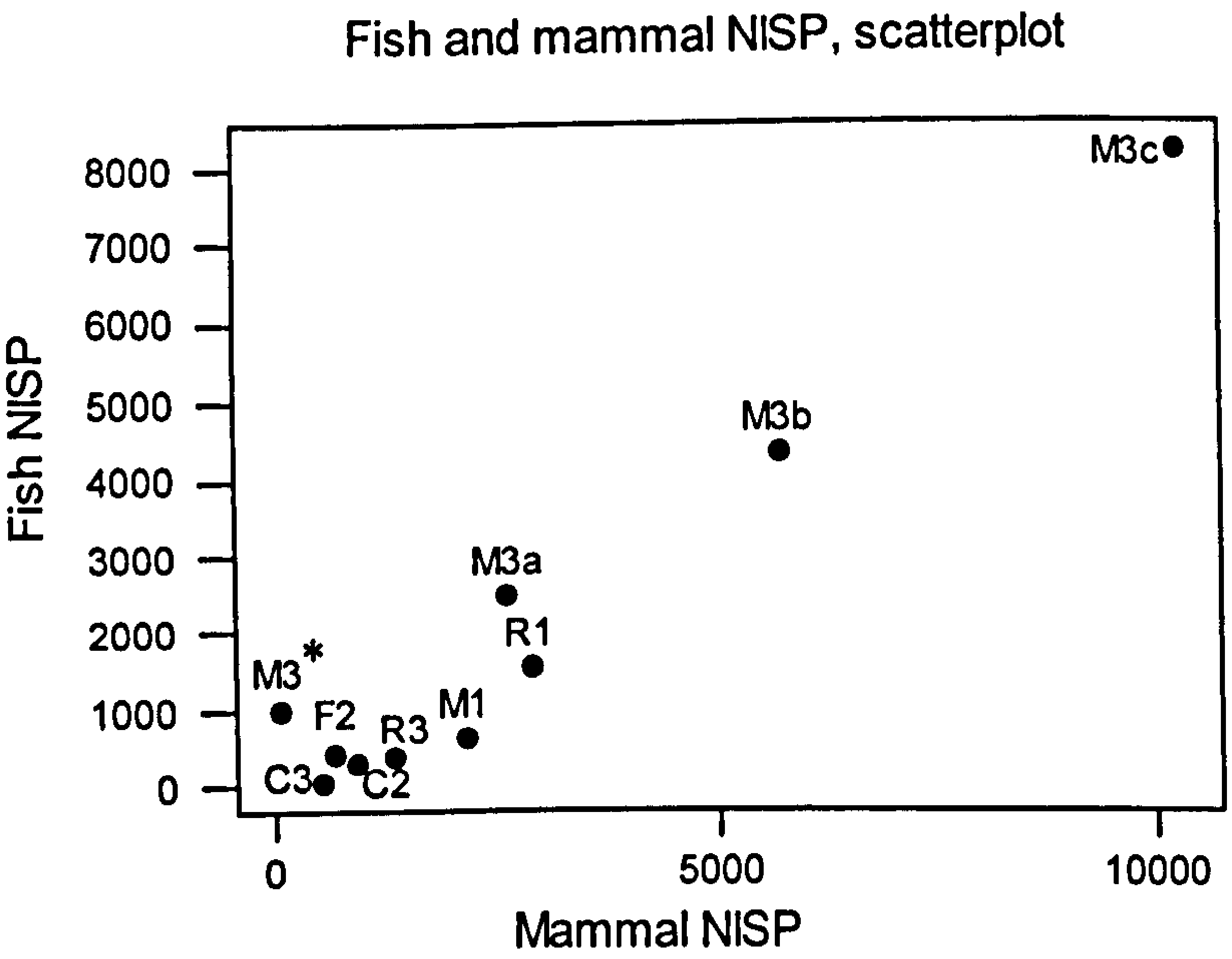
Columns:				Component 1			Component 2		
Points	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Caprine	0.742	0.038	0.109	-0.533	0.742	0.142	0.010	0.000	0.000
Cat	0.149	0.005	0.028	-0.108	0.015	0.001	0.319	0.133	0.027
Cattle	0.707	0.064	0.085	-0.340	0.662	0.099	-0.088	0.045	0.028
Cod	0.886	0.085	0.079	0.005	0.000	0.000	0.330	0.886	0.517
Gadid	0.921	0.121	0.122	0.349	0.917	0.196	0.022	0.004	0.003
Gad.Poll.	0.978	0.099	0.146	0.420	0.908	0.233	-0.117	0.070	0.076
Dog	0.261	0.005	0.010	-0.046	0.008	0.000	0.250	0.253	0.019
Dogfish	0.452	0.001	0.006	-0.386	0.123	0.001	0.631	0.329	0.015
Eel	0.070	0.001	0.007	-0.200	0.060	0.001	0.080	0.009	0.000
Haddock	0.872	0.079	0.072	0.317	0.829	0.105	0.072	0.043	0.023
Hake	0.034	0.001	0.005	-0.116	0.020	0.000	0.096	0.014	0.000
Horse	0.172	0.001	0.025	-0.814	0.118	0.005	-0.547	0.053	0.010
Large ung.	0.523	0.222	0.088	-0.130	0.322	0.050	-0.102	0.201	0.130
Ling	0.727	0.010	0.042	0.629	0.677	0.050	-0.172	0.051	0.016
Pig	0.729	0.035	0.045	-0.326	0.635	0.050	0.125	0.094	0.031
Saithe	0.616	0.006	0.010	-0.115	0.058	0.001	0.356	0.558	0.041
Salmonid	0.511	0.002	0.006	-0.132	0.041	0.000	0.447	0.470	0.019
Small mam.	0.115	0.020	0.026	-0.105	0.063	0.003	0.094	0.051	0.010
Small rum.	0.535	0.003	0.020	-0.634	0.435	0.015	0.303	0.099	0.015
Small ung.	0.406	0.203	0.069	-0.129	0.370	0.045	-0.040	0.036	0.018

Table 4.18: Contributions for CA plots Figure 4.18 and Figure 4.19



* very little mammal bone was assigned to this phase, a bias which will be investigated in future

Figure 4.20: Fish and mammal weight scatter plot, by phase group



* very little mammal bone was assigned to this phase, a bias which will be investigated in future

Figure 4.21: Fish and mammal NISP scatter plot, by phase group

4.5 Element variation

Element variation has the potential to indicate if fish were arriving complete or prepared in some way, as well as showing taphonomic biases. If cured fish are processed prior to transportation, certain elements may be found in higher quantities than others at the processing site or at the consumption site. These can include cranial elements removed at the processing site, with appendicular and vertebral elements being disposed of when and where consumed (including cleithra and supracleithra). Particular elements that are robust would be expected in higher quantities than those that are more fragile, examples being the dense areas found within the haddock posttemporal and cleithra. Others would not survive to the same extent because of their fragile and easily fragmented nature, including the gadid scapula, basipterygium and coracoid, and to a lesser degree, cod cleithra (Barrett 1997, 623; confirmed by the Earl's Bu data).

Most of the quantification presented here uses NISP data, but because certain elements may fragment into recognisable zones more readily than others, some exploration using MNE (minimum number of elements) data must be used. In particular, it became apparent that the parasphenoid was particularly prevalent when NISP counts were doubled for both the parasphenoid and the vomer, in order to enable comparison with elements that occur in left and right pairs (Figure 4.22). The parasphenoid is a relatively large and robust midline element that is often found broken in two or more pieces longitudinally, all of which may be identified. Therefore, both the basic cod and haddock NISP results (Figure 4.22 and Figure 4.24) were compared with their respective MNE results (Figure 4.23 and Figure 4.25). MNE was calculated by determining the maximum occurrence of any one diagnostic zone, with paired element zones taking the higher occurring value of left or right for that zone, thus enabling immediate comparison with singly-occurring elements.

The most obvious patterning in the cod assemblage is the high proportion of cod cleithra (a fragile element) in M3b compared to all other phase groups. This may be indicative of additional cleithra arriving without accompanying cranial elements. Phase group M3b is not as well preserved as M3a or M3, and is approximately equal in preservation to M3c (see section 4.2), making the high cleithra count in M3b more meaningful: this pattern appears to represent actual activity patterns.

Turning to haddock NISP and MNE results, the most immediate pattern is the predominance of cleithra among all but the R1 deposits (Figure 4.24). Along with phase group M3a, R1 is among the best preserved of all phases for haddock (see section 4.2), which might mean that the pattern is biased by the excellent preservation of all elements.

If this were true, however, R1 should display a similar element distribution to M3a, but it does not. Therefore, R1 is the only phase group without a predominance of cleithra. Moreover, this pattern does not disappear using MNE data, indicating that it is not the result of high fragmentation of elements into many readily identifiable zones. Because both haddock cleithra and posttemporals have an area of densely ossified bone, they might both be expected to survive much better than other elements. Posttemporals are found in quantity approaching that of the cleithra only in phase groups R1 and M3c using NISP data, but when considering MNE data, phase groups M3 and M3c also have comparable quantities. In contrast, phase group R3 has large quantities of cleithra and not a single posttemporal. It therefore appears that a real difference in element quantities can be observed: considerable extra haddock cleithra were introduced to M1 (but see below for further analysis of this phase group), M3a, M3b and R3 phase groups, and moderate additional quantities may be present in M3 and M3c. Phase group R1 uniquely is dominated by quadrate fragments, particularly when considering MNE data, suggesting a departure from both M1 and M3 patterning. The good preservation of haddock in this phase may account for the larger quantities of quadrate, but as M3a is equally well preserved, yet did not have correspondingly high quantities of quadrates, this pattern is probably real. For haddock, the quadrate is the next most robust element after the cleithrum and posttemporal, and the great difference between phase group R1 and all others could be indicative of entire fish being consumed without any processed fish arriving on site.

Having ascertained that a quantity of cod and haddock cleithra were probably introduced to the assemblage without an increase in other QC1 elements, size data can then be introduced to explore these patterns in more detail. Figure 4.26 expands upon the cod NISP results of Figure 4.22 by adding size categories for each element, while Figure 4.27 shows size categories for the haddock QC1 elements quantified in Figure 4.24.

Phase group M3a is the earliest to have substantial sample sizes for the major species. For cod, a mode in most element quantities occurs in the 300-500mm or 500-800mm total length categories, with a decrease towards >1000mm total lengths. There are two exceptions: articulars are highest in the >1000mm category and cleithra in the 800-1000mm total length category. M3b doesn't have a consistent mode across all elements, although only among the cleithra is there a substantial mode in the 800-1000mm total length category with a sharp decline to both smaller and larger. This is much less pronounced in the M3c deposits, although still present: here, almost every element has a mode in the 300-500mm or 500-800mm total length category and declines neatly to >1000mm, but the cleithra are notably higher in the >1000mm total length category. Using all data from M3 combined, the difference between cleithra size frequencies is very apparent: more 800-1000mm total length cod cleithra were introduced to the assemblage without other matching QC1 elements. This pattern cannot be observed in phase group M1.

Among the haddock, cleithra and posttemporals would naturally predominate over the other elements given their robust nature, but only the cleithra dominate most phase groups. Despite the small sample size, 300-500mm and 500-800mm total length cleithra outnumber all other element and sizes in phase group M1. In the later phase groups, particularly M3b and M3c, cleithra from fish of 500-800mm total length were the most common size, but considerable quantities of 800-1000mm total length cleithra were also recovered. Phase group M3 had more hand collected bone than M3a, M3b, M3c or M1 (see Table 4.2), which might account for the over-representation of the large and robust cleithra in this phase. However, the presence of this pattern in other phase groups with less hand collected bone indicates it is not a recovery bias. Combining all M3 data, it is apparent that a considerable addition of 500-800mm and 800-1000mm total length sized cleithra occurred.

Overall, the size data probably indicate the arrival of imported cleithra for both cod and haddock, particularly towards the later phase groups. As will be demonstrated with the vertebrae below – which are less biased by recovery methods than the cleithra – these imported cleithra arrived as prepared fish without cranial elements.

The ratio of cod to haddock throughout most of the phase groups (Figure 4.30), illustrated using NISP QC1 data, can provide further details on the introduction of haddock to the site, particularly extra cleithra. Direct comparison is difficult for some elements because of different morphology, particularly between robust haddock cleithra and fragile cod cleithra. Overall however, it is evident that during M1 considerably more cod were consumed than haddock for most elements, and the M3 deposits show generally less cod per haddock than found in M1.

QC3 elements were only identified to family and not to species for Earl's Bu, which makes any direct comparisons between haddock and cod impossible for this category. Figure 4.28 illustrates the abundance of each gadid QC3 and QC1 element by NISP and phase group, with appendicular elements (including the cleithra) represented by darker bars. The supracleithra are robust appendicular elements that could be expected to survive well, along with the basioccipital, another dense, robust and easily identifiable element. However, despite its potentially good survival rate, the supracleithrum is a long and thin element that can easily pass through a 4mm sieve. Experimental studies indicate that even 500-800mm total length sized cod, saithe and ling supracleithra can be lost (Barrett 1997, 623), and in addition, these elements were not routinely identified from the <4mm fraction (a problem corrected during the identification of the Quoygrew fish). Despite these biases against its recovery, the supracleithrum remains very abundant in most phase groups, a pattern consistent with the importation of prepared fish. Although haddock supracleithra may be less susceptible to loss, because of their broader morphology, they were only identified to family.

Figure 4.28 indicates high levels of appendicular elements are apparent in phase groups M3 (all), R3, and in particular, M3b, where the cleithra and supracleithra are both abundant compared to the other elements. The scapula is a fragile and small element, that although appendicular, is easily susceptible to taphonomic and preservation biases. Consequently no association was observed between it and the other appendicular elements.

Vertebral elements cannot be directly compared because of variations in the quantities found between – or within – species. Figure 4.29 therefore shows the abundance of vertebral elements for *Gadus/Pollachius*, haddock and ling, taking into account the variation in quantities by dividing the NISP of each vertebral element by the approximate quantity of that element in one fish. The ultimate and penultimate vertebrae do occur only once in each fish, but these elements are very small, even in large individuals, so are often not recovered; they are included here for consistency but are not discussed. This bias is also found in the posterior caudal vertebrae, so a reduction in quantities of the second caudal vertebrae category is both expected and observed. Hand collected, >4mm and <4mm data are used in order to include the smaller caudal vertebrae that originated with the larger fish. When the number of elements per fish is variable (based on modern comparative specimens), the maximum and minimum values are shown using a darker colour. Two QC1 elements have been added to this, the dentary and the premaxilla, because both were recorded using hand collection, >4mm and <4mm data, again with differences between left and right illustrated by darker bars. Approximately equal quantities of vertebrae and QC1 elements would be expected if entire fish were disposed of together, but although this is true for *Gadus/Pollachius* in M1, haddock display fewer QC1 elements than vertebrae, particularly for the M3b and M3c phase groups. The specimens identified only to *Gadus/Pollachius* display this trend to a lesser degree than haddock in phase group M3, though in phase groups M3b and M3c, the QC1 elements are markedly fewer in quantity than their corresponding vertebrae.

Within each species, the rank order of elements was used as a means of examining differences or similarities between phases; these were then statistically tested using Spearman's Rho. A preliminary examination of cod QC1 elements from hand collected and >4mm fractions, for the midden phase groups, illustrates the difference in ranks observable: for example, the quadrate ranks first, fourth, first, seventh and eighth in order from M1 to M3c. Significant correlations obtained using Spearman's Rho indicates phase groups that have statistically similar rank orders, and are likely to be caused by similar economic and taphonomic factors.

Only three correlations were found within the cod assemblage using the combined hand collected and >4mm datasets, of which two of these correlations were found within the >4mm dataset alone, indicating only one correlation was the result of differential collection of certain elements (see section 4.1) (Table 4.24). These results were surprising as it was thought that if correlations in rank order were to be found, they would be found within the midden deposits or within similar phase groups. The three significant correlations all involved the two phase groups contemporary with the use of the mill: C2 and F2, that is, those with the worst preservation (see section 4.2). Their rank orders are probably strongly determined by the preservation characteristics of each element. That the vast majority of phase group pairs were not significantly correlated suggests that a variety of factors other than preservation influenced their patterning, and thus supports the arguments raised above for differences in butchery and transport patterns – with more preserved fish imported in some phases than others.

Within the haddock QC1 assemblage, significant rank correlations were obtained on six pairs of phase groups, as shown in Table 4.23 (identical results were obtained using both the >4mm fraction alone and the combined hand collected and >4mm fraction, because the rank orders were identical for each). These results separate into two groups. Rank orders were statistically similar within the M3a-M3b-M3c group and within the M3-R1-R3 group; no other correlations were found, but there were insufficient quantities to include phase groups C2, C3 and F2. As discussed above, a slight over-representation of haddock cleithra in M1 suggested the possible arrival of processed fish even in this earliest phase, but the vertebral evidence was inconclusive compared to the later phases. M1 uniquely has no correlations in rank order with any other phase group, suggesting its causal factors vary considerably from the other phase groups. Thus the haddock in phase group M1 were mostly or all whole fish, caught locally and deposited in their entirety, but possibly a few prepared haddock were arriving at this time. The evidence suggests a considerable change in haddock patterning through time.

In conclusion, despite the many potential biases, the abundance of haddock cleithra in phase groups M3a, M3b and R3 is indicative of processed fish arriving at Earl's Bu. A similar but less extreme pattern can be observed among the cod assemblage for phase group M3b. The deposits from M3a were found to be better preserved than others (see section 4.2), and given the tendency of the cod cleithra towards easy fragmentation, the over abundance of cod cleithra within M3b – and not M3a – reduces the possibility that this pattern was the result of a preservation bias. There is no indication of prepared cod arriving during phase group M1, but during this time some small quantities of prepared haddock may have arrived. During this early phase group, cod were the predominant fish species exploited, with haddock only becoming more important in the later phases. Haddock cleithra and posttemporals are naturally robust, but haddock were still an important economic species when considering the prevalence of other less robust elements.

Elements	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3	Total	Rank order
Articular	2	2	4	4	4	26	27	47	16	6	138	9
Cleithrum	2	2	4	9	13	27	66	67	12	5	207	3
Dentary	1	2	7	7	7	18	26	67	8	3	146	8
Maxilla	4	2	8	7	8	26	55	70	12	1	193	4
Parasphenoid*	13	2	9	11	14	24	37	86	26	6	228	1
Posttemporal	1		5	7	11	27	39	65	20	5	180	7
Premaxilla	7	2	10	11	7	27	35	95	17	7	218	2
Quadrate	7		7	16	10	30	33	58	23	2	186	5
Vomer*	4		8	9	6	29	36	76	17		185	6
Total per phase group	41	12	62	81	80	234	354	631	151	35	1681	

* actual raw counts, not doubled as for figures

Table 4.19: Cod QC1 elements by phase group, >4mm and hand collected only

Elements	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3	Total	Rank order
Articular				1	4	11	16	37	1	2	72	4
Cleithrum	6	1	4	6	21	39	76	102	14	20	289	1
Dentary			1	4	4	4	9	16	5	3	46	8
Maxilla				1	5	6	8	26	4	1	51	5
Parasphenoid			1	1	6	5	7	12	7	5	44	9
Posttemporal	1	1	1	1	11	11	23	54	11		114	2
Premaxilla			3	1	1	9	10	22	3		49	7
Quadrate				1	9	13	15	31	18	7	94	3
Vomer				1	1	10	11	22	5		50	6
Total per phase group	7	2	10	17	62	108	175	322	68	38	809	

Table 4.20: Haddock QC1 elements by phase group, >4mm and hand collected only

Elements	M1	M3	M3a	M3b	M3c	R1	Total	Rank order
Articular		1		2	4		7	3
Cleithrum			1	2	2		5	5
Dentary				2	10		12	1
Maxilla		1			2		3	8
Parasphenoid			2		4	1	7	3
Posttemporal	1			1	3		5	5
Premaxilla				1	10		11	2
Quadrate			1		4		5	5
Vomer					3		3	8
Total per phase group	1	2	4	8	42	1	58	

Table 4.21: Saithe QC1 elements by phase group, >4mm and hand collected only

Elements	C3	F2	M3	M3a	M3b	M3c	R1	R3	Total	Rank order
Articular		1	1	5	1	4			12	3
Cleithrum					3	9	2	1	15	1
Dentary			2	1	2	1	1		7	5
Maxilla			1	1	1	4			7	5
Parasphenoid					1	2	2	1	6	7
Posttemporal				1		2		1	4	9
Premaxilla	1		1		5	5		1	13	2
Quadrate			2	3		5		2	12	3
Vomer	1		2	1		1			5	8
Total per phase group	2	1	9	12	13	33	5	6	81	

Table 4.22: Ling QC1 elements by phase group, >4mm and hand collected only

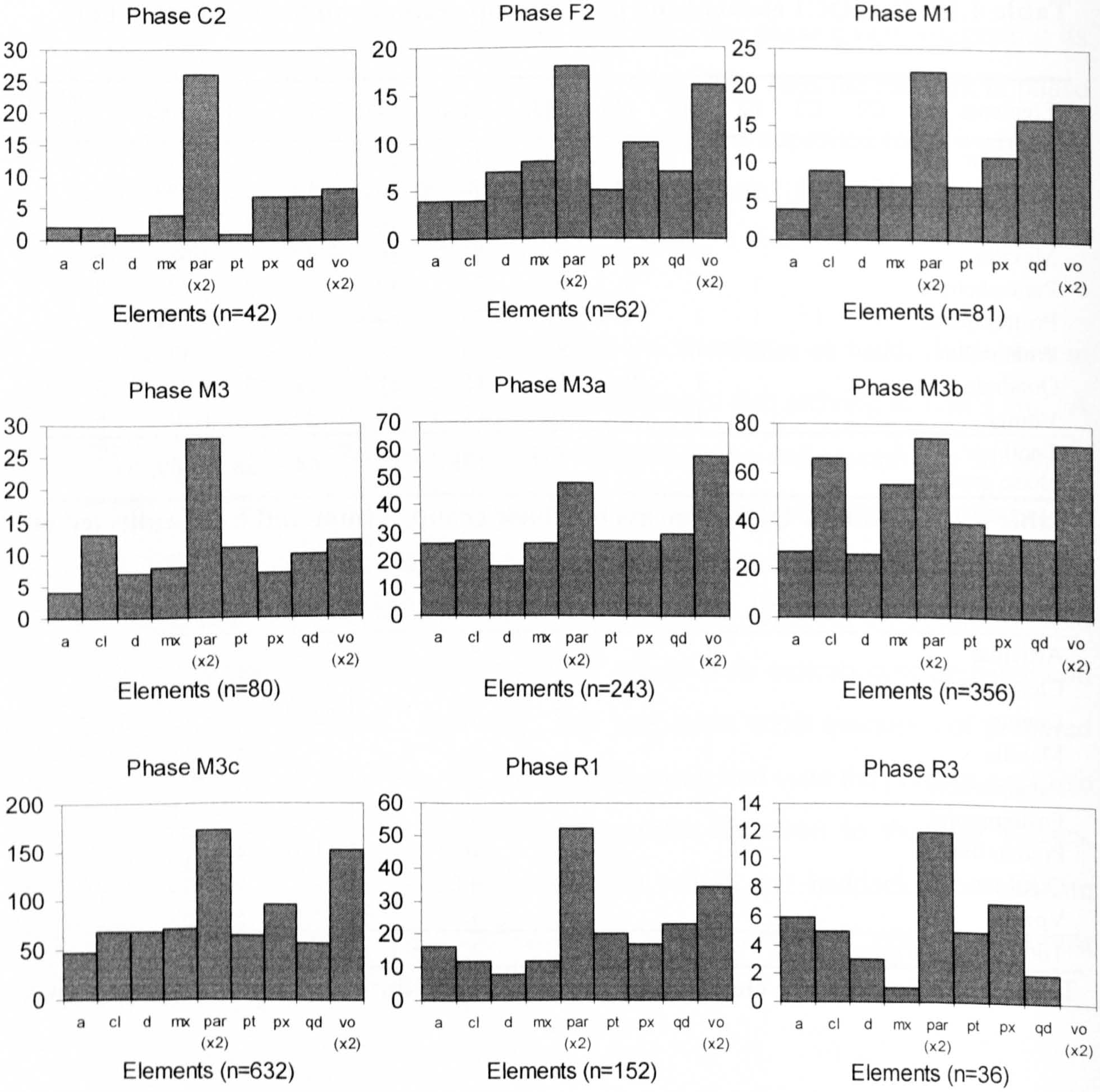


Figure 4.22: Cod element counts per phase group, NISP of all QC1 elements, hand collected and >4mm recovery (parasphenoid and vomer counts doubled, but n refers to actual total)

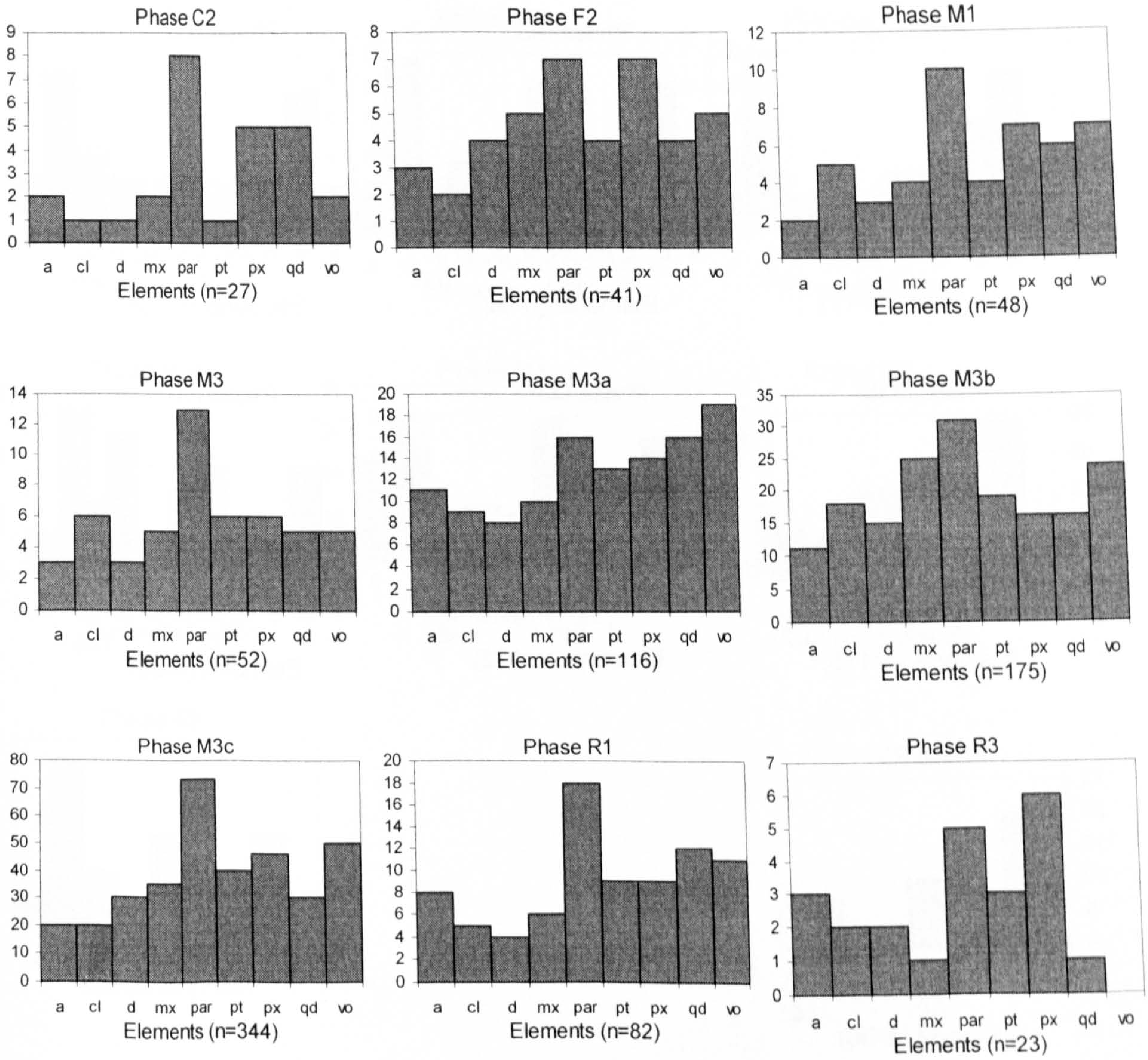


Figure 4.23: Cod element counts per phase group, MNE of all QC1 elements, hand collected and >4mm recovery

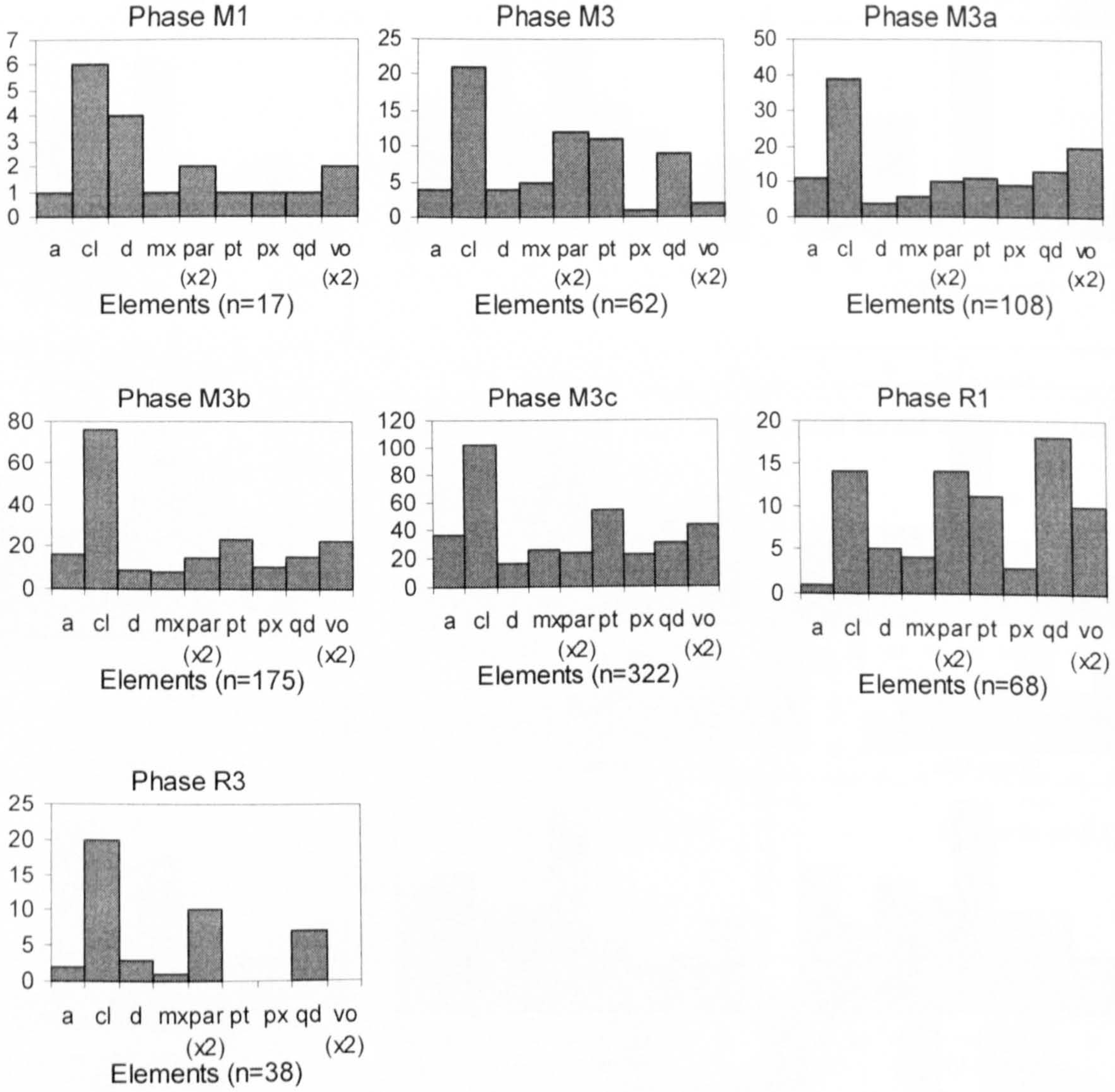


Figure 4.24: Haddock element counts per phase group, NISP of all QC1 elements, hand collected and >4mm recovery (parasphenoid and vomer counts doubled, but n refers to actual total)

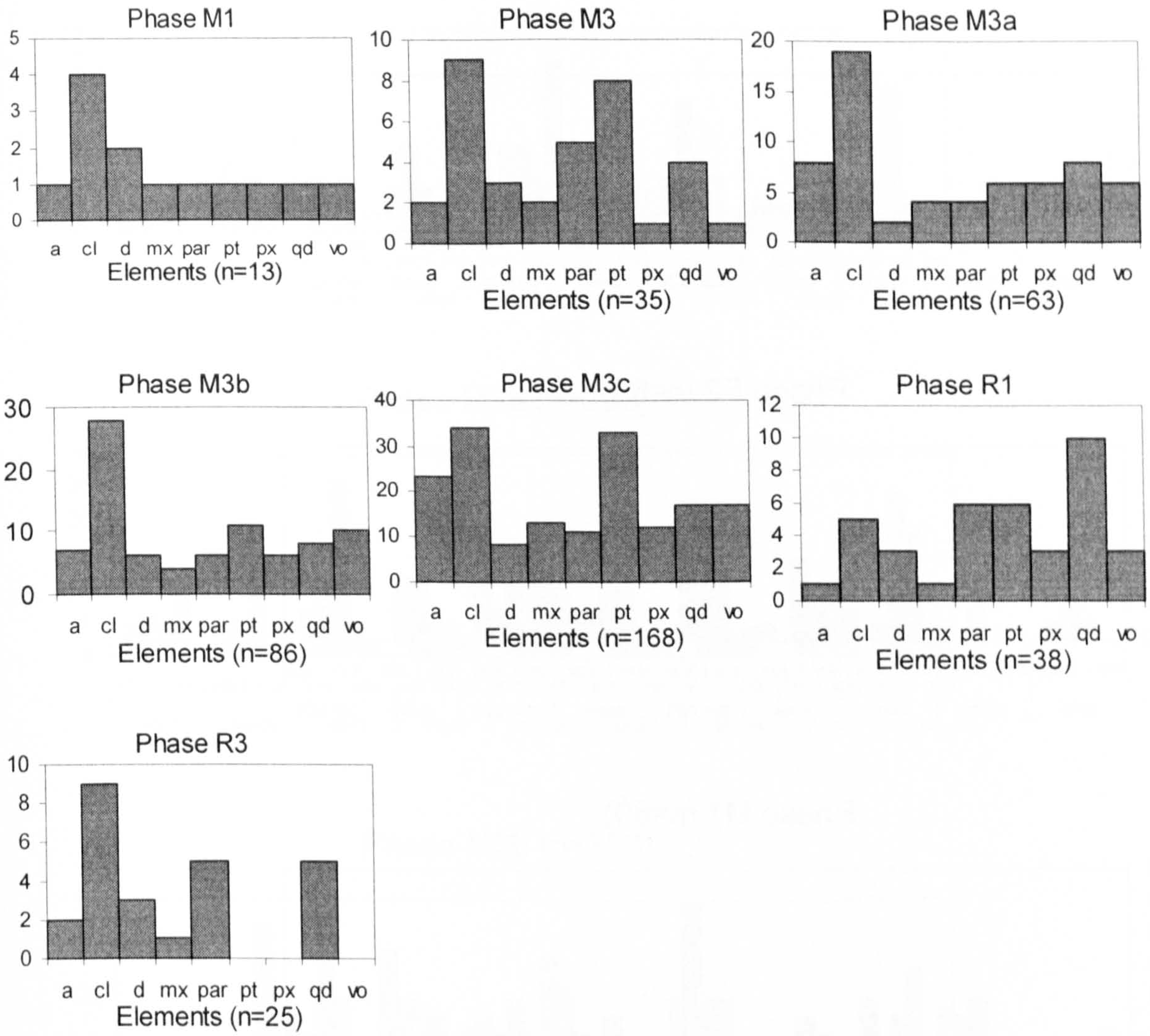
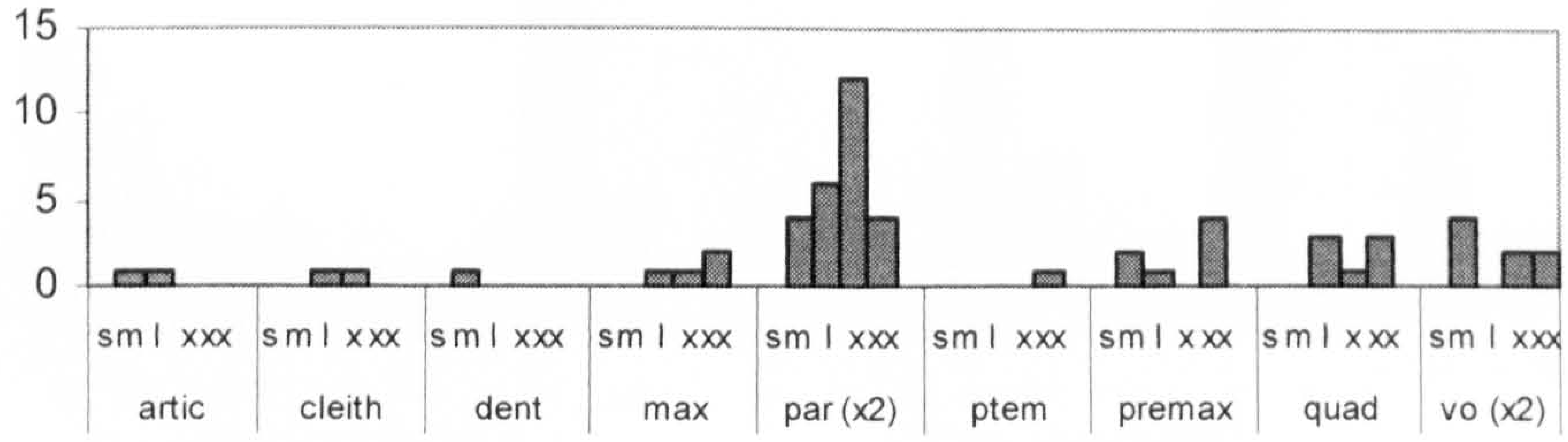
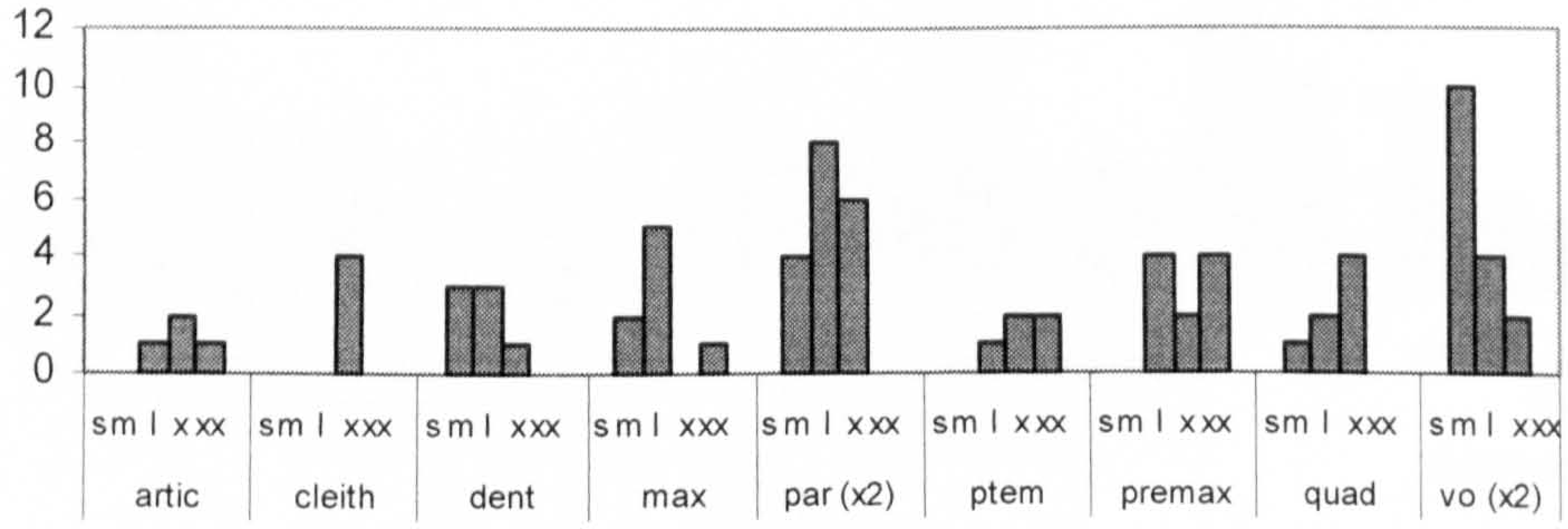


Figure 4.25: Haddock element counts per phase group, MNE of all QC1 elements, hand collected and >4mm recovery

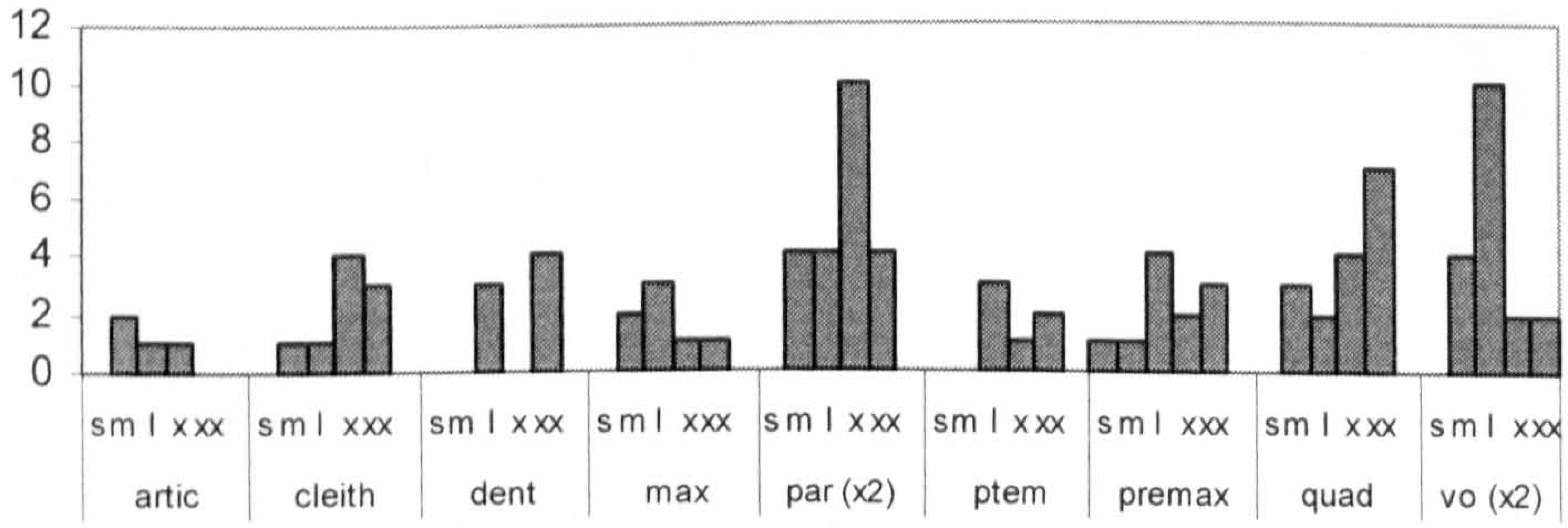
Phase C2 (n=41)

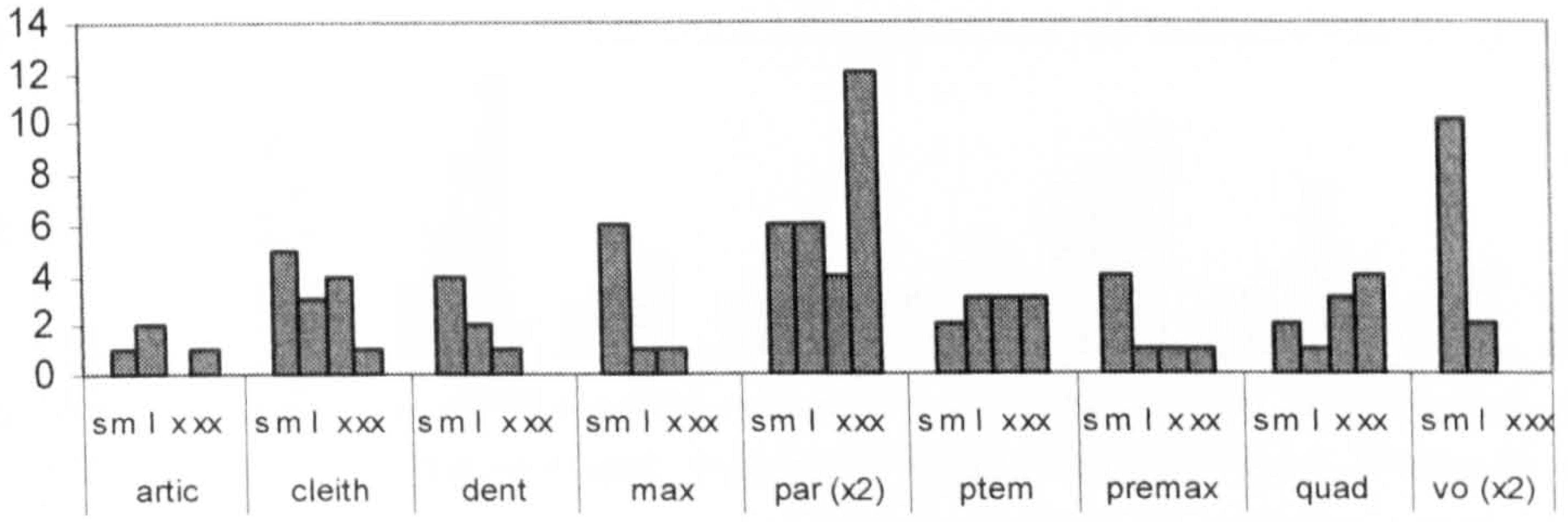


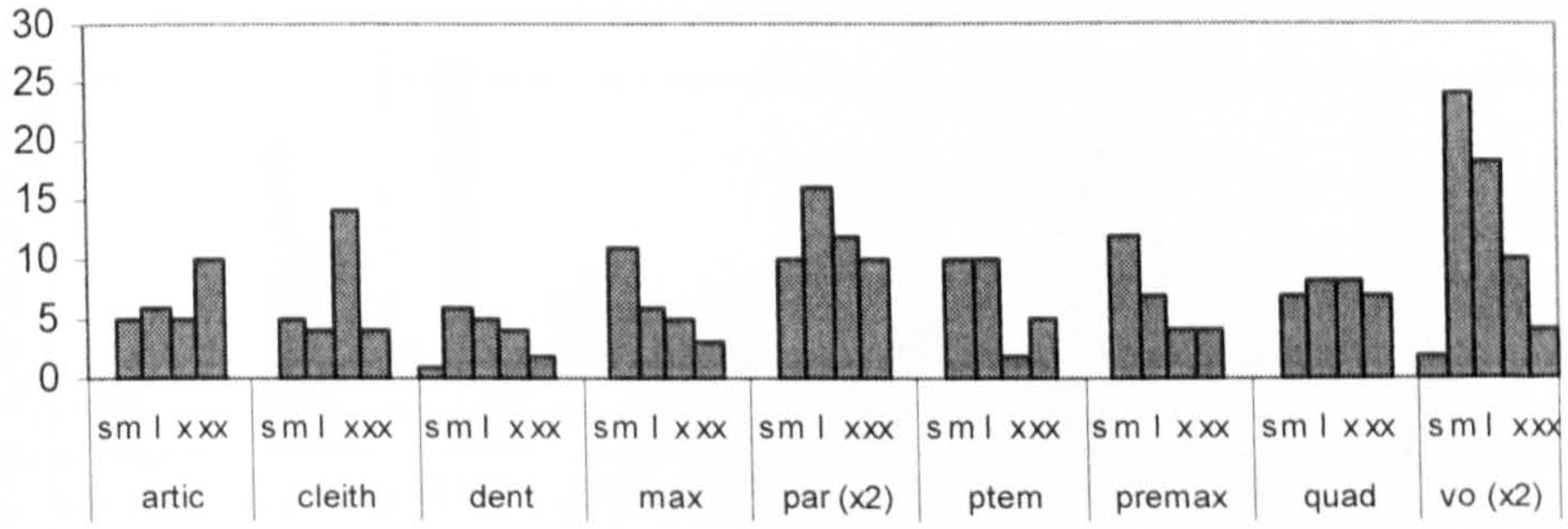
Phase F2 (n=62)

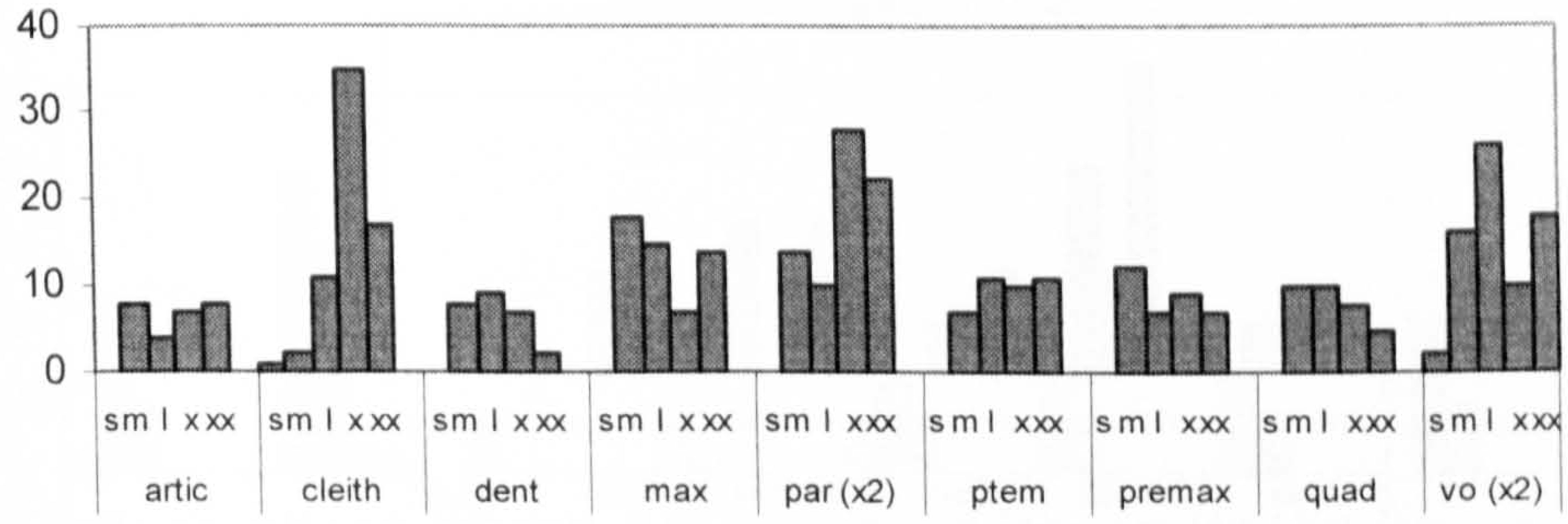


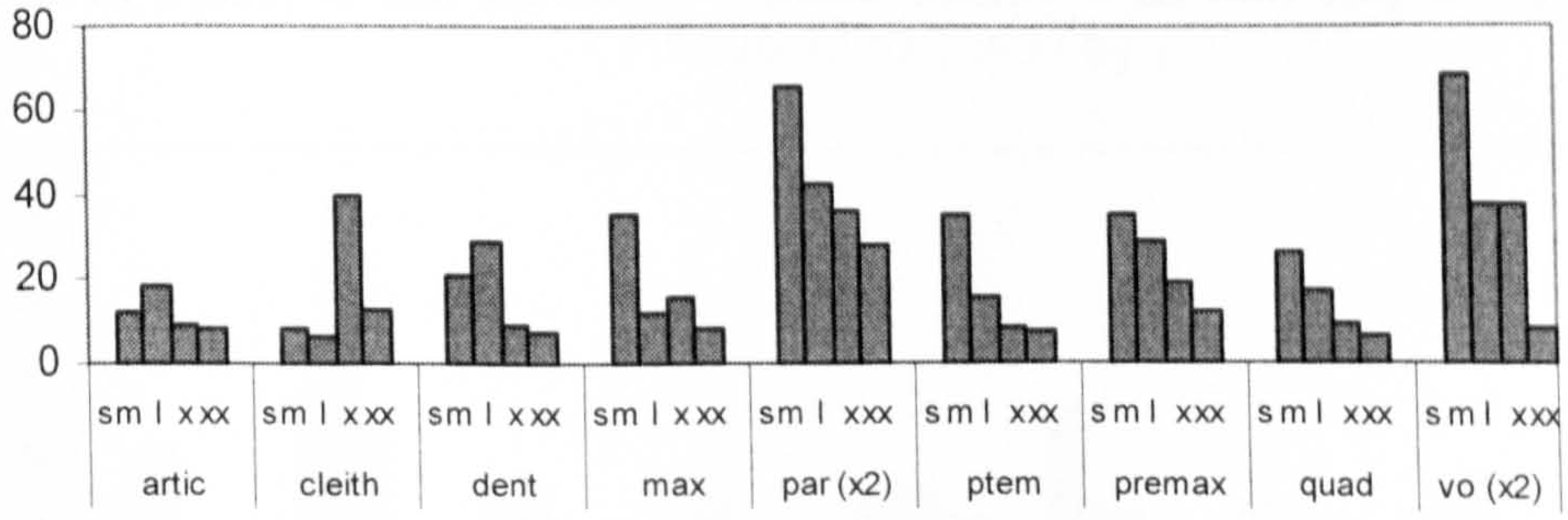
Phase M1 (n=80)

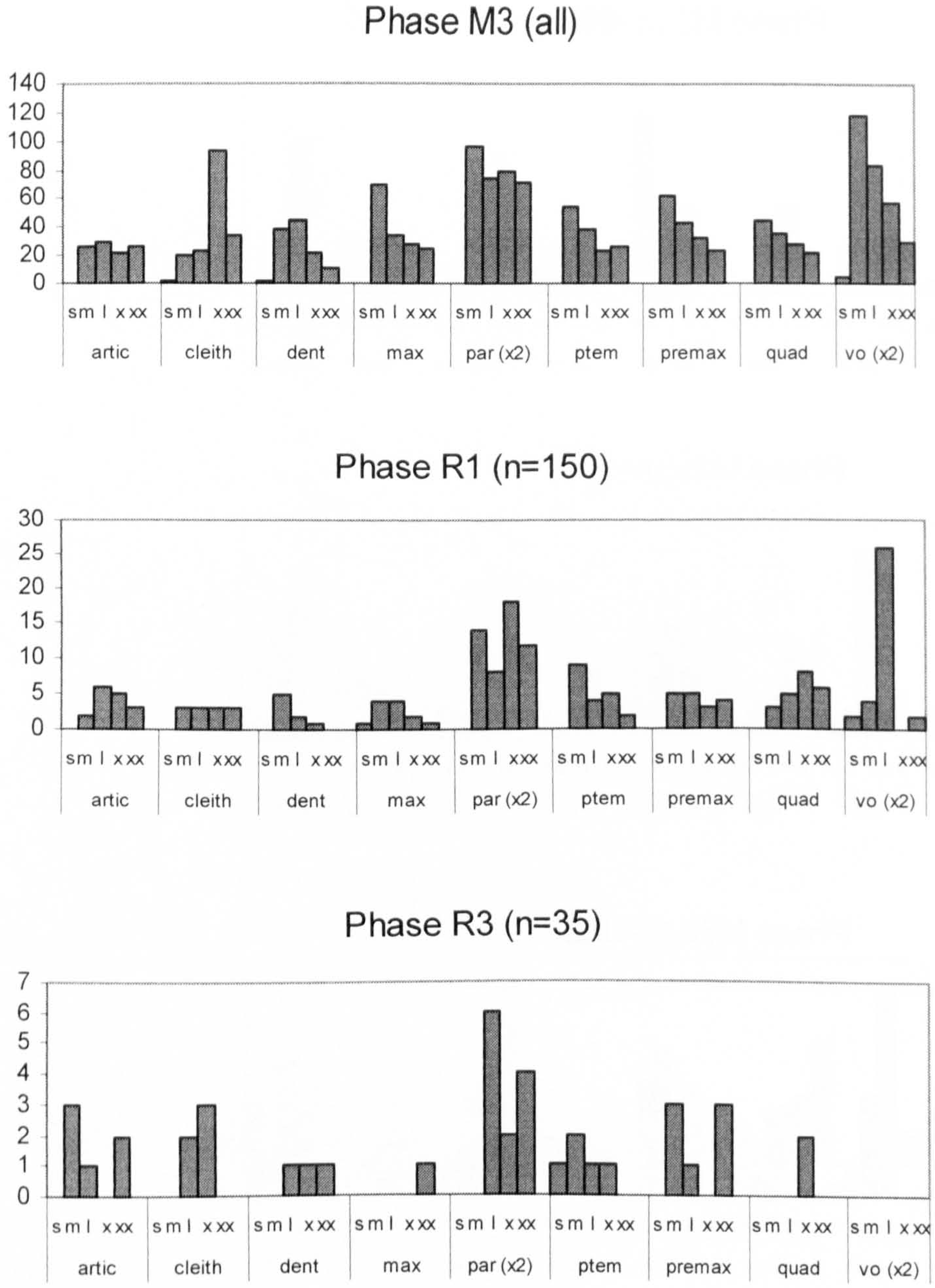



Phase M3 (n=80)


Phase M3a (n=233)


Phase M3b (n=353)


Phase M3c (n=630)

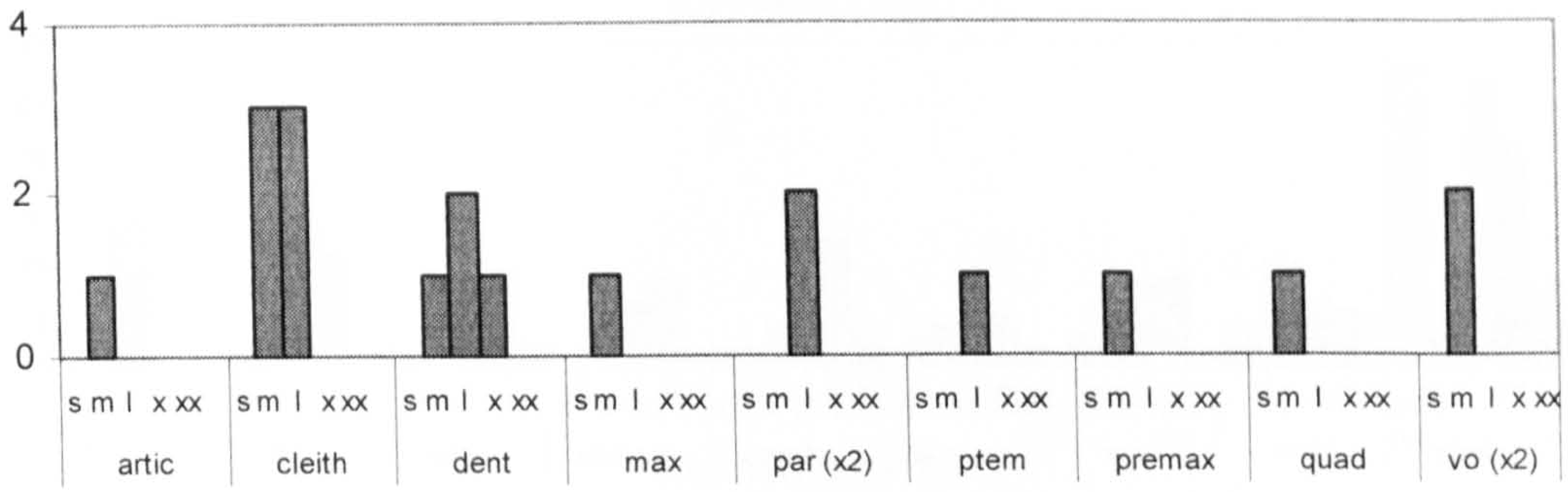

Phase M3 (all)

Phase R1 (n=150)

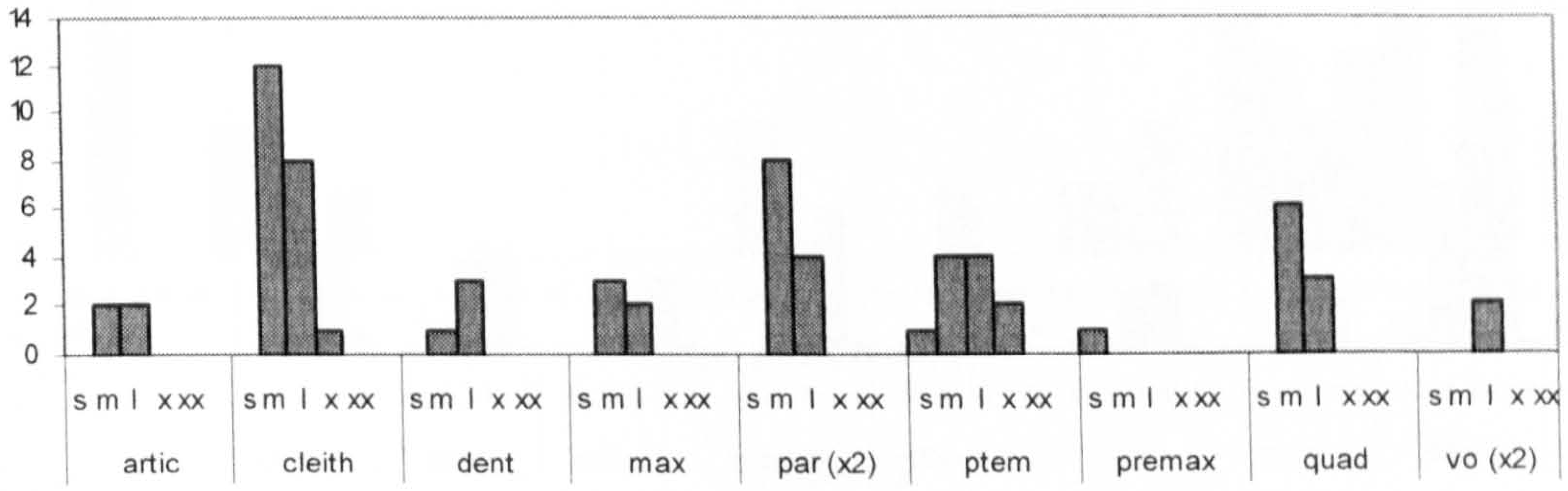
Phase R3 (n=35)

Figure 4.26: Cod elements and sizes by phase group, NISP of all hand collected and >4mm specimens (parasphenoid and vomer counts doubled, but n refers to actual total)

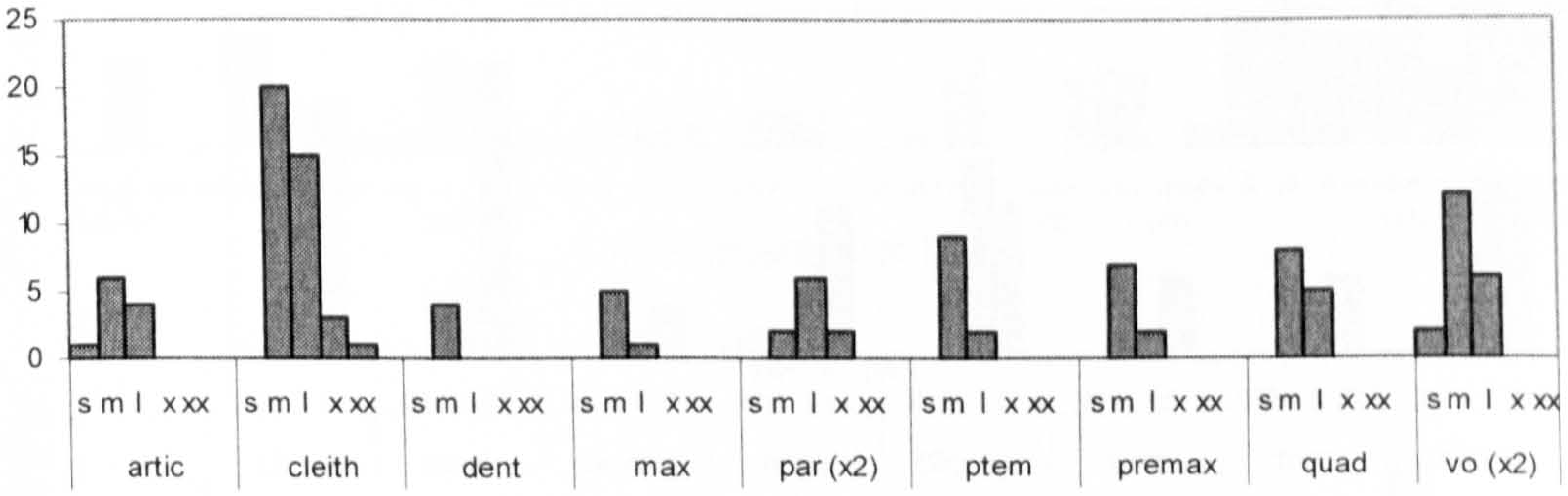
Phase M1 (n=17)



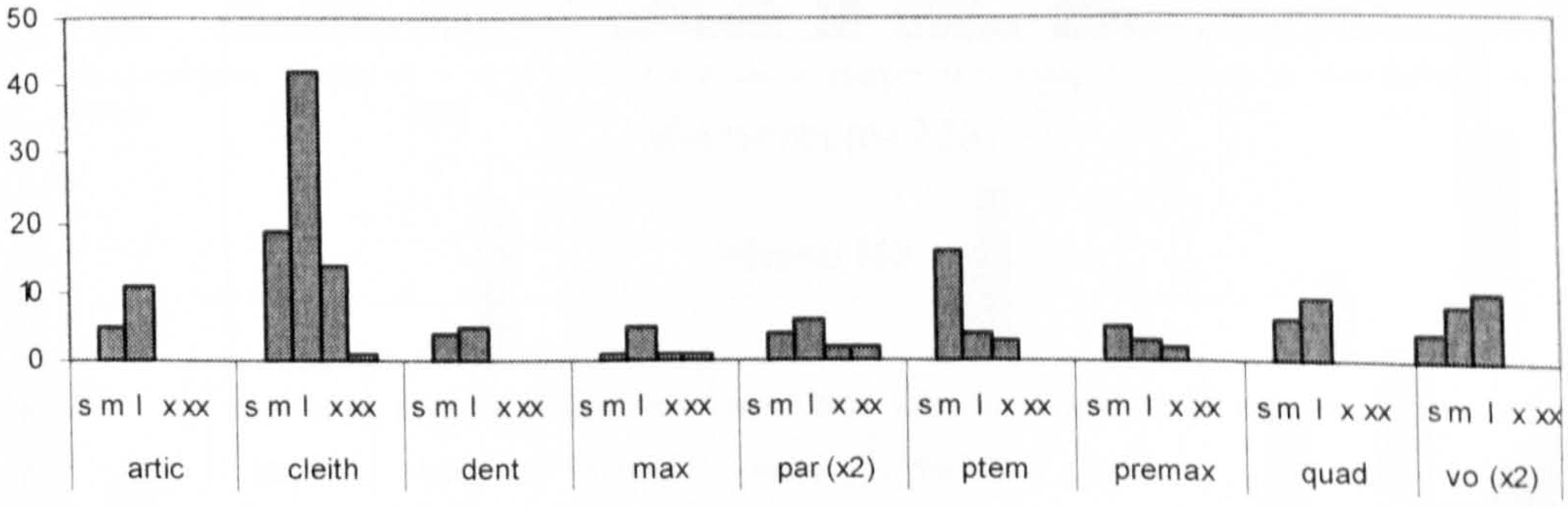
Phase M3 (n=62)



Phase M3a (n=108)



Phase M3b (n=175)



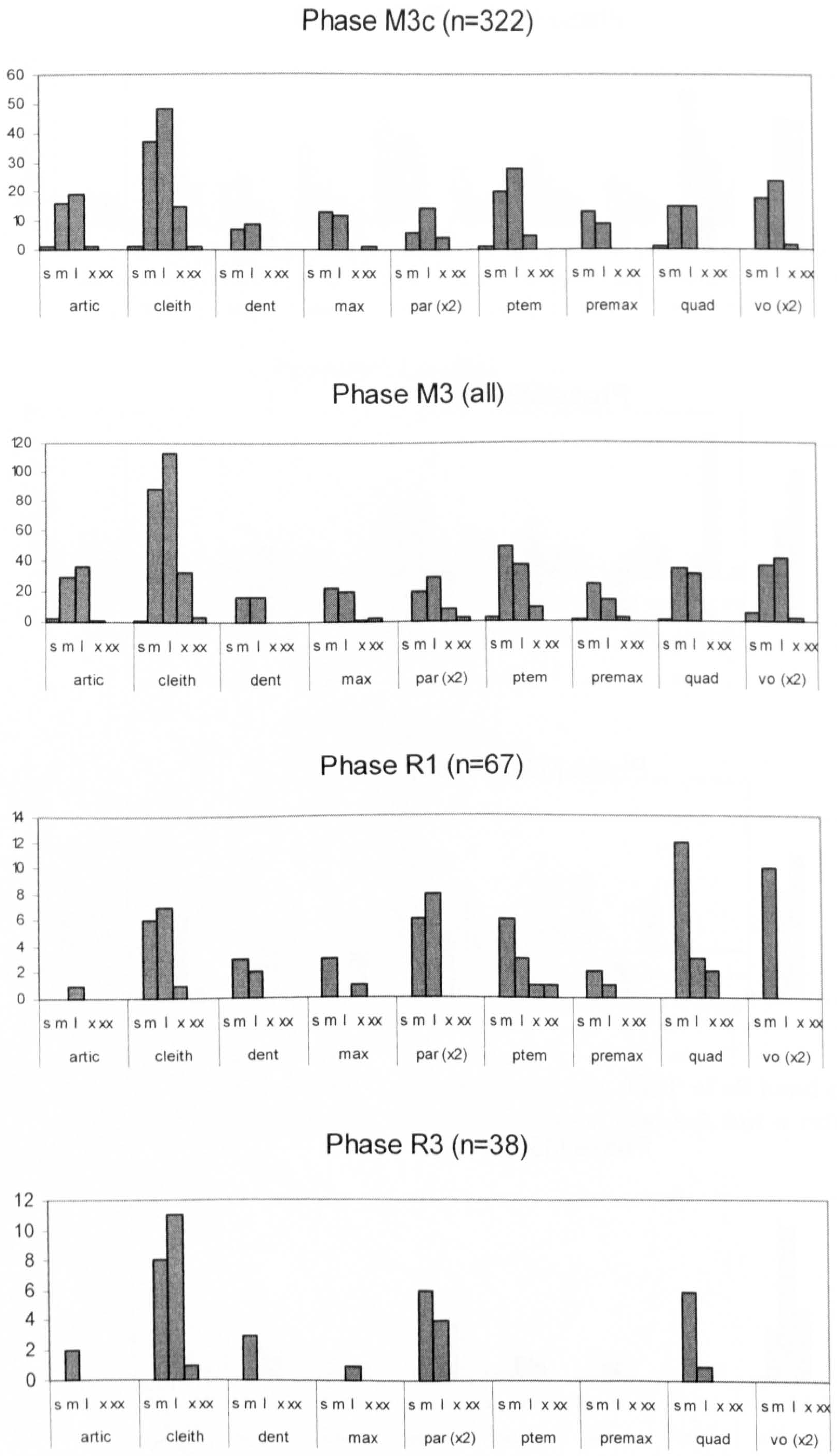
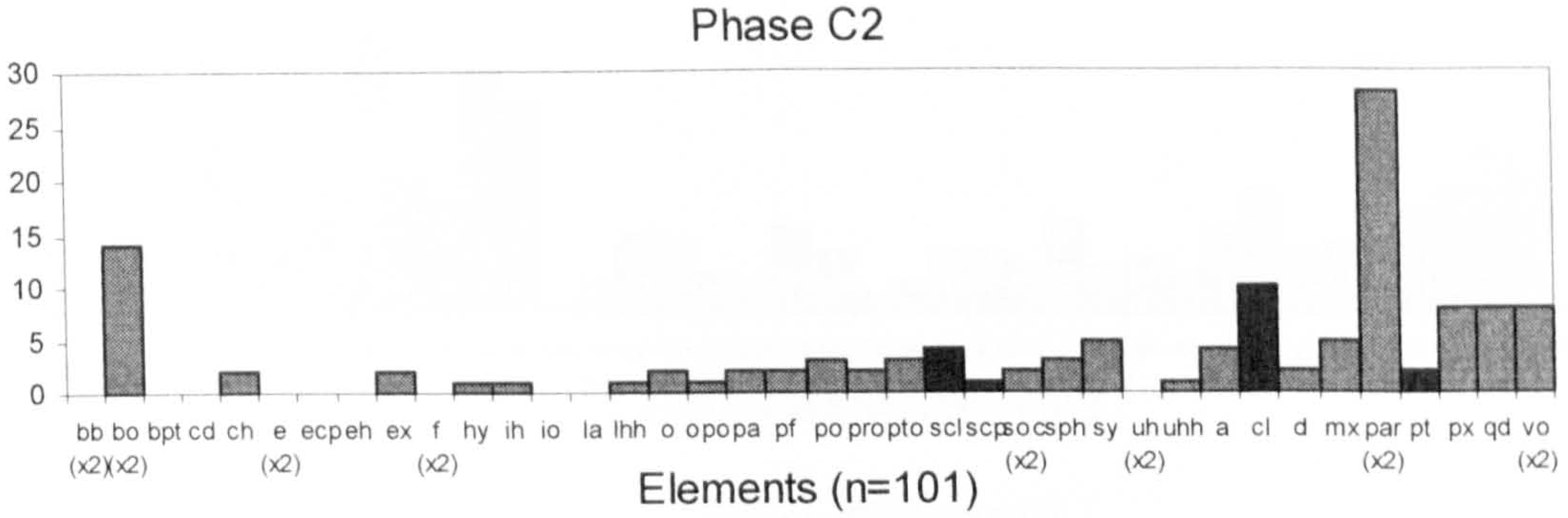
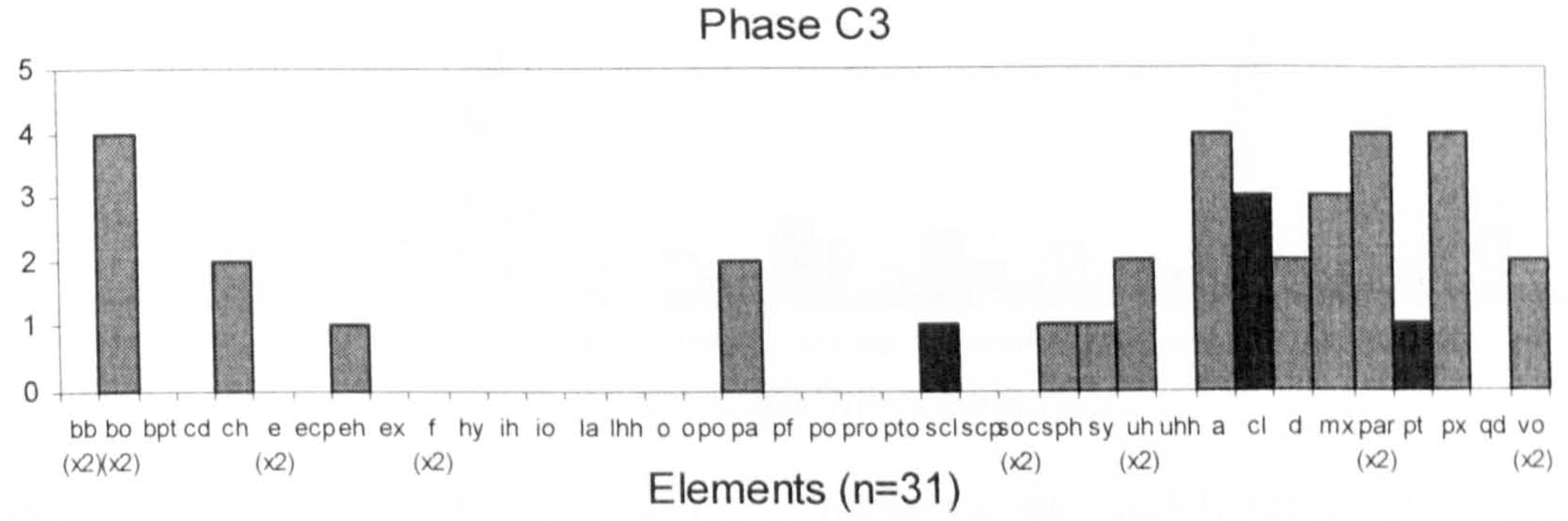
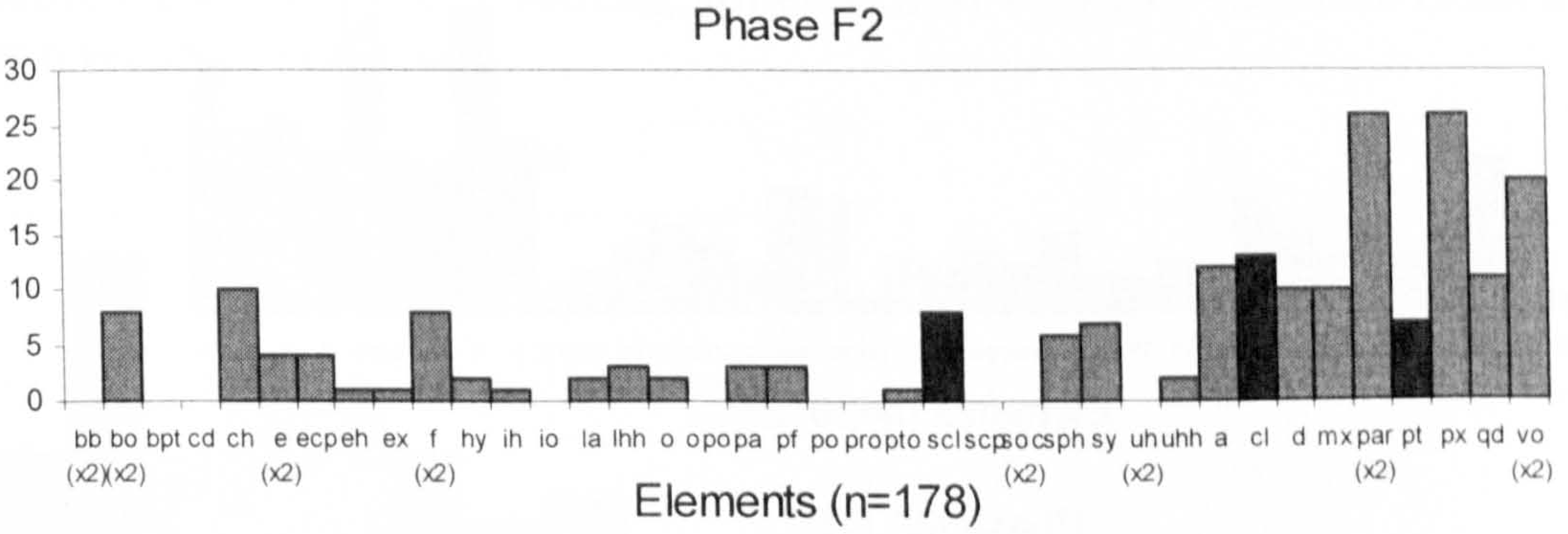
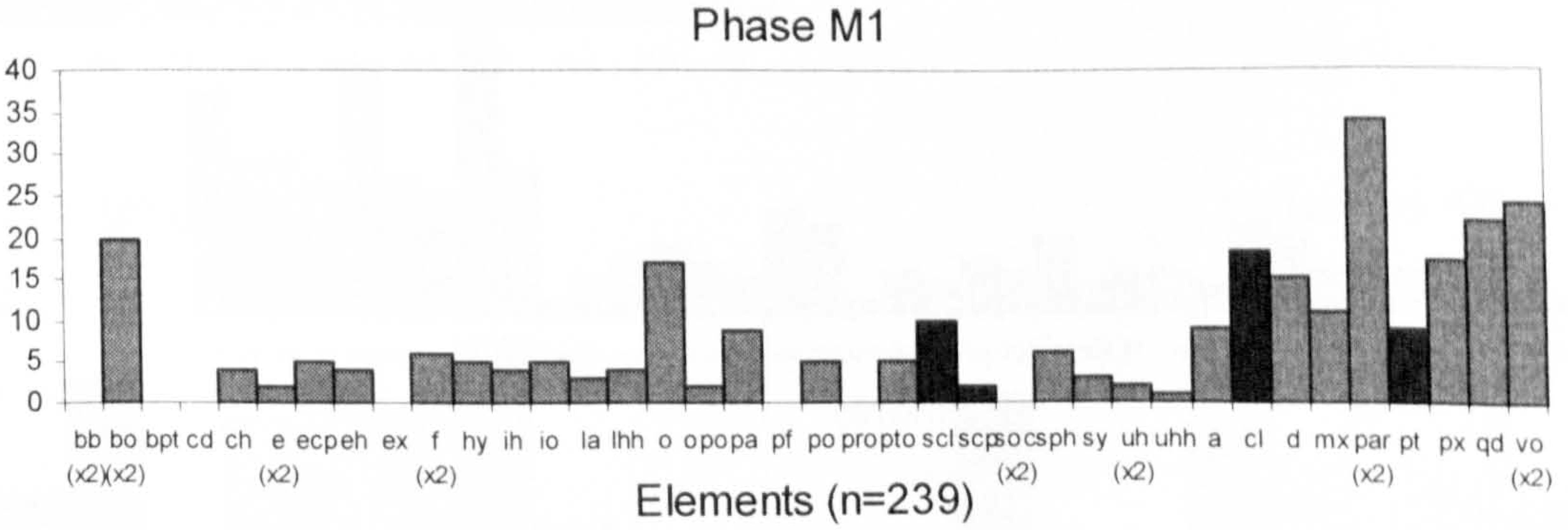


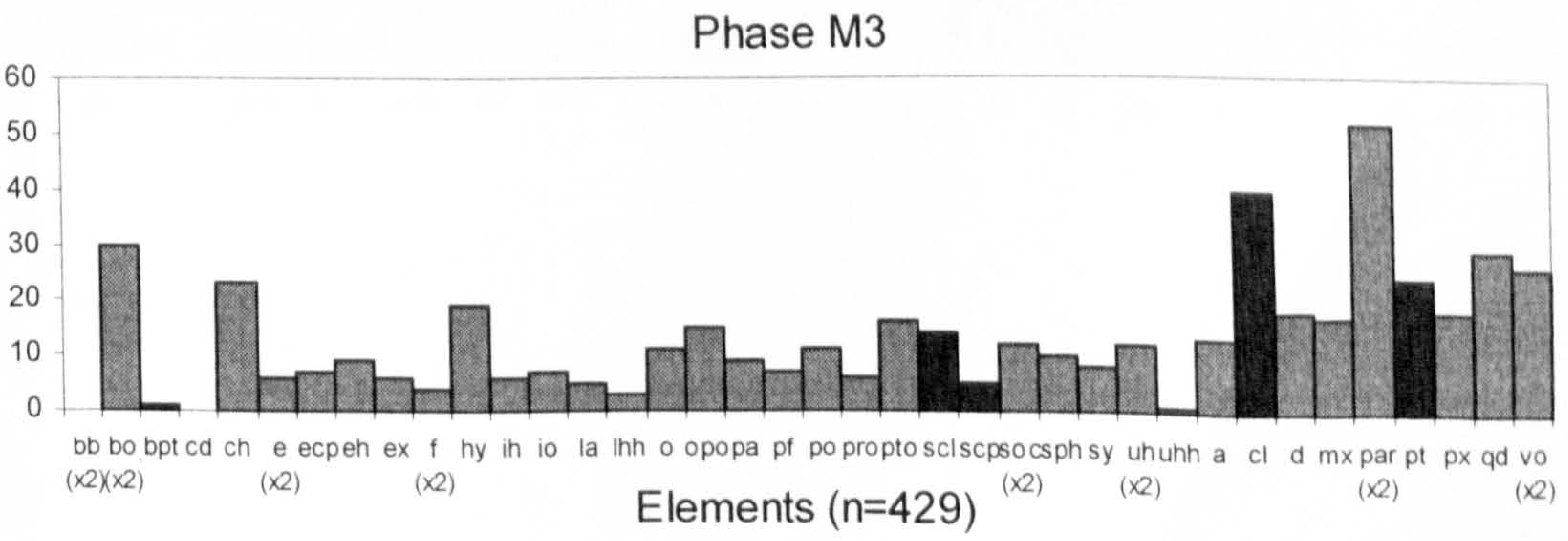
Figure 4.27: Haddock elements and sizes by phase group, NISP of all hand collected and >4mm specimens (parasphenoid and vomer counts doubled, but n refers to actual total)


Phase C2
30
25
20
15
10
5
0
bb (x2) bo (x2) bpt cd ch e (x2) ecp eh ex f (x2) hy ih io la lhh o opo pa pf po pro pto scl scp so (x2) csph sy uh (x2) uhh a cl d mx par (x2) pt px qd vo (x2)
Elements (n=101)

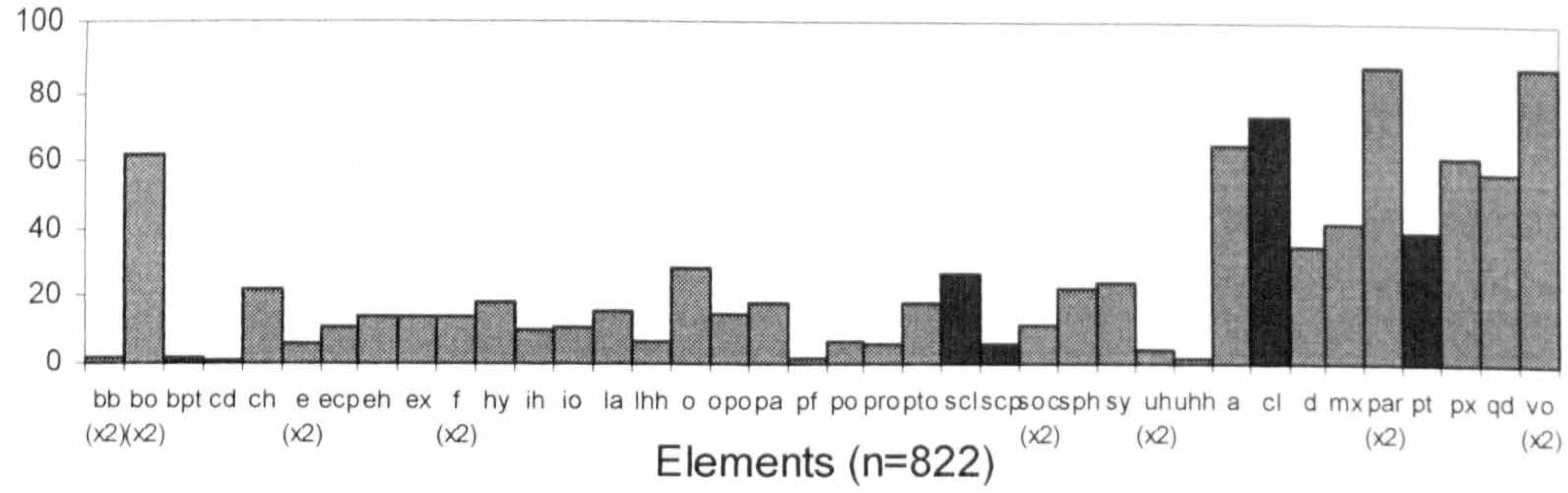

Phase C3
5
4
3
2
1
0
bb (x2) bo (x2) bpt cd ch e (x2) ecp eh ex f (x2) hy ih io la lhh o opo pa pf po pro pto scl scp so (x2) csph sy uh (x2) uhh a cl d mx par (x2) pt px qd vo (x2)
Elements (n=31)


Phase F2
30
25
20
15
10
5
0
bb (x2) bo (x2) bpt cd ch e (x2) ecp eh ex f (x2) hy ih io la lhh o opo pa pf po pro pto scl scp so (x2) csph sy uh (x2) uhh a cl d mx par (x2) pt px qd vo (x2)
Elements (n=178)

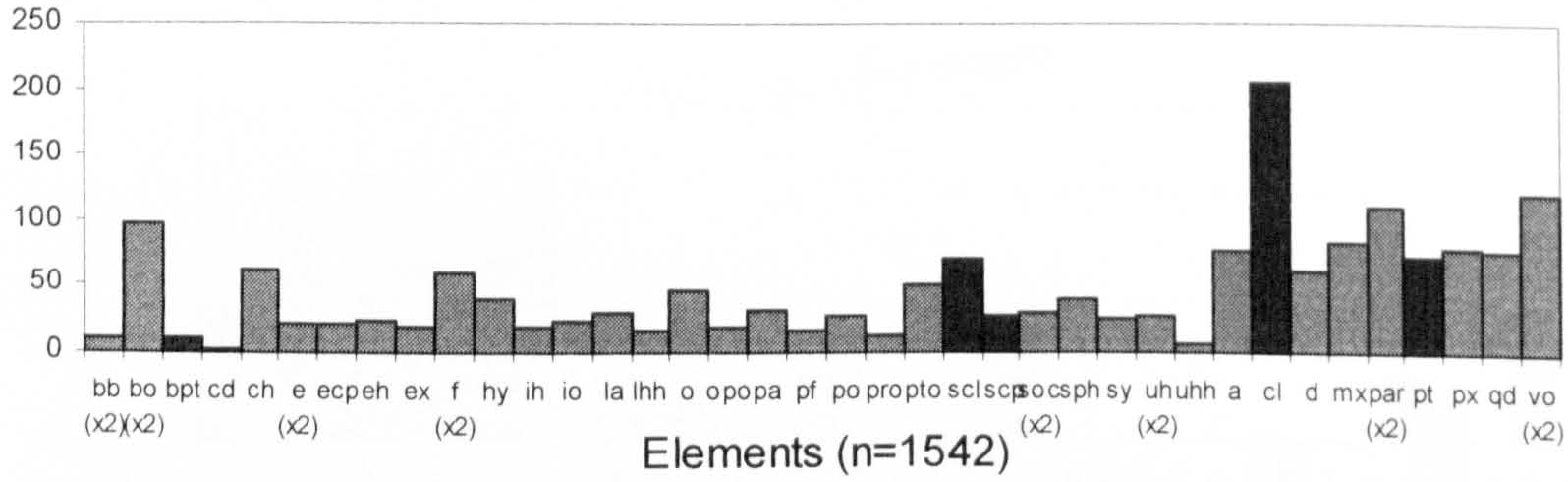

Phase M1
40
35
30
25
20
15
10
5
0
bb (x2) bo (x2) bpt cd ch e (x2) ecp eh ex f (x2) hy ih io la lhh o opo pa pf po pro pto scl scp so (x2) csph sy uh (x2) uhh a cl d mx par (x2) pt px qd vo (x2)
Elements (n=239)


Phase M3
60
50
40
30
20
10
0
bb (x2) bo (x2) bpt cd ch e (x2) ecp eh ex f (x2) hy ih io la lhh o opo pa pf po pro pto scl scp so (x2) csph sy uh (x2) uhh a cl d mx par (x2) pt px qd vo (x2)
Elements (n=429)

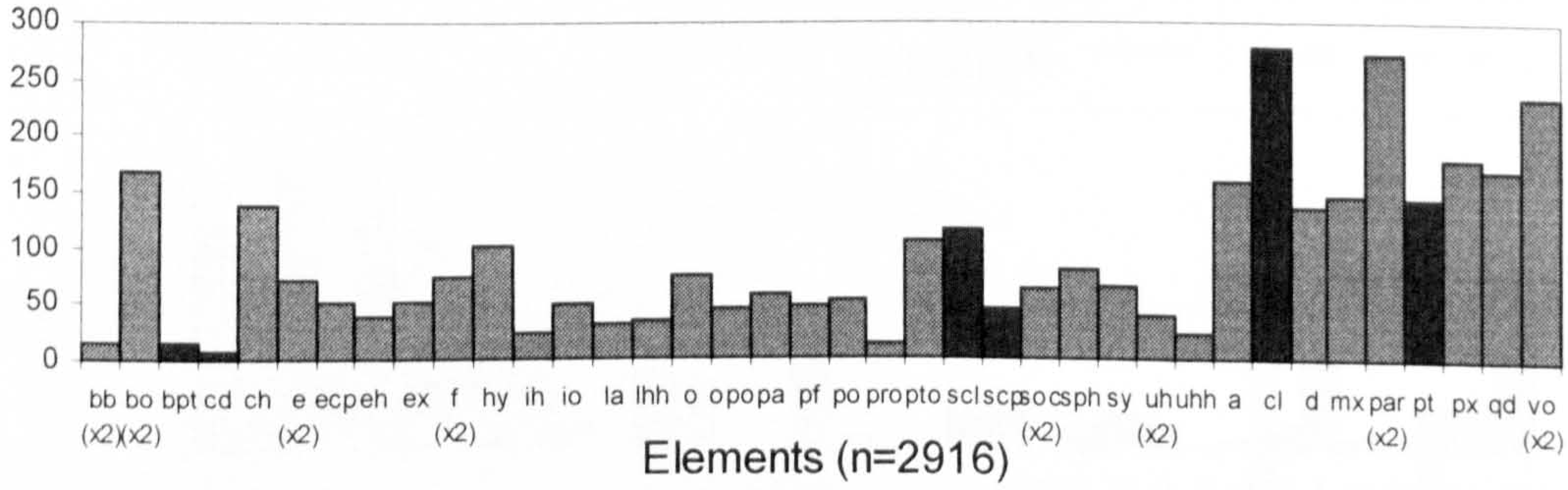
Phase M3a



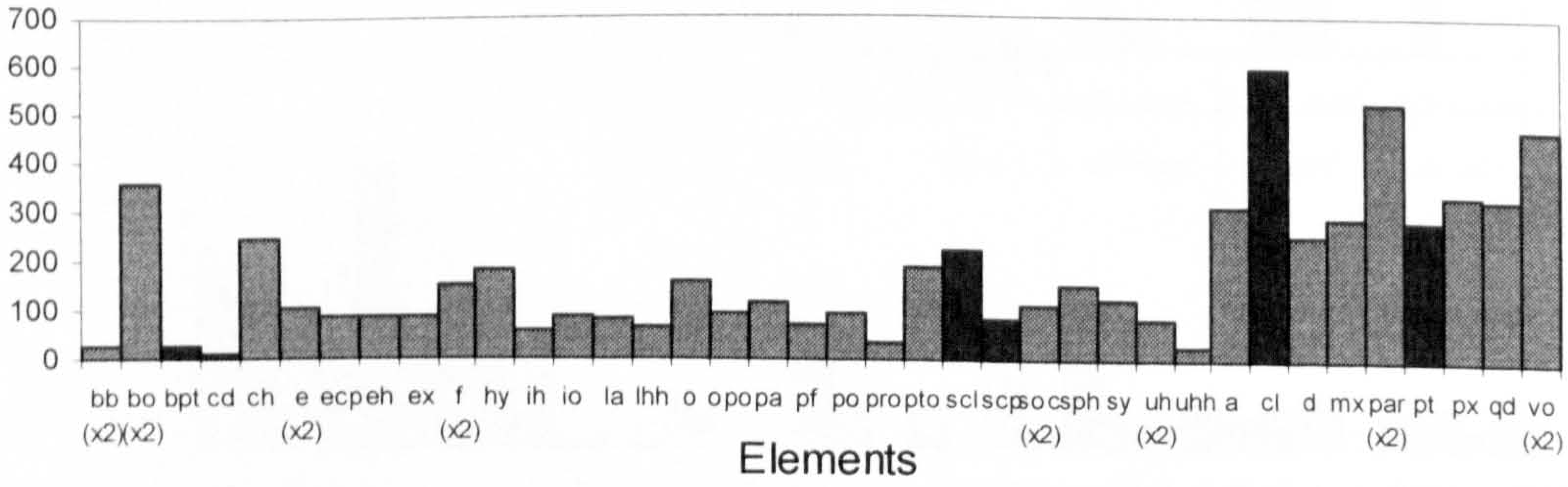
Phase M3b



Phase M3c



Phase M3 (all)



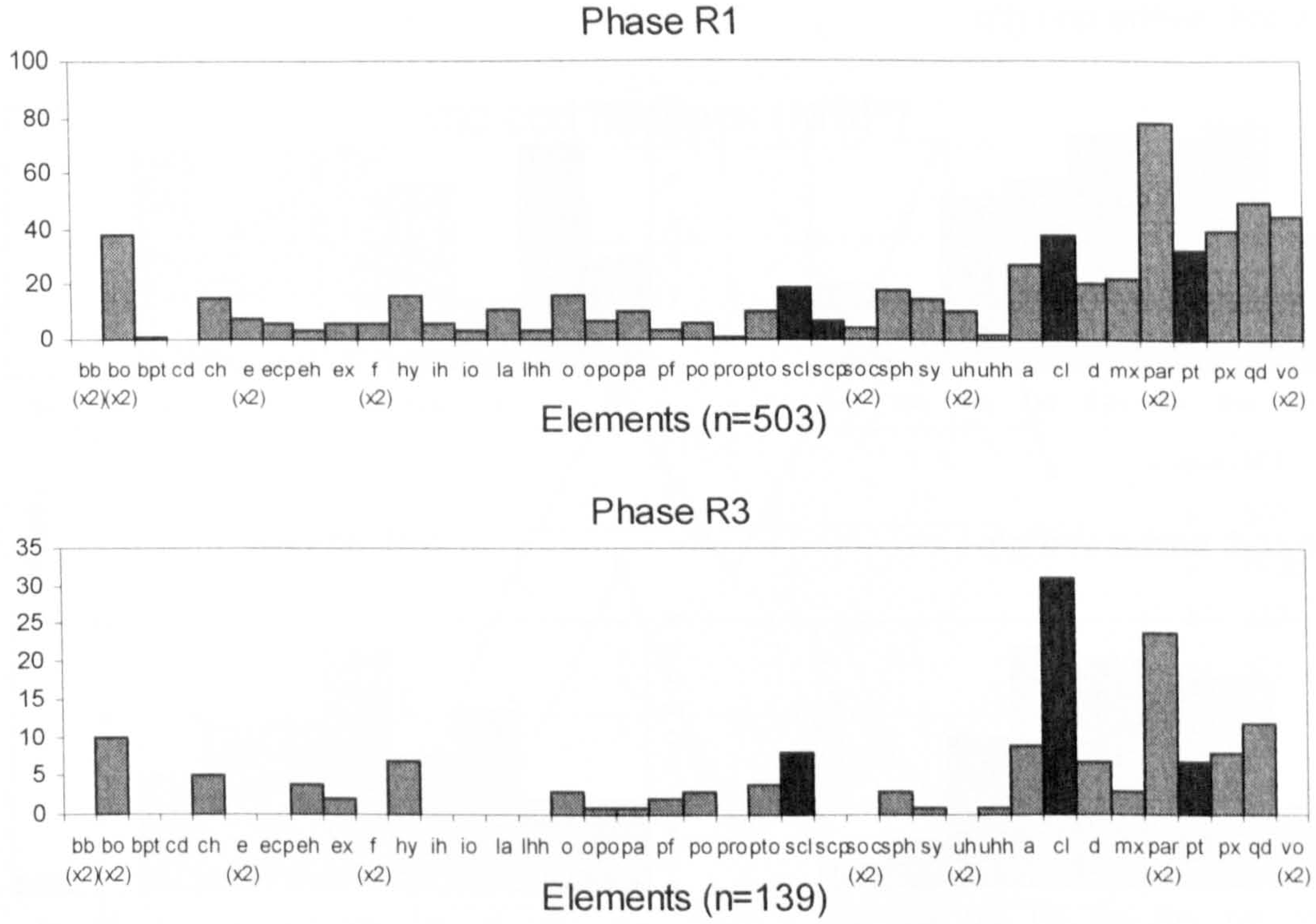
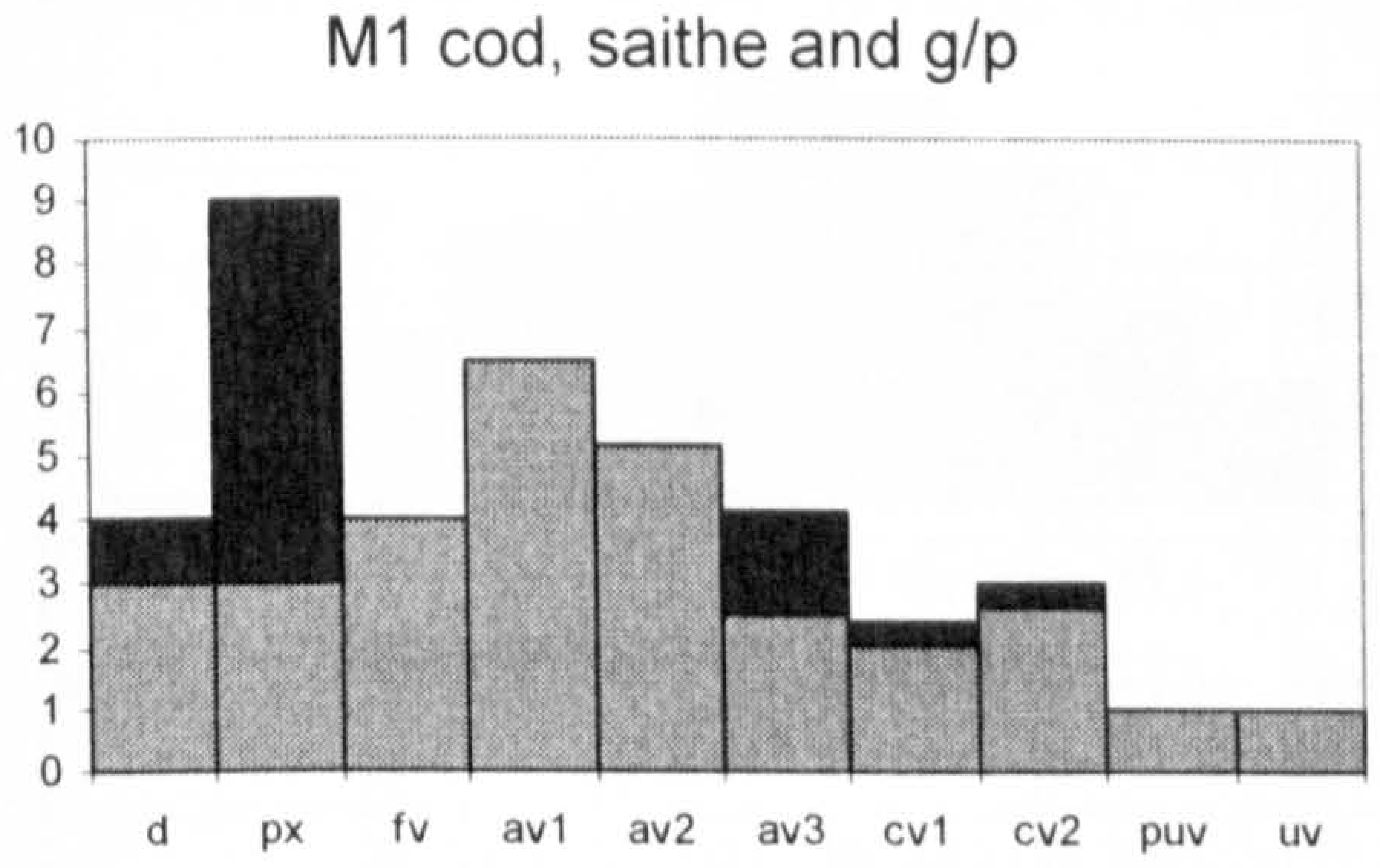
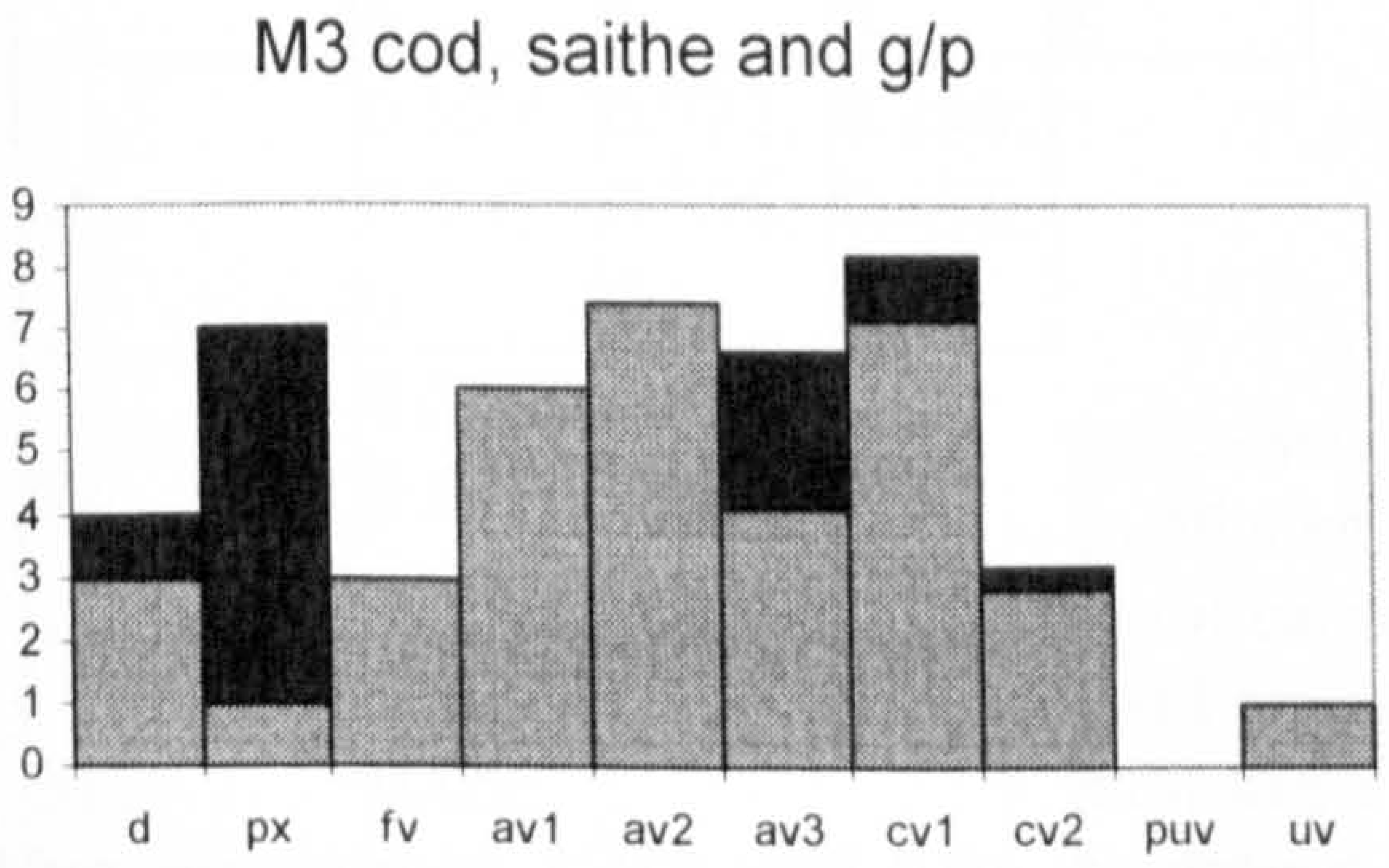
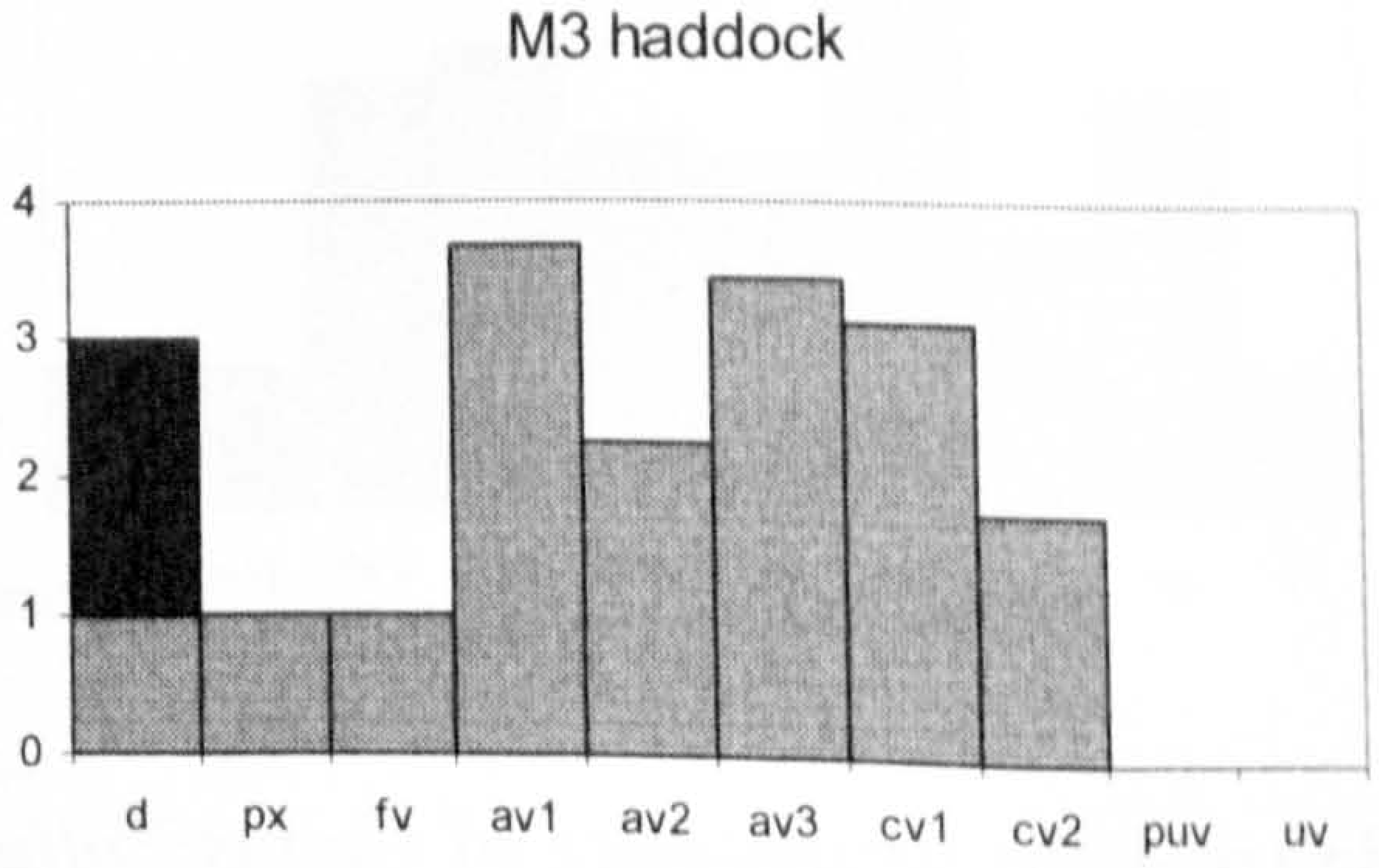


Figure 4.28: Gadid QC3 elements by phase group (with QC1), hand collected and >4mm, darker bars representing appendicular elements (midline elements doubled, but n refers to real total)







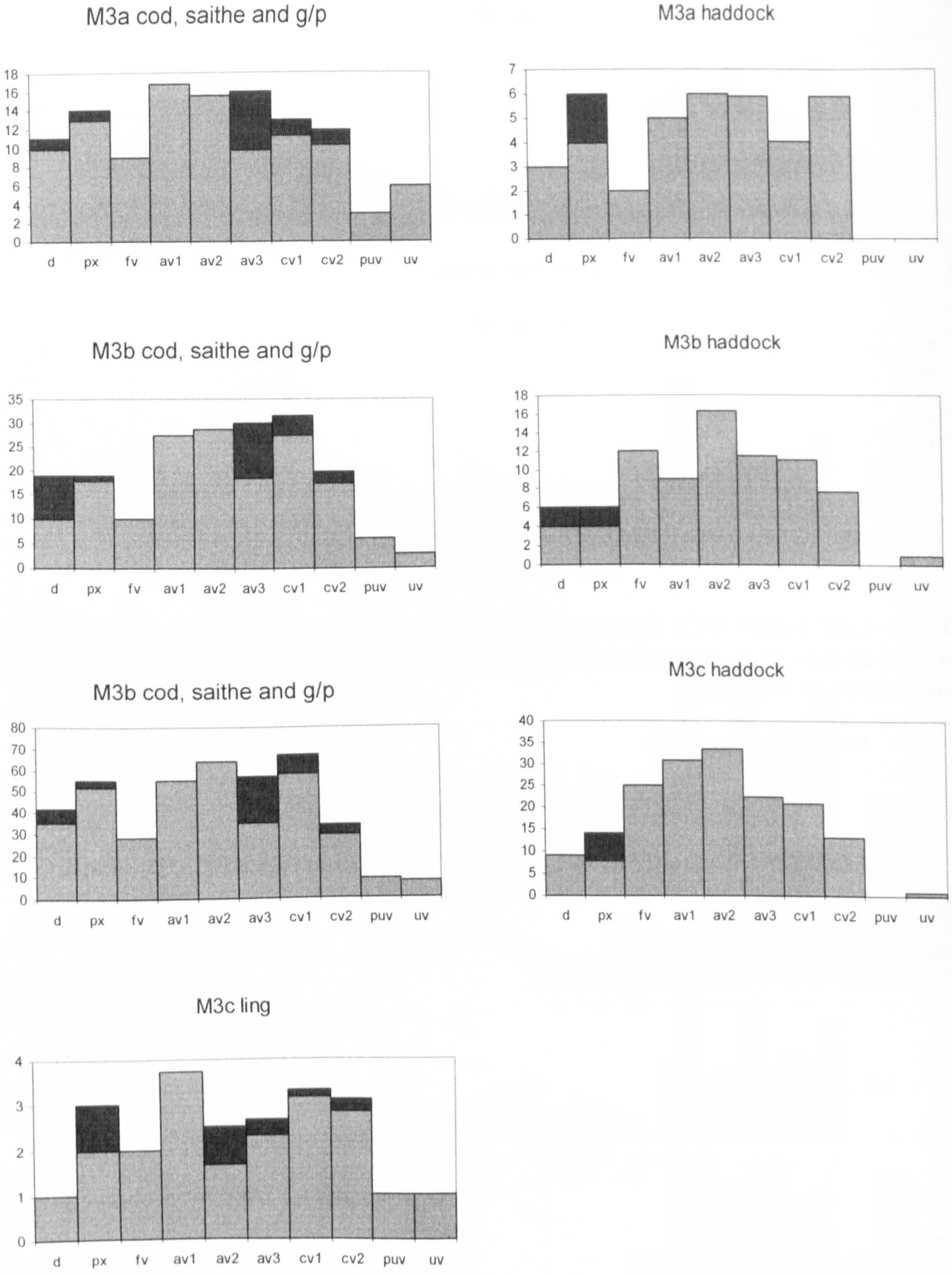


Figure 4.29: Abundance of *Gadus/Pollachius*, haddock and ling QC1 (dentaries and premaxillae only) and QC2 per phase group, divided by elements per fish, indicating differences between left and right for QC1 (darker bars), and taking into account the variation in quantities of each vertebral element (darker bars indicating difference between maximum and minimum observed vertebrae from modern comparative specimens)

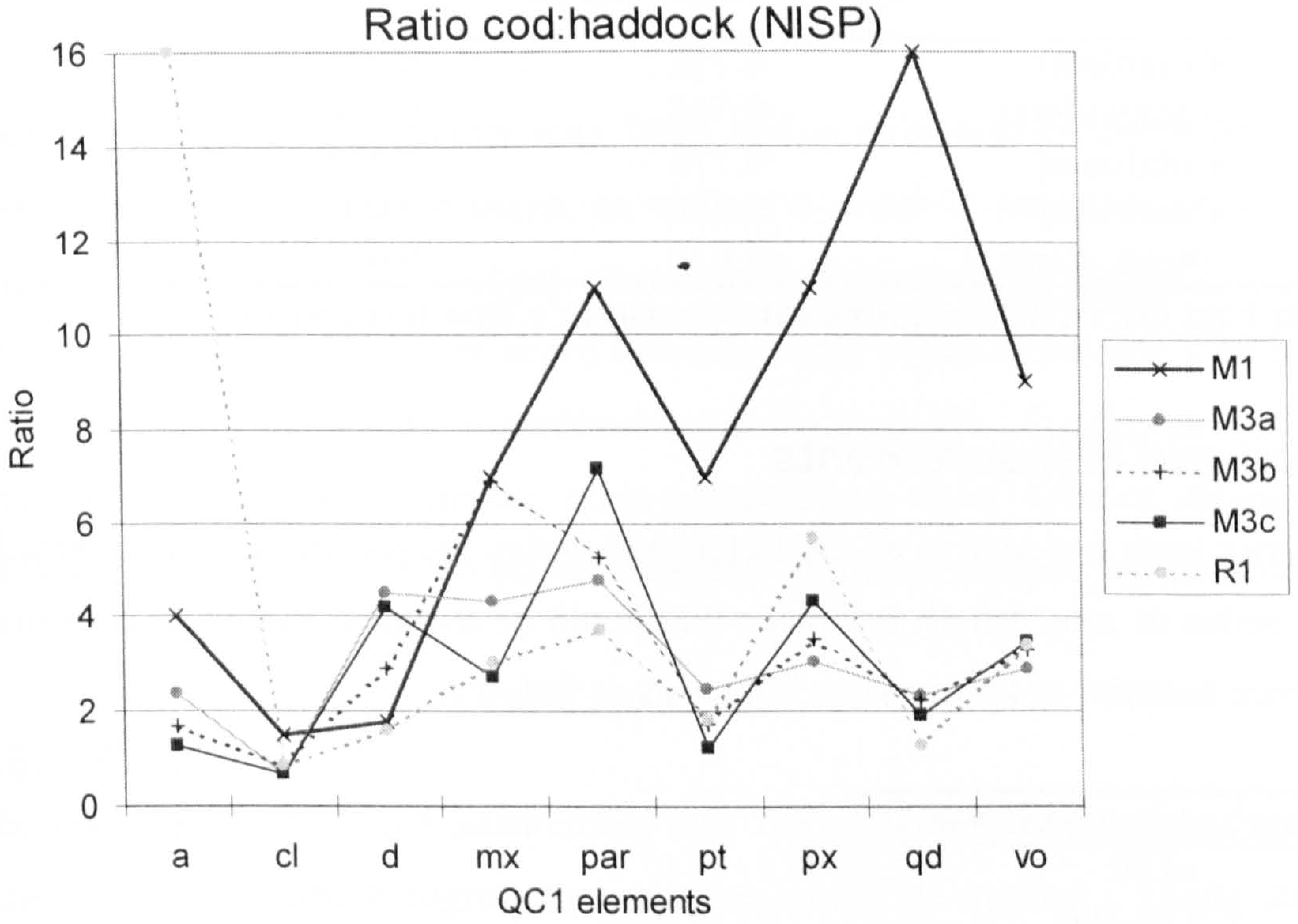


Figure 4.30: Ratio of cod: haddock QC1 elements, by NISP, derived from hand collection and >4mm sieving, by phase group

	R3	M3	R1	M1	M3c	M3b
M3a	0.543; 0.266; 6	0.519; 0.152; 9	0.454; 0.22; 9	0.092; 0.815; 9	**0.874; 0.002; 9**	**0.895; 0.001; 9**
M3b	0.429; 0.397; 6	0.445; 0.23; 9	0.335; 0.379; 9	0.274; 0.476; 9	**0.895; 0.001; 9**	
M3c	0.314; 0.544; 6	0.591; 0.094; 9	0.282; 0.463; 9	0.183; 0.637; 9		
M1	0.507; 0.305; 6	0.322; 0.398; 9	0.298; 0.436; 9			
R1	**0.886; 0.019; 6**	**0.776; 0.014; 9**				
M3	**0.812; 0.05; 6**					

Cells show correlation coefficient, significance level and n
Bold formatting indicates significant pairing

Table 4.23: Haddock QC1 NISP, Spearman's Rho test results, hand collected and >4mm

Pairs of phase groups	Dataset	Spearman's Rho correlation coefficient	Significance level	N
C2 & F2	Combined	0.712	0.031	9
	>4mm alone	0.751	0.020	9
C2 & M1	Combined	0.778	0.013	9
F2 & M3c	Combined	0.864	0.003	9
	>4mm alone	0.827	0.006	9

Table 4.24: Cod QC1 NISP, significant Spearman's Rho test results

4.6 Sizes and Measurements

Size categories were assigned to all QC1 elements during the recording process, based on an ordinal series of total length estimates that could be assigned following comparison with reference material of known size. This was as follows:

Size category	Actual size (mm)
t	<150
s	150-300
m	300-500
l	500-800
x	800-1000
xx	>1000

Table 4.25: Fish size categories

Variation between analysts was apparent here, with the author preferring to record only those six categories listed above, and James Barrett using marginal categories including (x)/xx, x/(xx) and x/xx, with similar variations between other sizes. Where a preference was indicated, the non-bracketed value was chosen, i.e. (x)/xx became xx, but for those few specimens with two categories of equal importance, random assignment to one or other category was used to standardise the dataset.

Using the regression equations determined by Jones (1991), the total fish lengths could be determined using the first and second measurements taken from cod, haddock, saithe and ling premaxillae and dentaries (see Harland *et al.* 2003 for illustrations of measurements). The most frequently recorded measurement was then used to produce histograms of the total fish lengths for the minor species, but for cod, sample sizes permitted some comparison of results obtained from different measurements and elements. The results for each of the less frequently occurring taxa could have been combined to produce a larger sample size, but given the differences between cod elements and measurements (see below), this option was rejected.

Poorly preserved phase groups may have had a reduction in the overall number of measurements that could be taken, as well as a possible reduction in the numbers of smaller and therefore less robust elements that could have measurements recorded. However, no correlations were noted between better preservation and a broader range of sizes (comparing the results of section 4.2 and Figure 4.37). The numbers of premaxillae that had recorded measurements were compared to those without measurements, but again there was no correlation between the rate of measuring and preservation.

4.6.1 Cod

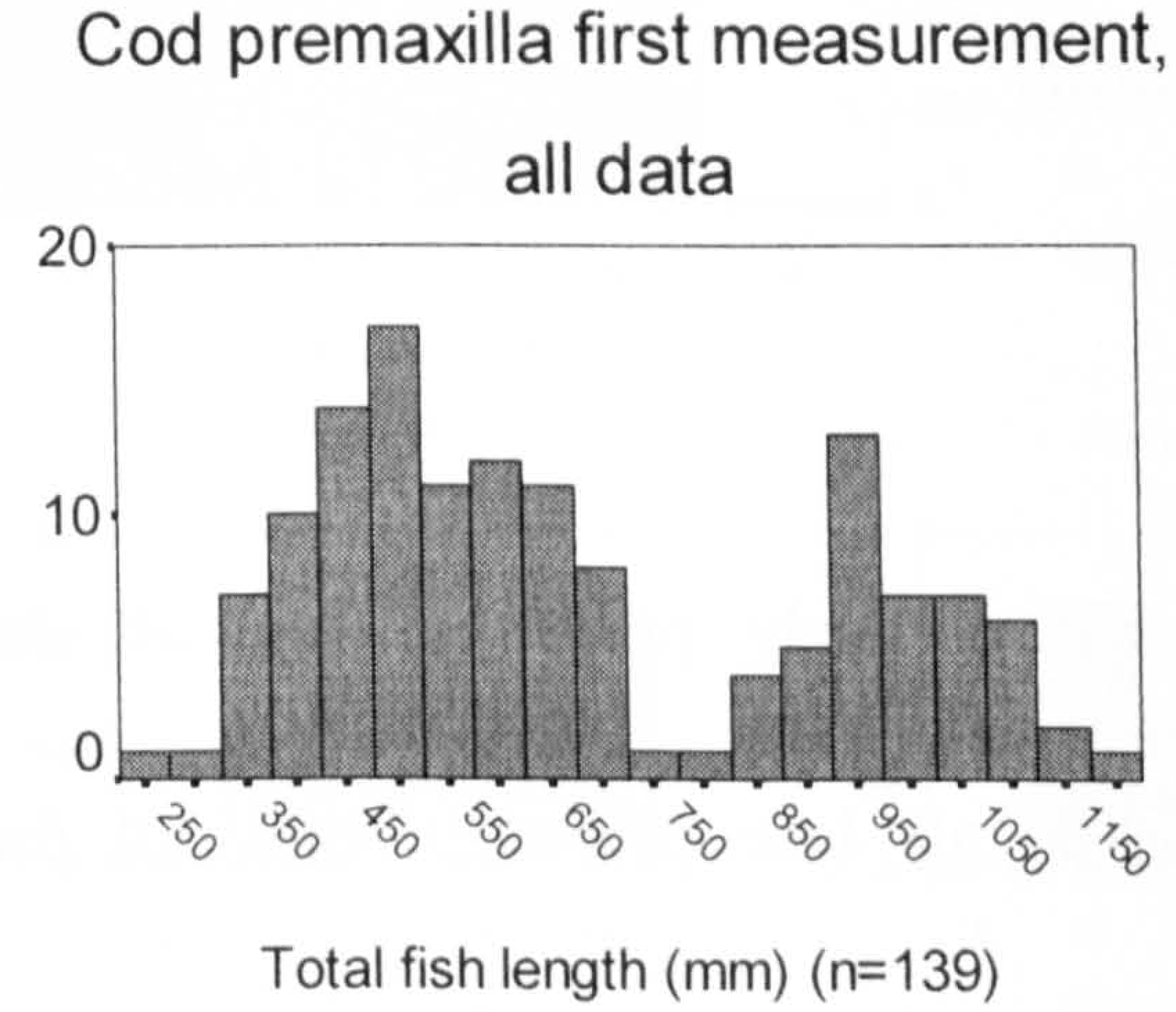
The cod premaxilla first measurement was the most frequently occurring of the four measurements to which regression equations could be applied. Using data from the entire site, a bimodal distribution was observed (Figure 4.31) with modes of about 500mm and 950mm, and a marked absence of individuals in the 725-825mm range. The cod ordinal size categories are not of sufficient resolution to capture this bimodality (Figure 4.32), but are certainly not inconsistent with the results from the first premaxilla measurement regression equation.

The bimodal nature of the cod assemblage was observed in both the early and late phase groups at Earl's Bu (Figure 4.33 and Figure 4.34), with insufficient sample sizes for illustration from the phase groups contemporary with the construction and use of the mill. The small sample size of the early phase groups (including midden, redeposited midden and construction phase groups) provides a coarse resolution of this bimodality, with the modes of about 600mm and 1000mm mirroring those found using the entire dataset. However, the first mode represents a slightly larger total length than was found in the site as a whole. Despite the small sample sizes involved, this slightly larger mode can be seen in the size distributions for all QC1 elements from the early phase groups: Figure 4.35 indicates a mode in the 500-800mm total length category for the early phase groups, and not the 300-500mm total length category observed as the mode for the site as a whole (Figure 4.32) or for the later phase groups (Figure 4.36; see below for statistical tests).

The bimodality of the later phase groups (Figure 4.34) was very similar to that of the site as a whole (Figure 4.31) (though given the large number of fragments found in the later phases, the overall pattern is biased more towards these phases than the earlier ones). The separation between the smaller and larger modes is more pronounced because not one fish between a total length of 725 and 875mm was recovered, when using the first premaxilla measurement. The most commonly occurring size was 500mm, followed by a second less prominent mode at 950mm. The only major difference is that, compared to the site as a whole, the second mode at 950mm was less common during the late phase group. This would suggest that the cod from the earlier phase groups were larger than those from the later phase groups.

Sample sizes did not permit any examination of spatial differences using fish total lengths, but these could be approached using the size categories for each of the phase groups. Figure 4.43 displays these data for the 10 phase group categories, and despite the difference in sample numbers, some patterns can be seen. The most unusual phase group, C3, can be dismissed because of its small sample size and general variance from the norm (see Table 4.3 and Table 4.4), while the differences between C2 and F2 can be attributed to real differences in the activities that contributed to each assemblage. As seen above, no great differences in recovery method (section 4.1) can explain this. During the construction of the mill, >1000mm total length cod were being consumed and disposed of, while during its use, 500-800mm total length sized cod accumulated in the silts of the mill's channels and chamber. Some of the midden deposits displayed only slight tendencies to one or another size (R3, M3b), but others, particularly M3, indicated a real predominance of 300-500mm total lengths. Cod from M1 were slightly bimodal towards 500-800mm and >1000mm total length, M3a tended towards a single mode at 300-500mm total length, M3b tending towards a mode at >1000mm total length, and M3c returned to a total length mode of 300-500mm total length; no great chronological changes were noted between the early and late phases.

A Kruskal-Wallis test on cod sizes by phase groups indicated significant differences within the assemblage (Chi-Square value 56.043, nine degrees of freedom, significance 0.000). This was further investigated by applying Kolmogorov-Smirnov tests to pairs of phase groups. Significant results are displayed in Table 4.26. Differences were found between phase group M1 and two of the four M3 phase groups, as expected, while a difference between M3b and M3c confirmed the pattern observed graphically in Figure 4.37.



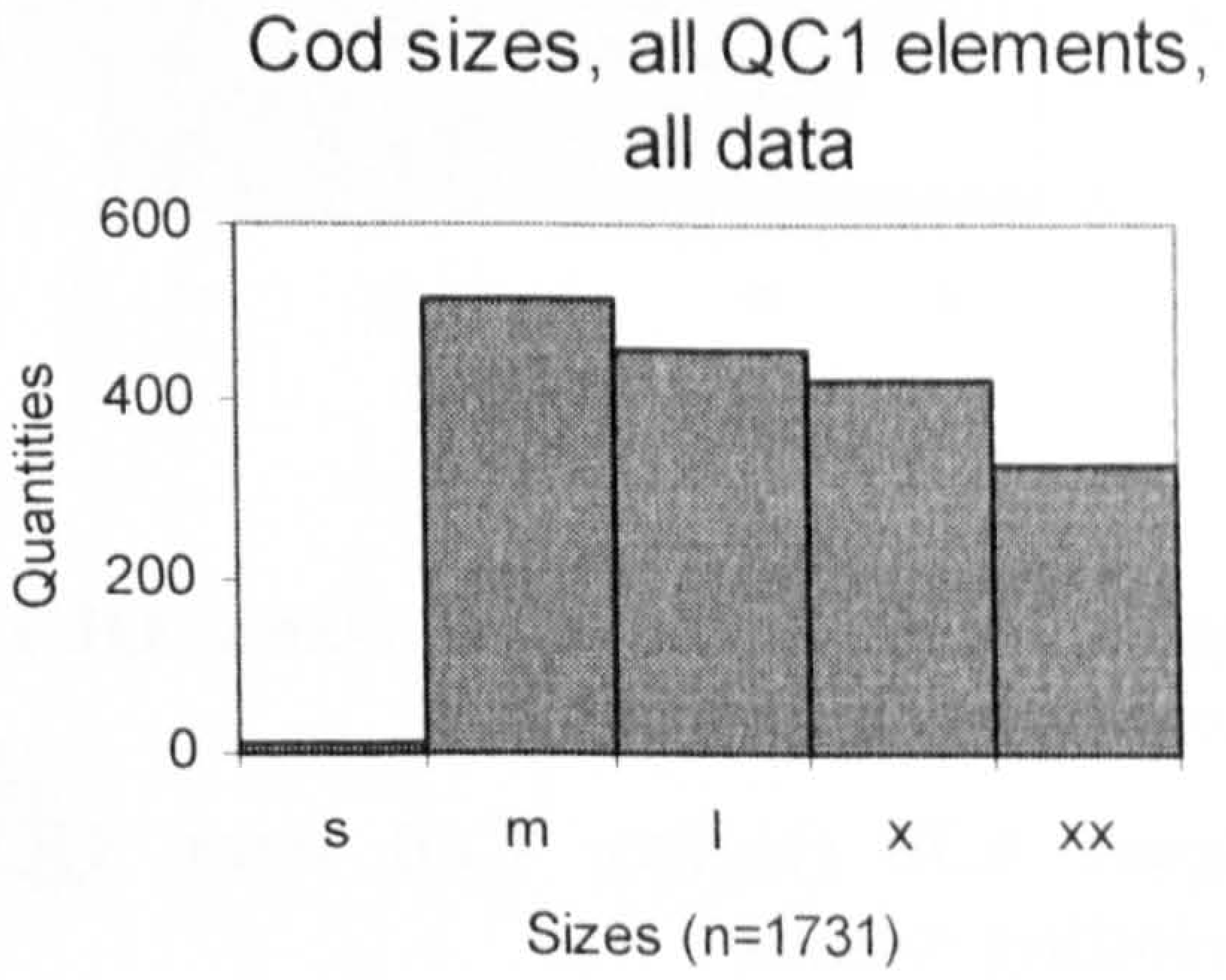
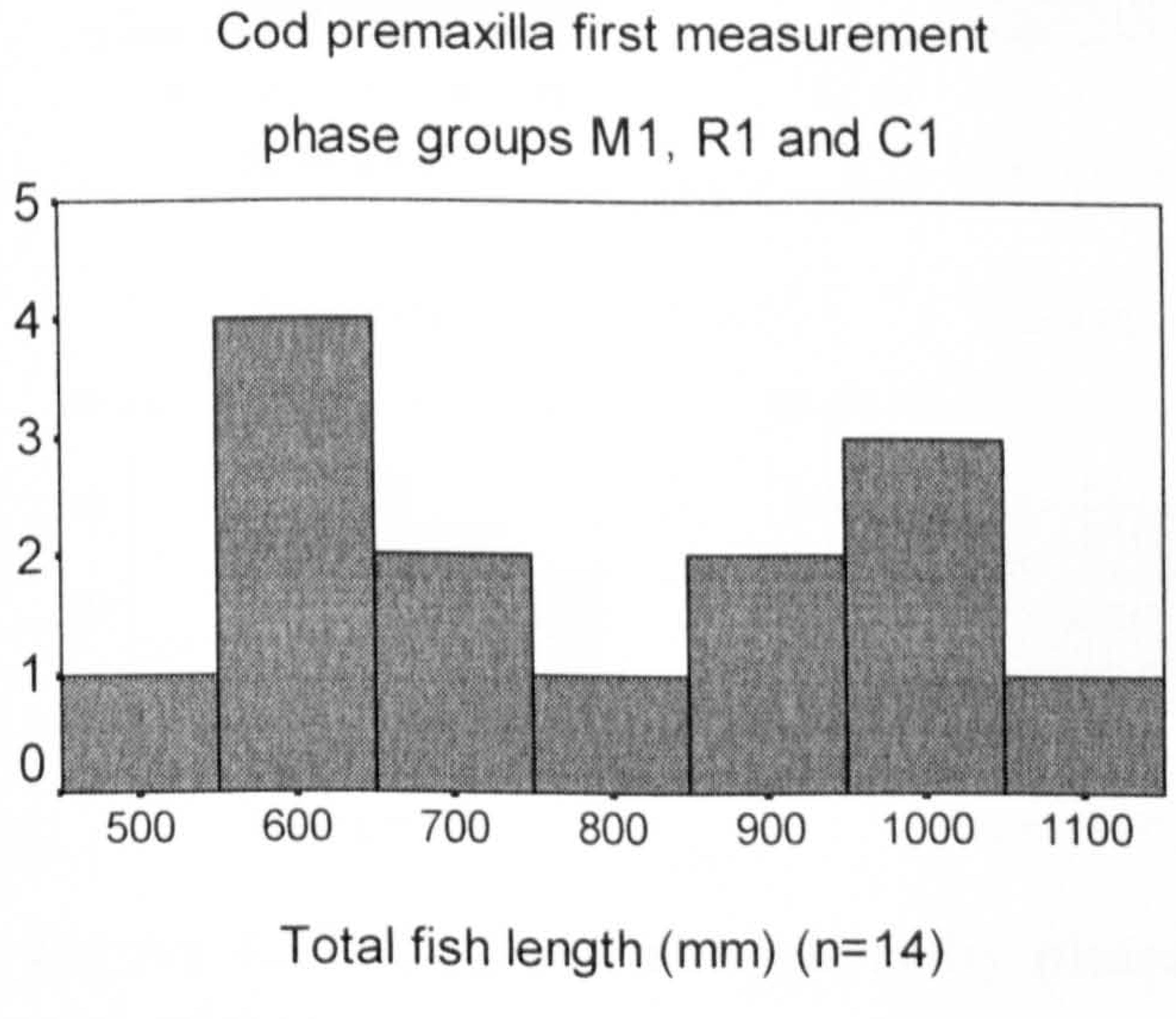


Figure 4.31 (left): Total cod lengths determined from the first premaxillae measurement, all data including <4mm

Figure 4.32 (right): Cod size categories for all QC1 elements, all data including <4mm



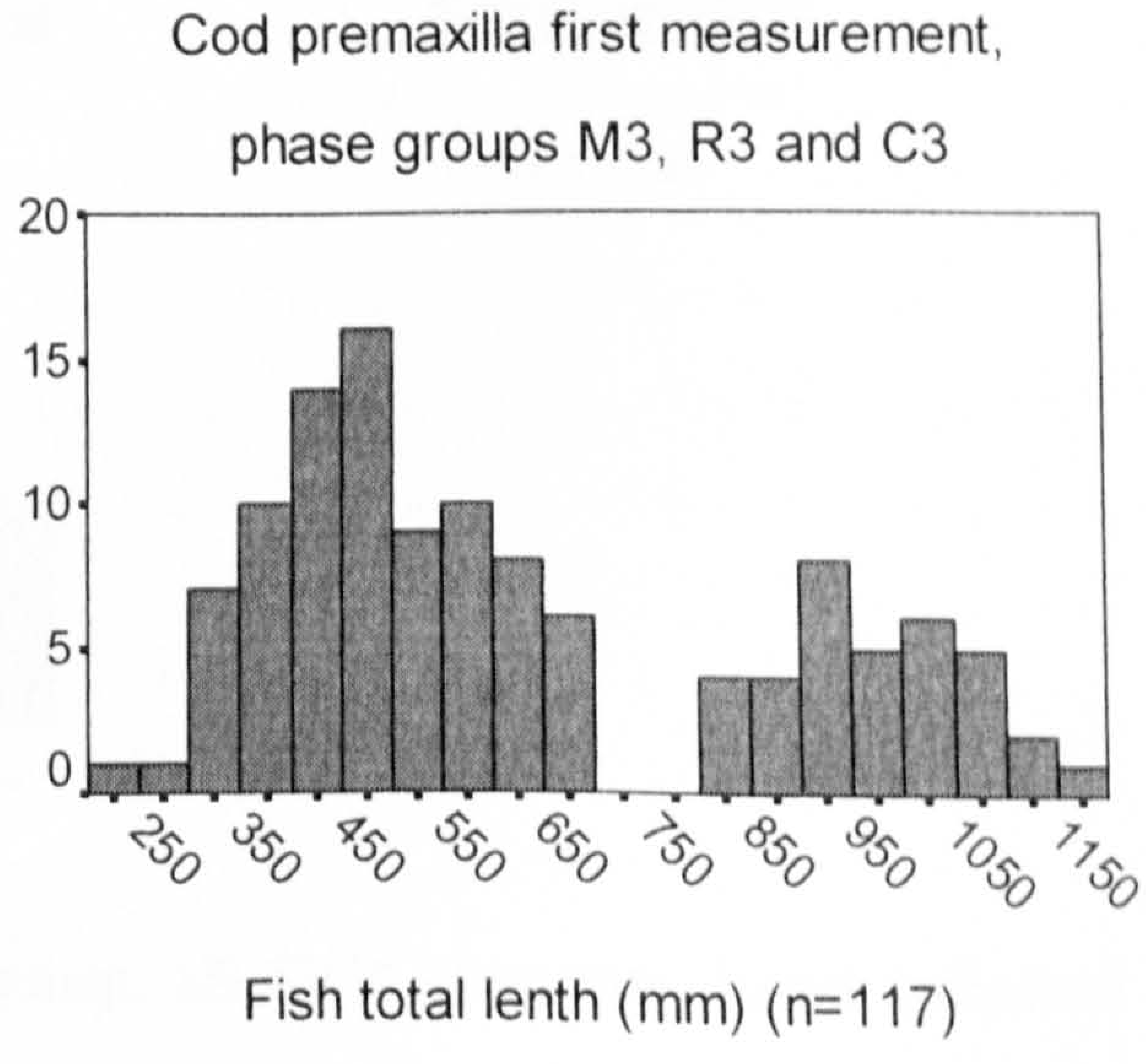
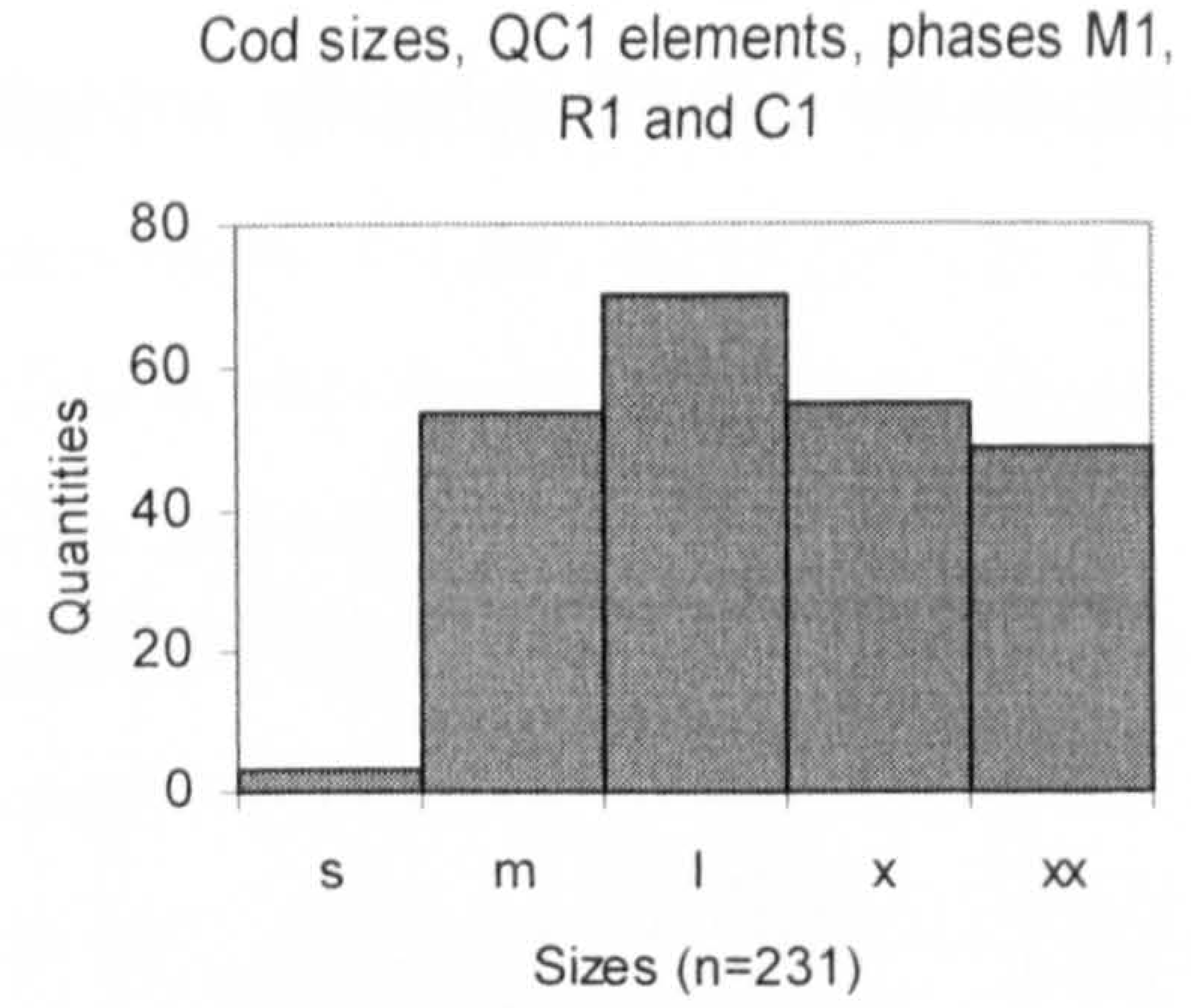


Figure 4.33 (left): Total cod lengths determined from the first premaxilla measurement, early phase groups, all data including <4mm

Figure 4.34 (right): Total cod lengths determined from the first premaxilla measurement, late phase groups, all data including <4mm



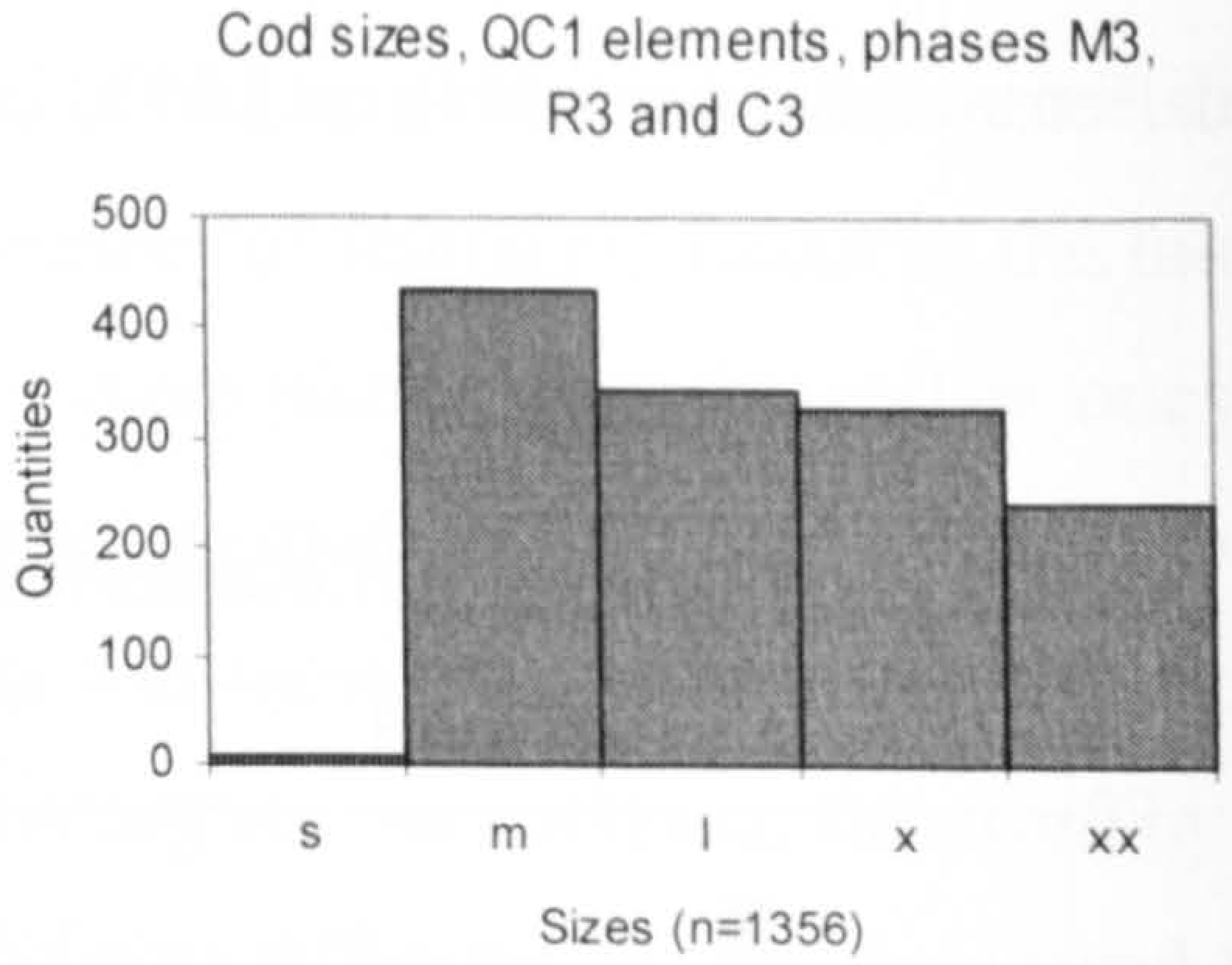


Figure 4.35 (left): Cod sizes, QC1 elements, all early phase groups, all data including <4mm

Figure 4.36 (right): Cod sizes, QC1 elements, all late phase groups, all data including <4mm

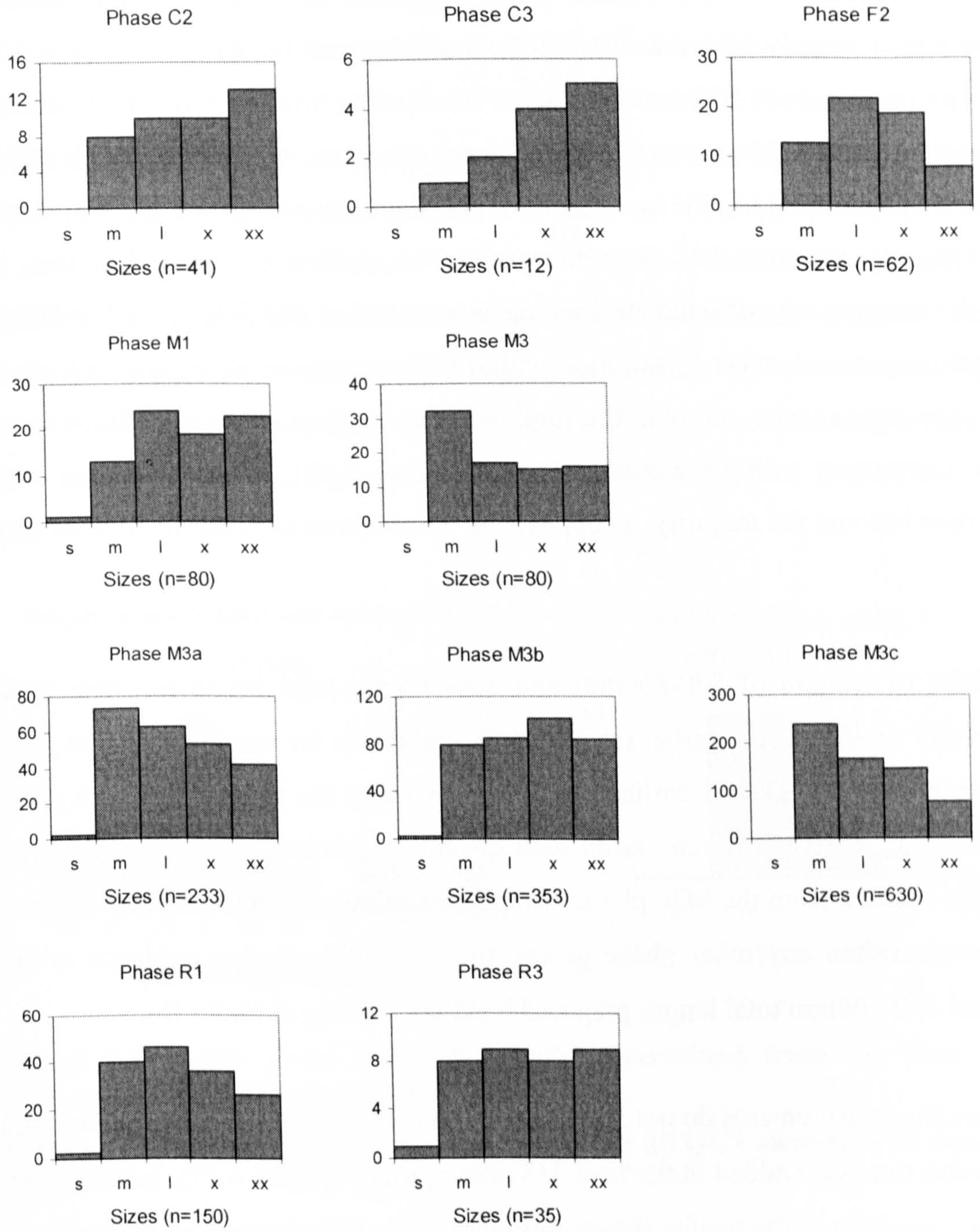


Figure 4.37: Cod size categories by phase group, all QC1 elements, hand collected and >4mm

Pair of phase groups	Greatest difference	Kolmogorov-Smirnov Z value	Significance
M1 & M3	0.225	1.423	0.035
M1 & M3c	0.204	1.722	0.005
M3a & R3	0.119	1.412	0.037
M3b & M3c	0.170	2.554	0.000

Table 4.26: Significant Kolmogorov-Smirnov tests of cod QC1 sizes for all QC1 elements derived from hand collection and >4mm (as graphically depicted in Figure 4.37)

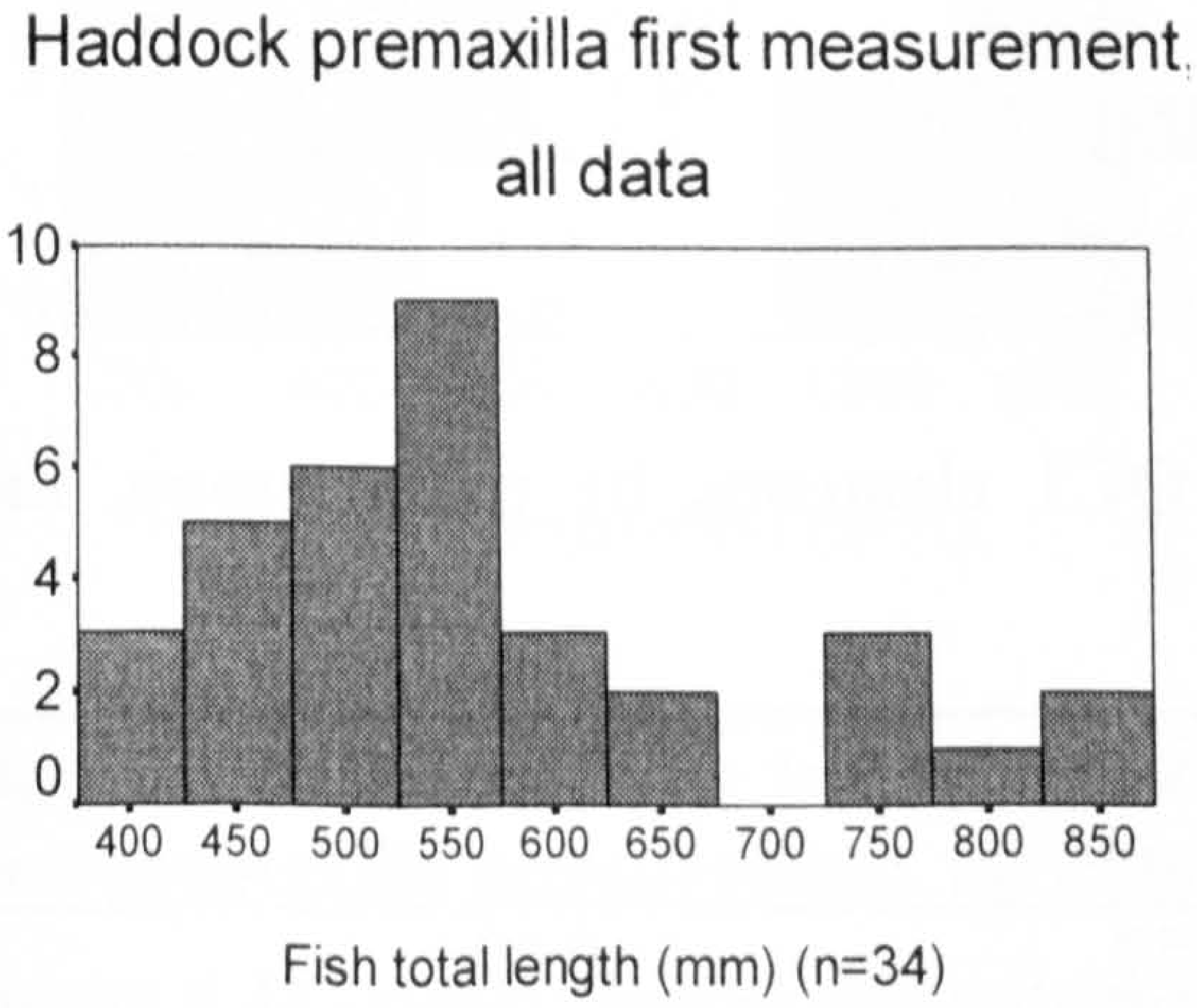
4.6.2 Haddock

Again, the first premaxilla measurement was most commonly recorded. Using data from the entire site, a weakly bimodal distribution was observed for haddock (Figure 4.38) with a major mode around 550mm and a lesser one tending towards 750mm. An absence of individuals measuring between 675 and 725mm was observed, similar though slightly smaller to that found among the cod from the phase groups post-dating the mill (Figure 4.34). The size category data from the entire site confirm the general pattern, but because the vast majority of haddock specimens were either 300-500mm or 500-800mm total length, any examination of variation within these broad categories must rely on the metrical regression results. Only in the final two phase groups, M3b and M3c is there a change to the pattern within the size categories (Figure 4.42): 500-800mm total length haddock then become the majority, as opposed to 300-500mm as found in all other phase groups.

The addition of cleithra of 500-800mm and 300-500mm total length to phase groups M3b and M3c was identified earlier (section 4.5), and this is the main explanation for the differences between these and earlier phase groups using the ordinal size data (which include cleithra, whereas the regression data do not). Butchery data (see section 4.7) confirm that cleithra from the M3c phase group show more cut marks indicative of dried fish preparation than any other phase group, thus providing further evidence of 500-800mm and 300-500mm total length prepared haddock arriving at Earl's Bu.

The premaxilla measurements do not include the extra 500-800mm and 300-500mm total length cleithra that were added in the later M3 phase groups (Figure 4.27), but these extra cleithra do contribute to the results shown in Figure 4.39. Sample sizes were insufficient to contrast the metrical regression results across phase groups, but a visual comparison of the premaxillae and cleithra ordinal sizes in Figure 4.27 reveals substantial differences between the size profiles of these two elements, with premaxillae tending towards a mode at 300-500mm and cleithra at 500-800mm total length. The regression histogram in Figure 4.38 in effect shows the size profile of the haddock caught and consumed at the site, while the bar chart in Figure 4.39 shows both the haddock caught locally, plus those imported ready prepared. This is also emphasised by Figure 4.40 and Figure 4.41, displaying all sizes for haddock premaxillae and cleithra in order to contrast the populations that contributed to each, using all haddock data from Earl's Bu. Premaxillae are mostly fish of the 300-500mm total length, while cleithra are mostly 500-800mm total length. These two elements have statistically different size distributions (Kolmogorov-Smirnov greatest difference 0.216, Z value 1.410, significance 0.038).

A Kruskal-Wallis test of all phase groups and ordinal size data indicated a significant difference was present within the haddock data set (Chi-Square value 33.590, nine degrees of freedom, significance 0.000). This was further investigated using the Kolmogorov-Smirnov test on pairs of phase groups. Significant results are displayed in Table 4.27. M3a was significantly different from phase groups M3b and M3c, which was expected given that M3a is predominantly 300-500mm total length fish, while the other phase groups contain greater quantities of 500-800mm total length fish.



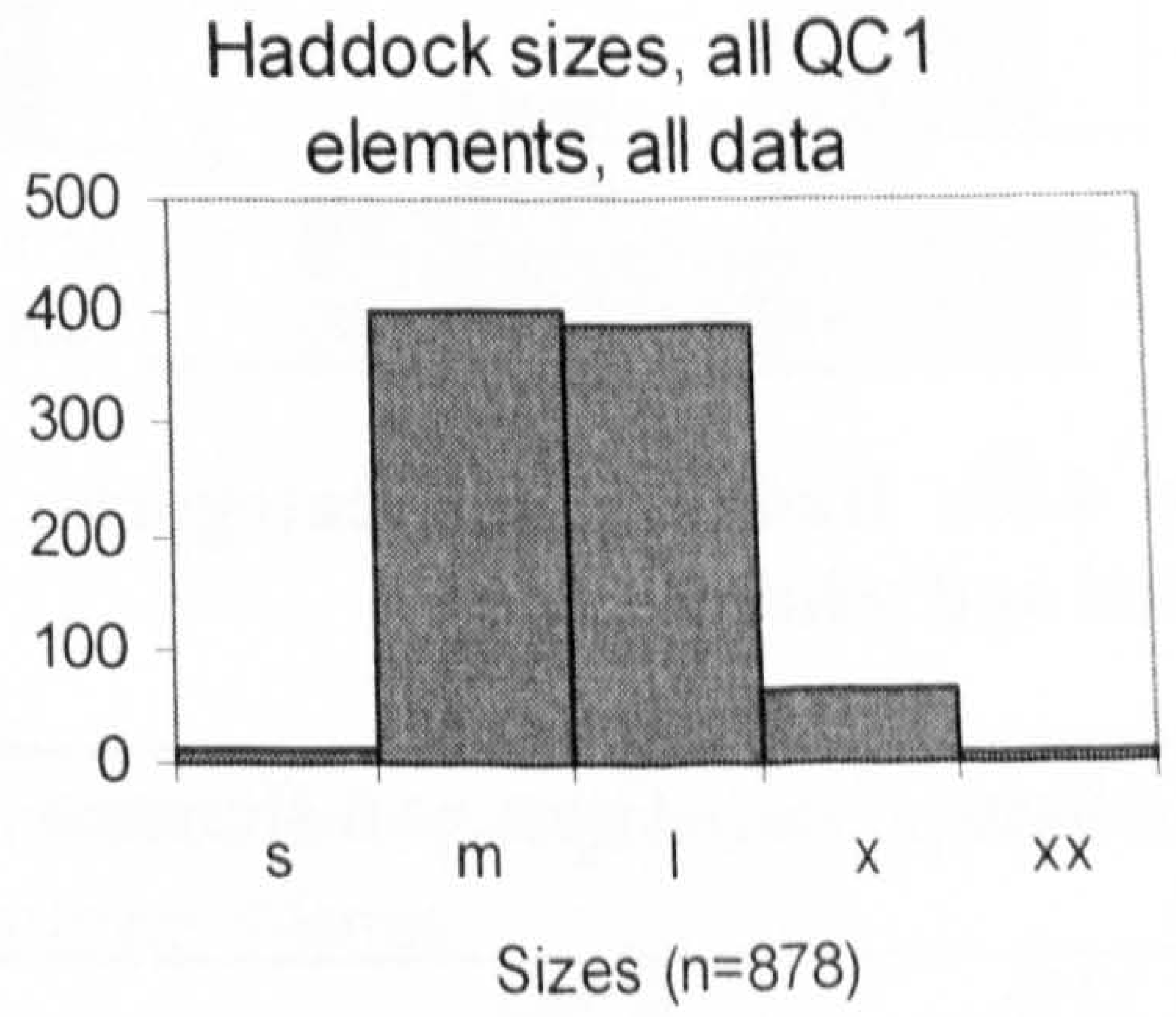
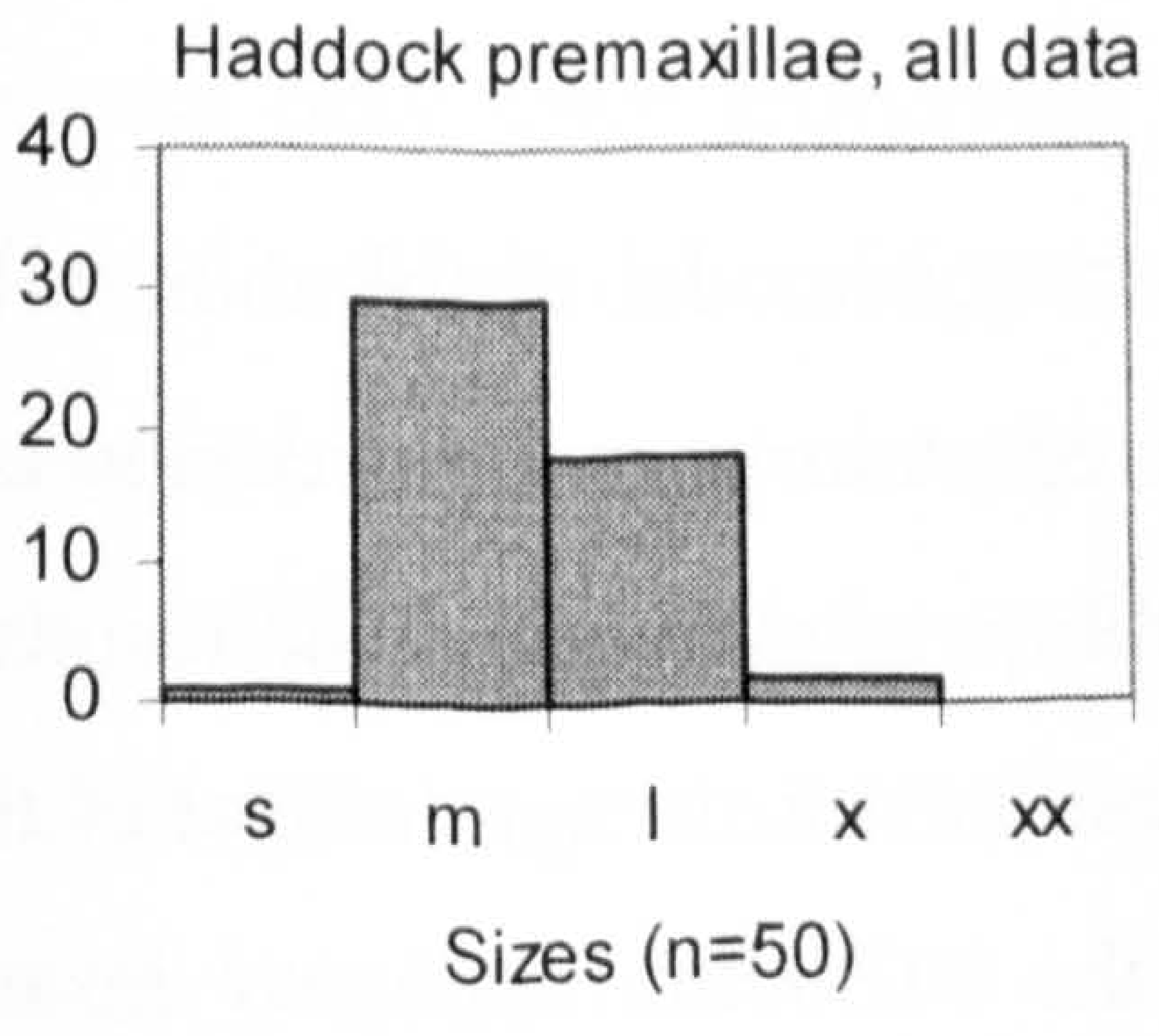


Figure 4.38 (left): Total haddock length, determined from the first premaxilla measurement, all data including <4mm

Figure 4.39 (right): Haddock size categories for all QC1 elements, all data including <4mm



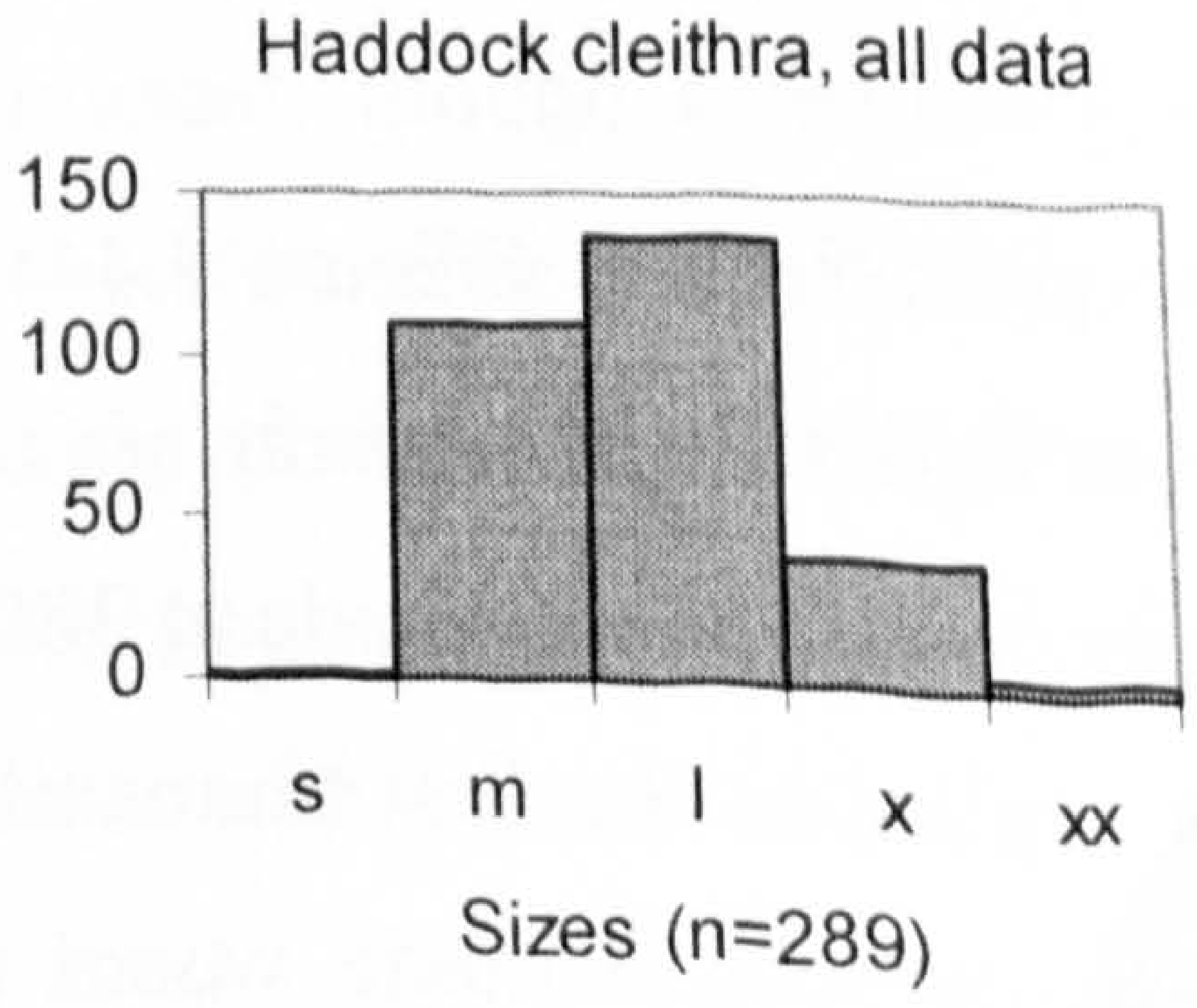


Figure 4.40 (left): Haddock premaxillae sizes, all data
Figure 4.41 (right): Haddock cleithra sizes, all data

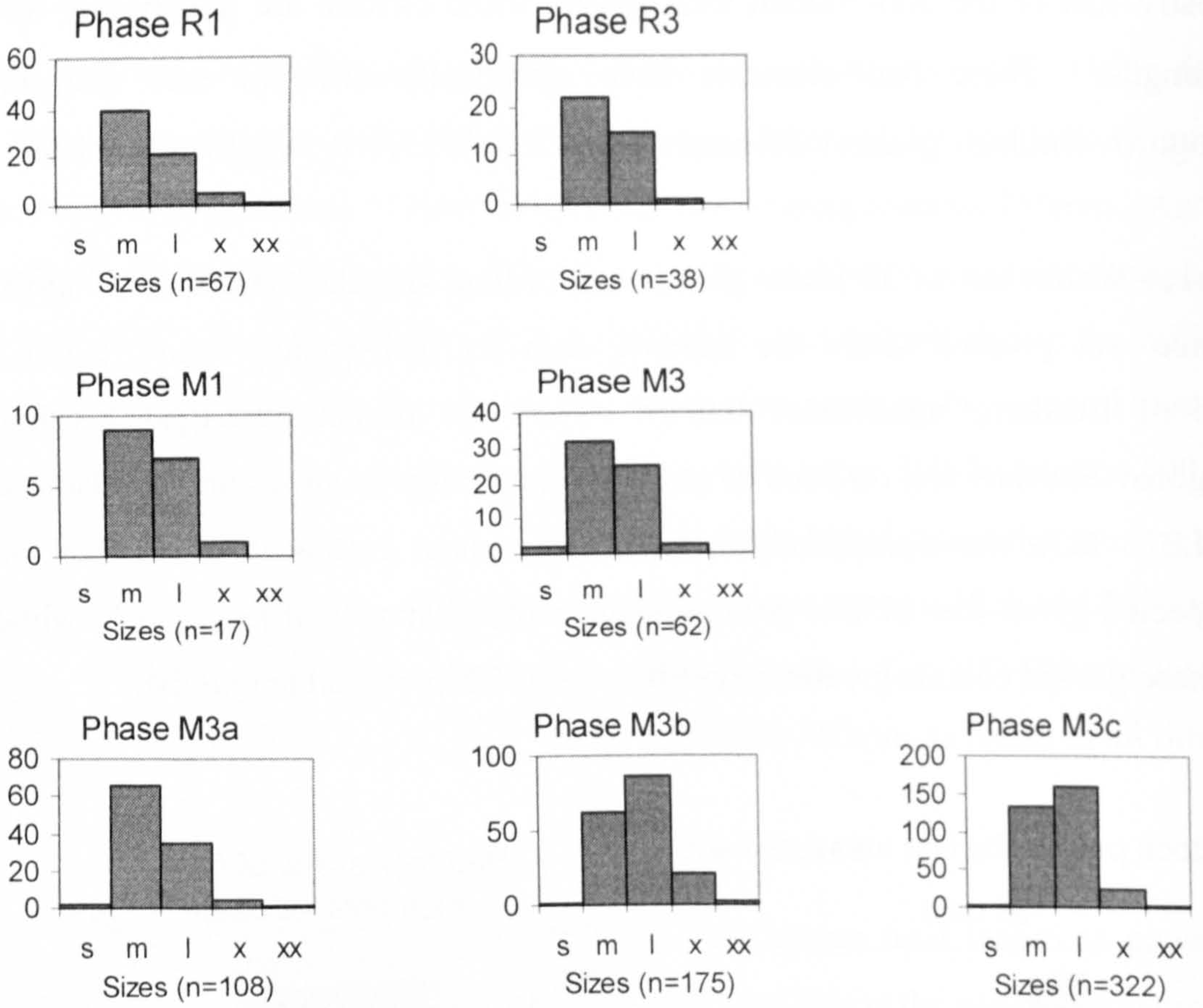


Figure 4.42: Haddock size categories, all QC1 elements, by phase group, hand collected and >4mm

Pair of phase groups	Greatest difference	K-S Z value	Significance
M3a & M3b	0.264	2.157	0.000
M3a & M3c	0.204	1.836	0.002
M3b & R1	0.231	1.610	0.011

Table 4.27: Significant Kolmogorov-Smirnov tests on haddock QC1 sizes for all QC1 elements derived from hand collection and >4mm (as graphically depicted in Figure 4.42)

4.6.3 Saithe

Saithe size category quantification (Figure 4.44) suggests a bimodal distribution, when all QC1 elements from Earl's Bu as a whole are considered. A large mode occurs at total length 800 to 1000mm, with a minor mode at 300 to 500mm total length. The results of regression equations applied to the first premaxilla measurement do not contradict this, although they suggest the second mode would be in the >1000mm category instead. However, sample sizes are too small to investigate this further, and the other premaxilla and dentary measurements are too few in number to use. Sample sizes are insufficient to investigate any internal variation within the site. It is interesting to note that the saithe distribution has the same modality as the cod data set, but with a greater quantity of fish occurring in the larger mode and not the small – the opposite of the cod pattern.

The distribution of saithe fish sizes becomes much more meaningful when compared to other sites, because the more common tendency in the Northern Isles is of a bimodal distribution, with a much greater mode in smaller (<400mm total length) fish than in the larger (i.e. Fig 4b, Barrett *et al.* 1999). The tendency towards larger saithe at Earl's Bu will be discussed in greater detail in Chapter Eight; possible correlations include the higher status of Earl's Bu.

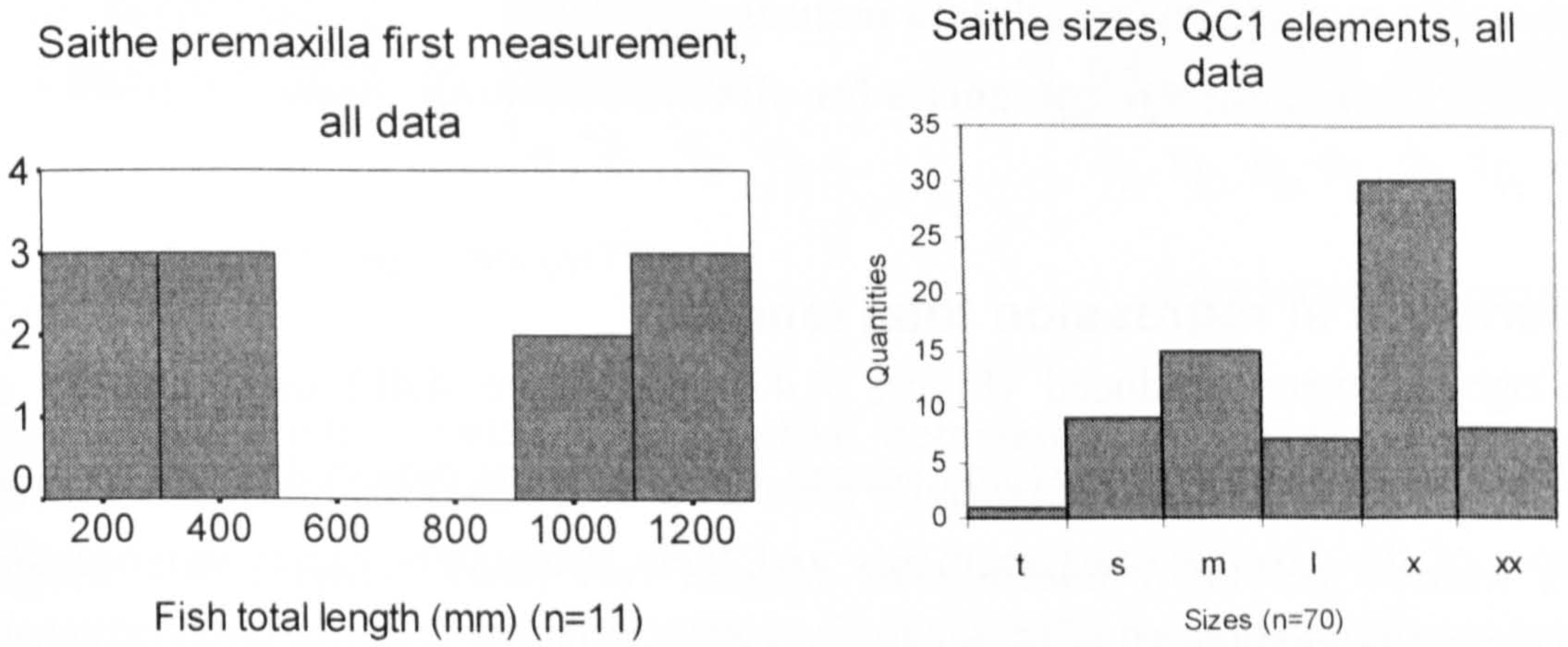
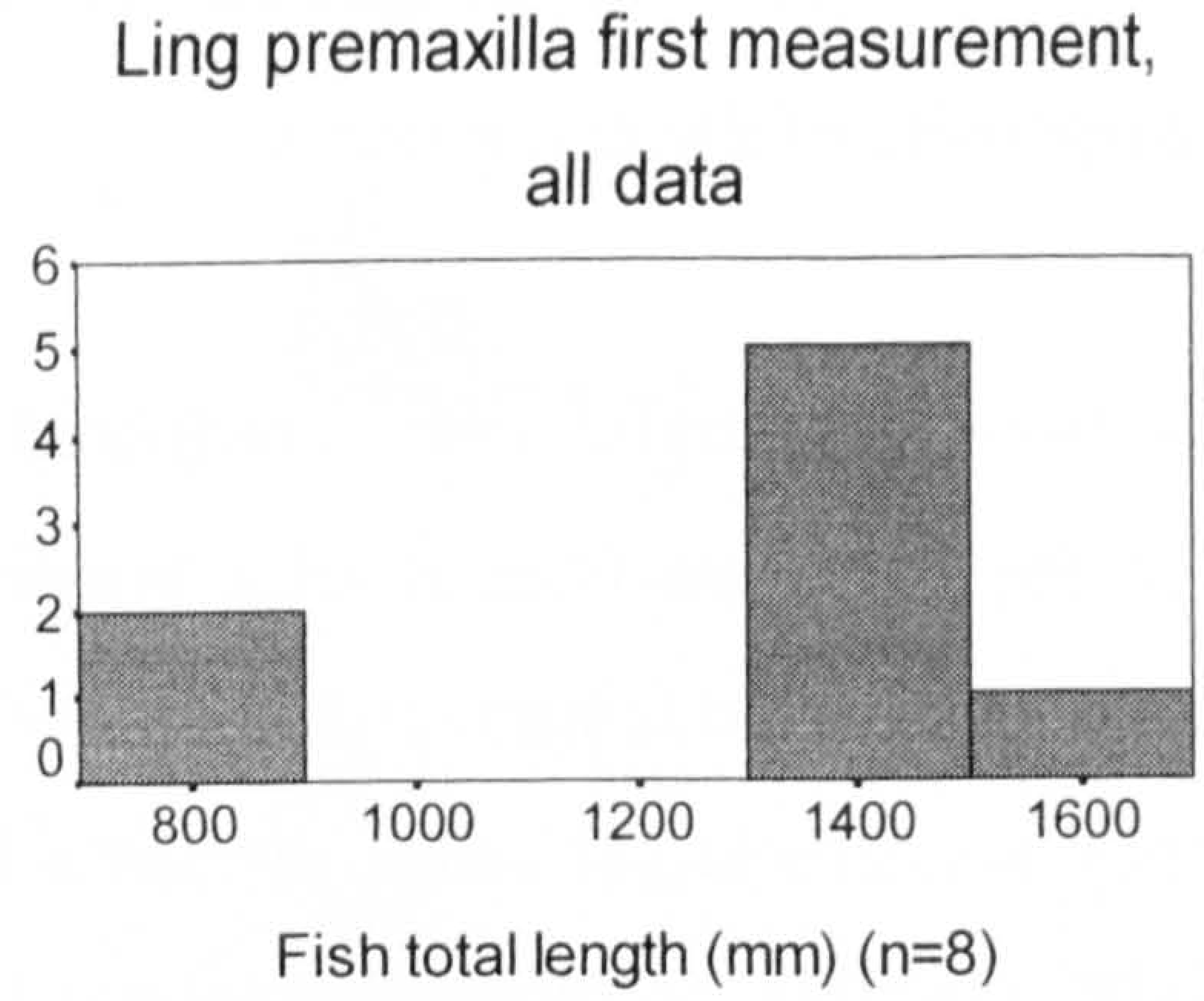


Figure 4.43 (left): Saithe total lengths determined using regression equations on the first premaxilla measurement, all data including <4mm

Figure 4.44 (right): Saithe size categories for all data including <4mm

4.6.4 Ling

Using size category data from throughout the site (Figure 4.46), it appears only ling of >500mm total length were consumed at Earl's Bu. No polymodality could be observed because only three categories were present, though a tendency towards fish of over 800mm total length is apparent. Very few ling premaxillae or dentaries could be measured, the largest sample being eight of the first premaxilla measurement (Figure 4.46). While this confirms the size category observations, this also indicates that ling could reach lengths of 1600mm or more, with a mode around the 1400mm total length (albeit based on only five measurements). Use of the >1000mm category hides the variation that can be found in the larger ling. Sample sizes are too small to investigate intra-site variation.



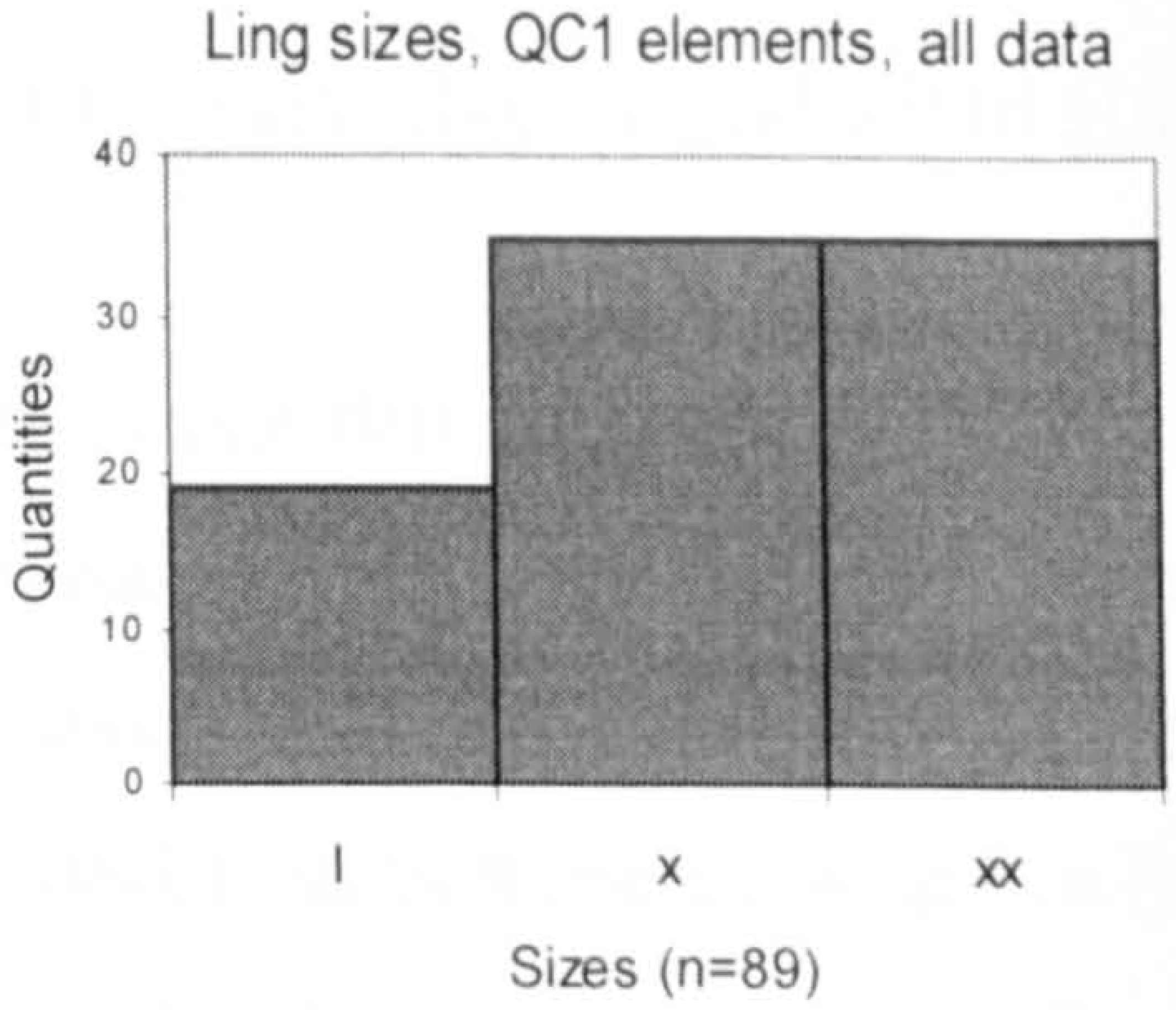


Figure 4.45 (left): Ling total lengths determined using regression equations on the first premaxilla measurement, all data including <4mm

Figure 4.46 (right): Ling size categories for all data including <4mm

4.6.5 Variation in regression total lengths

Two histograms were produced (Figure 4.47 and Figure 4.48) using the 70 cod premaxillae that had both the first and second measurements recorded. This allowed a comparison of the original measurements and their subsequent regression equations. Both histograms were bimodal, with modes around the 500mm and 1000mm total length, but while the histogram of the first measurement showed a marked absence of specimens around the 725 to 875mm range, the histogram of the second measurement lacked this absence altogether. Furthermore, the second measurement included specimens in the >1150mm size range and a much less pronounced second mode. The range of specimens below the 700mm range was similar using both regression equations.

This issue was further investigated using a line chart (Figure 4.49) that linked the two values from each specimen. A discrepancy in measurements occurred from about 800mm total length onwards, with a maximum difference of almost 200mm between the two estimated total lengths. It is possible that the accuracy of measuring larger elements decreases for the second measurement, while remaining more consistent for the first measurement.

Looking at the ordinal sizes recorded for these 70 cod premaxillae (Figure 4.50), a marked decrease is observed at the 800-1000mm total length category. This is not observed on the total lengths determined from either regression equation, suggesting either that it was difficult to correctly classify specimens to the 800-1000mm or >1000mm total length categories, or that the regression equations overestimated 800-1000mm and underestimated >1000mm total length fish. The former possibility is more likely.

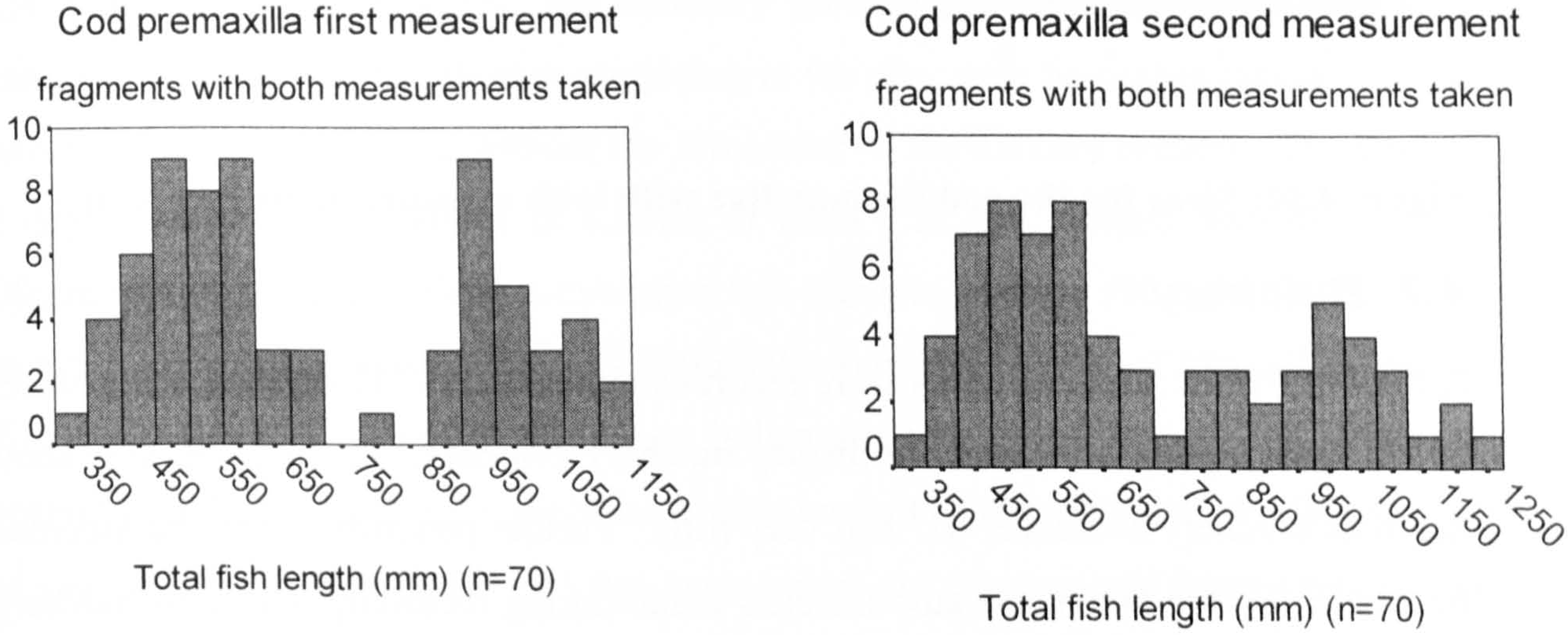


Figure 4.47 (left): Total cod lengths determined from the first premaxilla measurement, for all fragments with both measurements recorded

Figure 4.48 (right): Total cod lengths determined from the second premaxilla measurement, for all fragments with both premaxilla measurements recorded

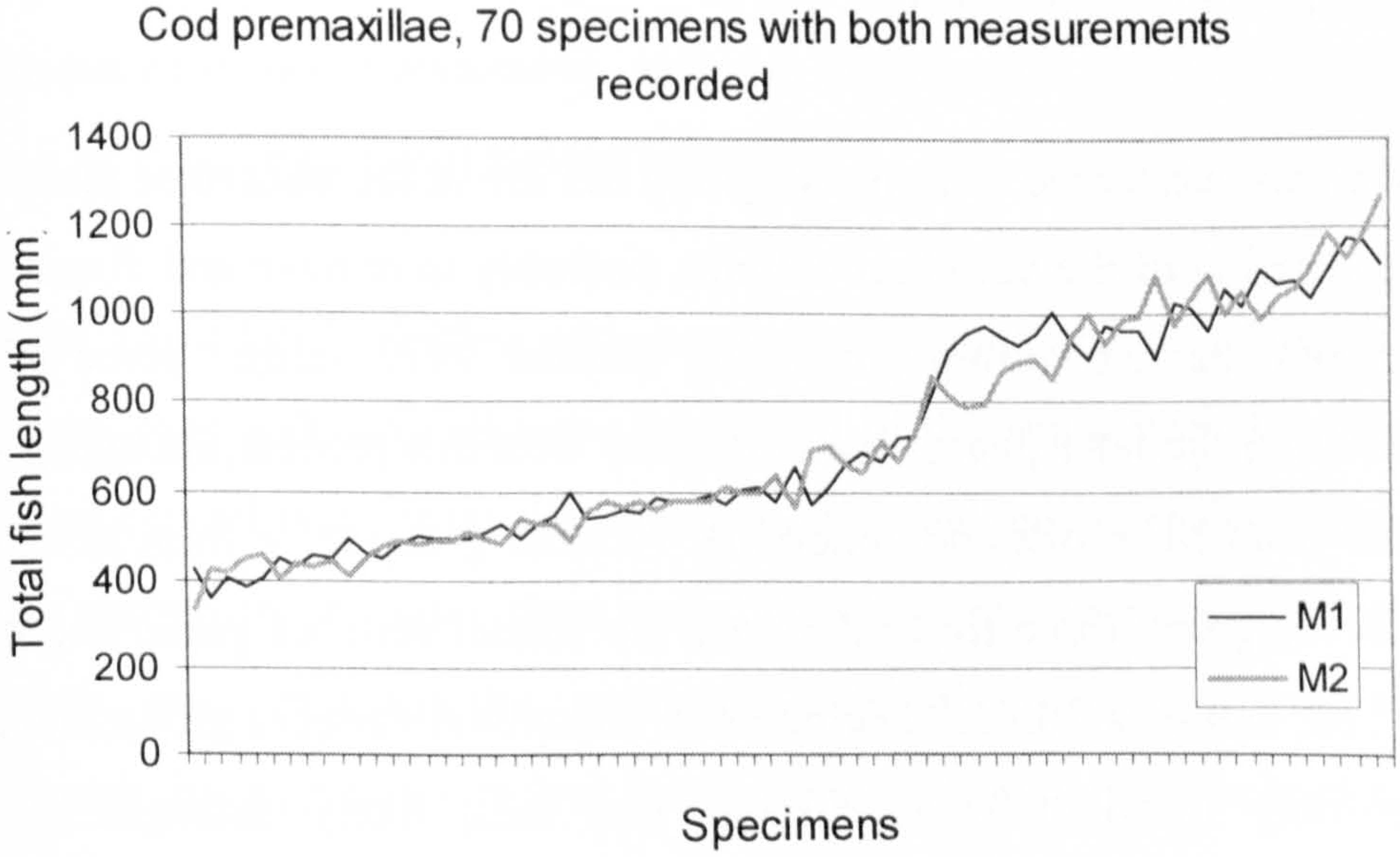


Figure 4.49: Differences in total fish lengths for cod premaxillae regression equations

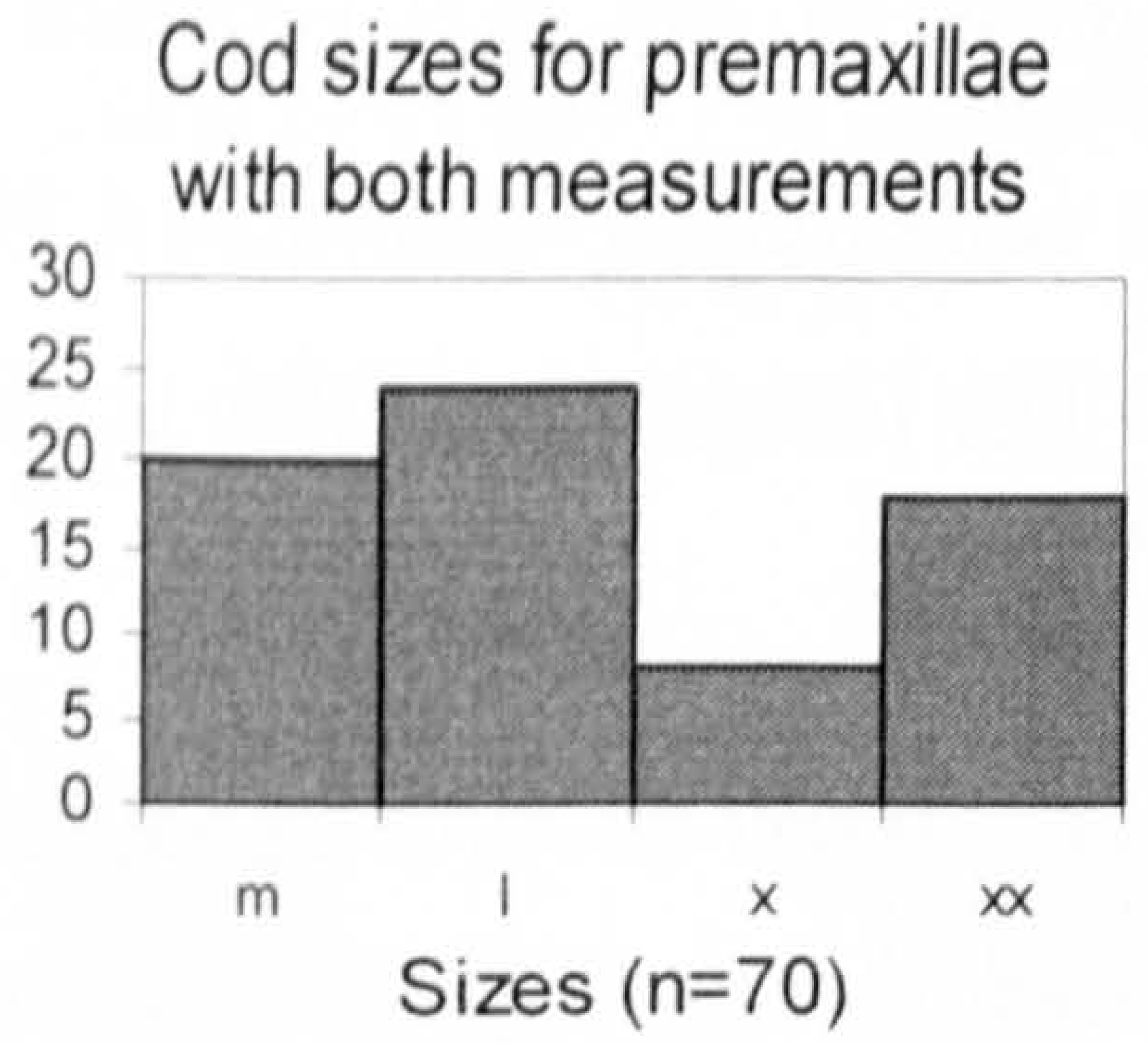


Figure 4.50: Sizes for the cod premaxillae with both measurements recorded

4.7 Butchery

A total of 77 cut or chop marks were recorded (Table 4.28). Haddock cleithra were by far the most numerous element to display butchery evidence. Phase group M3c showed the most butchery evidence; M1 had very little. Further patterning could be ascertained by examining the butchery mark sketches made during recording, but most butchery is consistent with decapitation involving the cleithra, supracleithra and posttemporals (49 out of 77). Inter-analyst variation meant that butchery cards were recorded for some of these, but not all, but butchery diagrams were recorded for all vertebrae. These have been digitised and overlaid, with one diagram now indicating all the marks for each type of element from each phase (Figure 4.51).

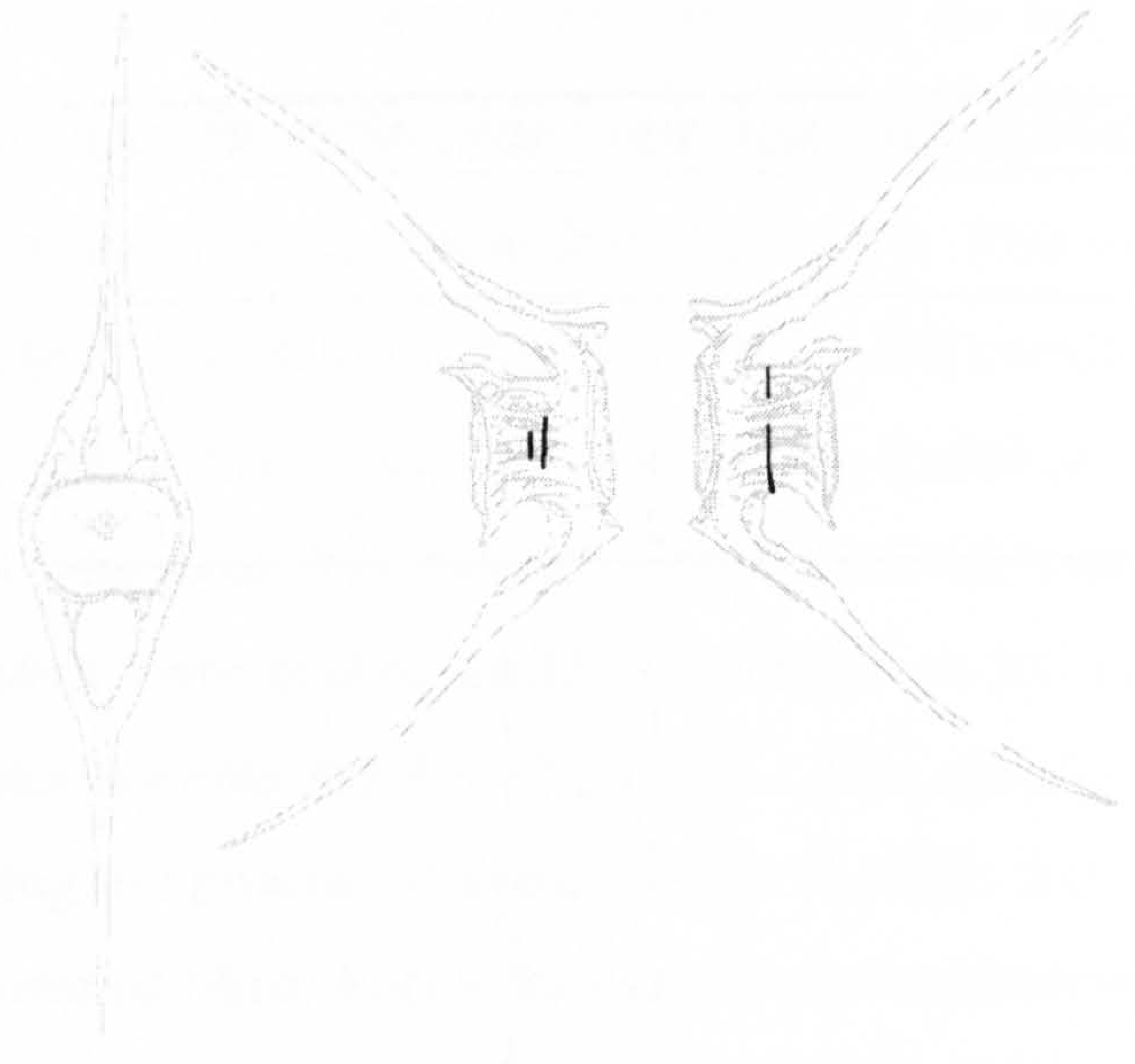
The two illustrated caudal vertebrae from phase group M1 are in the transverse plane and are consistent with severing of the vertebral column, probably to remove and discard the anterior vertebrae from the fish during processing (Barrett 1997, 628). Some of the illustrated vertebrae from the later phases are consistent with this process, including two cod caudal vertebrae from M3a, one cod abdominal vertebra group three from M3b, one ling abdominal vertebra group three from M3c, and six caudal vertebra group one from M3c, representing cod, saithe and ling. The one cod abdominal vertebra group one that was butchered ventrally in the transverse plane was most likely damaged during decapitation and the separation of the anterior vertebral column from the cranium. The other cuts to the first and anterior vertebrae were probably consistent with this practice. The few cuts to the vertebral column in the sagittal plane were likely caused by gutting (including two from M3c) or by splitting along the vertebral column (including one possible example from M3b).

Ventral cleithra were found during initial assessment of the late medieval deposits at Knowe of Skea, Westray, but there, all cleithra derived from cod, *Gadus/Pollachius* or gadid, all of at least 800mm long – none was haddock (Kilroy 2005, Tables 3.23 and 3.24, pers. comm.). However, the butchery method appears similar, with only the triangular ventral tip of the cleithra remaining at the site, with few other cranial elements from similarly sized fish and without the remainder of the cleithra present. The intensity of deposition was considerable at Knowe of Skea. In one context, two thirds of all 800mm and longer gadid cleithra exhibited this butchery pattern (96 out of 147), and in the other phase, an astonishing 94% exhibited this pattern (174 out of 186). The absence of other elements at Knowe of Skea may indicate it functioned as a short term storage location or collection point for prepared gadids en route for continental or other markets (as suggested by Kilroy (2005, 35), but excavations are ongoing and interpretations may change). The ventral cleithra were possibly being removed to aid packing during transport, because it would otherwise form a sharp corner to the prepared fish (Kilroy 2005, 24). An alternative suggestion is that they were accidentally created during decapitation, and have remained with the heads, but the absence of any other cod cranial elements of a similar size range makes this less likely. They may have been collected as a means of marking ownership, sources, destinations or as a tally, but the interpretation of all of these must await further research.

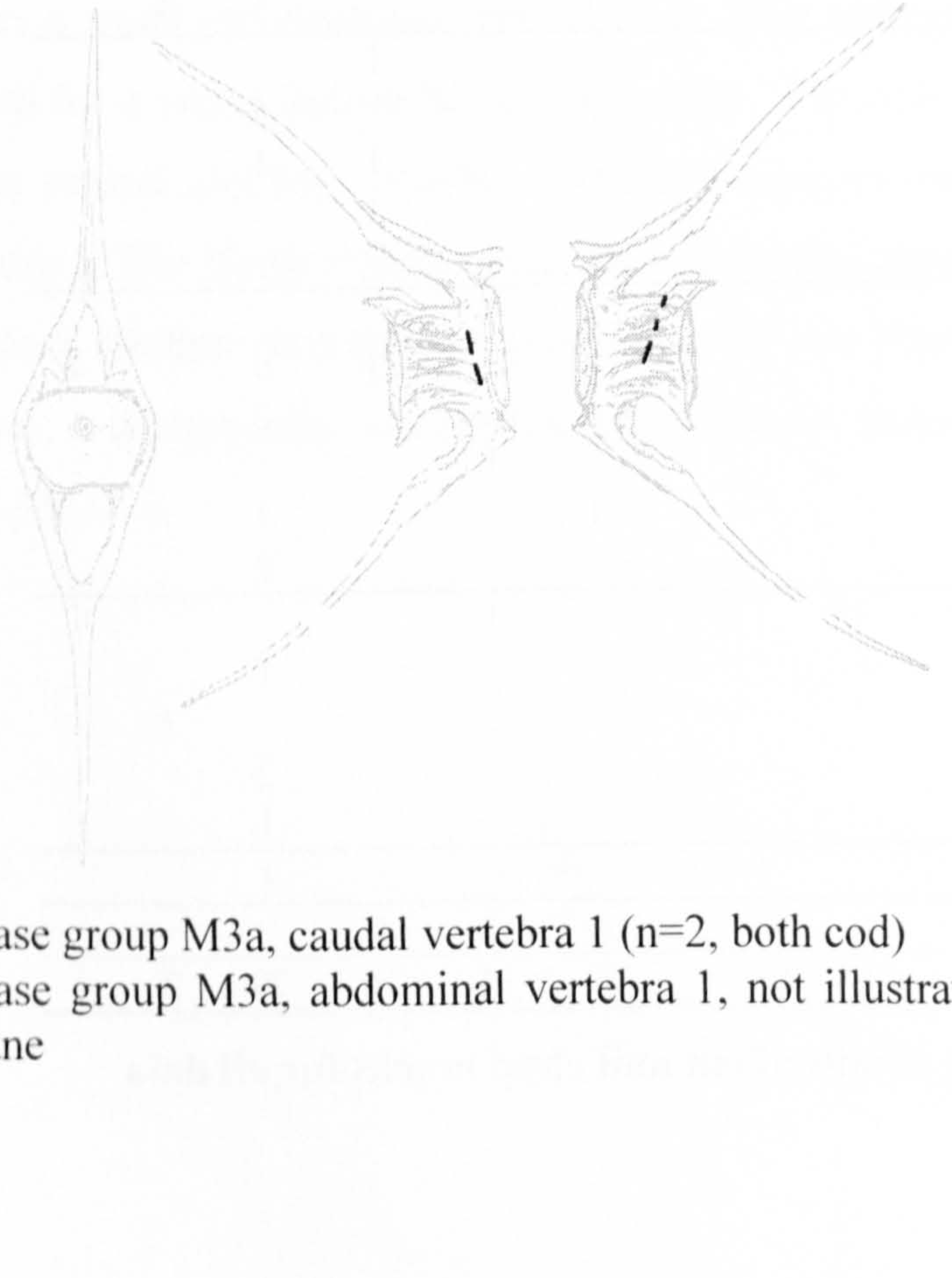
Of the 14 haddock cleithra with butchery evidence at Earl's Bu, nine were from 500 to 800mm long fish, and all were butchered in the same way, leaving only the triangular ventral tip; all were from the later period 3 middens or redeposited midden. A further three were from the same time period but encompassing a wider size range and included slightly more than just the ventral tip. No other species displayed similar patterning, although this may again reflect the extreme ossification and robust nature of the haddock compared to cod, saithe and ling. These haddock cleithra are from 500 to 800mm length fish, which as demonstrated above when discussing size categories, are a distinctive population with few cranial elements. This would suggest this butchery pattern is connected to the importation of processed haddock, but before placing too much significance on this pattern, it must be remembered that these 12 cleithra represent less than 5% of all haddock cleithra. If these ventral triangles had been removed during decapitation, they would be at the processing site with the cranial elements, which clearly is not the case at Earl's Bu. However, the butchery process would have left a similar chop or knife mark on the rest of the cleithra when the ventral tip was removed, but these dorsal cleithra are absent from Earl's Bu. This may be taphonomic, but given the robust nature of the cleithra, this is unlikely, so it therefore appears that the majority of element was left at the processing site and not found at Earl's Bu. One ling cleithrum from R1 was butchered, but did not follow the same pattern, while the remaining 10 butchered cleithra were cod or gadid, all were from the later phase 3, and most had small knife marks towards the dorsal process. This group of butchery marks was probably caused during the process of decapitation. Through this admittedly tenuous comparison with the Knowe of Skea, Earl's Bu *may* have also functioned as a temporary storage point. Even if the inhabitants consumed the majority of the prepared haddock and cod that arrived there, a small (or unknown) portion may have arrived at Earl's Bu, been collected and stored for a while, before being shipped on. The only indication of this process may be these ventral cleithra. Further work and comparisons with butchery practice in other regions of the North Atlantic may illuminate this pattern. It is also possible that the 12 haddock cleithra ventral tips represent the off cuts from preparing carved cleithra gaming pieces, a recognisable and contemporary use for these elements in Iceland (Batey 2005, 353-355).

Taxon	Element	C2	F2	M1	M3	M3a	M3b	M3c	R1	R3
Gadus/ Pollachius	Cleithrum						1			
Gadid	Basioccipital									1
	Cleithrum						2			
	Maxilla					1				
	Supracleithrum					2	1	3		
Cod	Abdominal Vertebra 1					1				
	Abdominal Vertebra 3						1	1		
	Cleithrum					1	1			
	Caudal vertebra						1			
	Caudal vertebra 1			2		2				
	Caudal vertebra 2						2			
	First vertebra					1				
	Parasphenoid						1			
	Posttemporal					2	3	2		
	Supracleithrum	1	1		1			1	1	
Cod?	Basioccipital						1			
	Cleithrum							5		
	Caudal vertebra 1						1	1		
	First vertebra						1			
	Supracleithra				1					
Haddock	Abdominal vertebra 3					1				
	Cleithrum					1	3	6		4
	Caudal vertebra 1							2		
	Maxilla					1				
	Posttemporal				1			1		
	Supracleithra							2		
Ling	Abdominal vertebra 2					1				
	Abdominal vertebra 3							1		
	Cleithrum								1	
	Caudal vertebra 1							2		
	Supracleithrum							1		
Saithe	Abdominal vertebra 3							1		
Unidentified	Abdominal vertebra						1			
Total		1	1	2	3	14	20	29	2	5

Table 4.28: Species and element details of cut and chop marks for all data

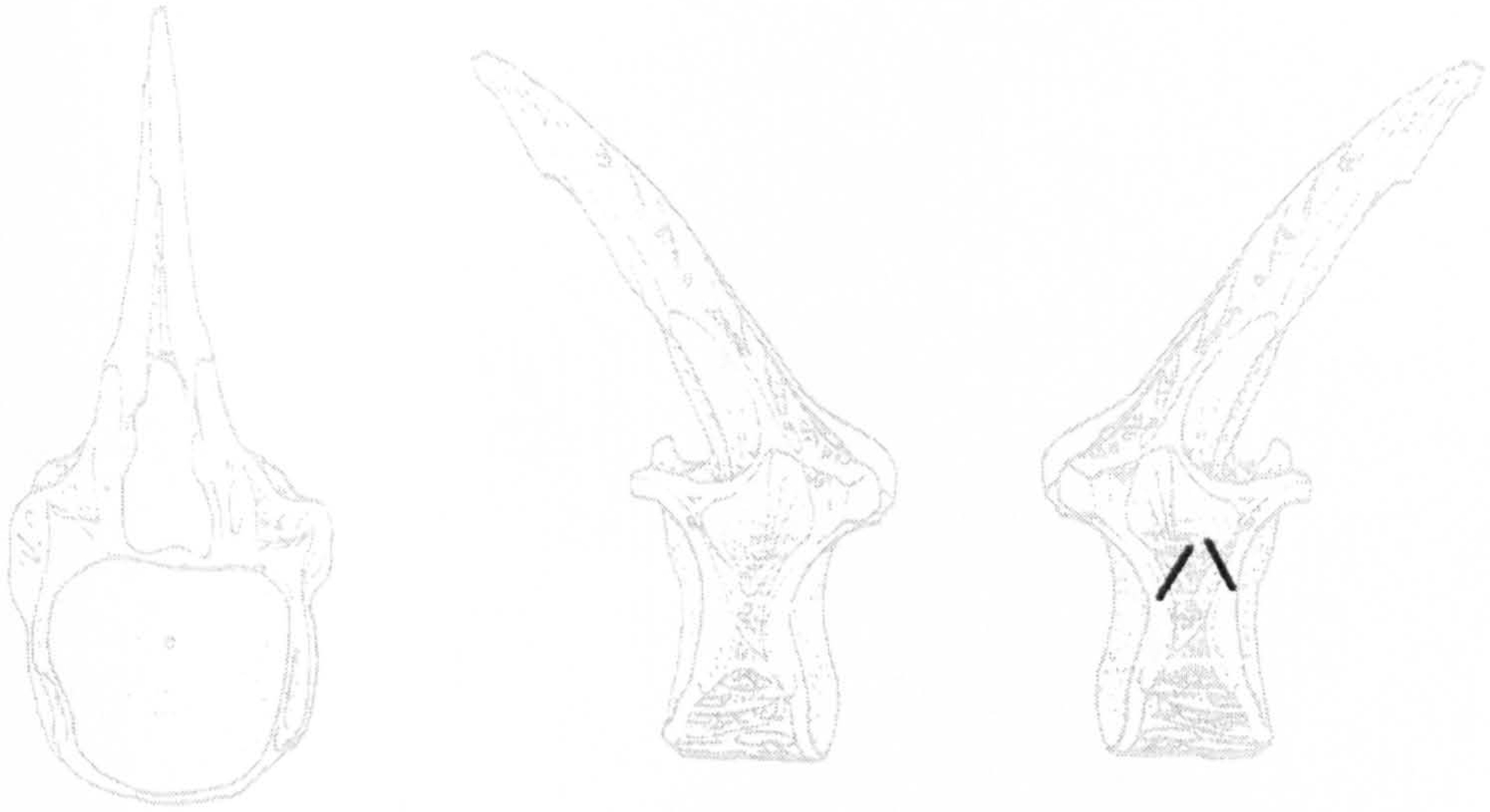


Phase group M1, caudal vertebra 1 (n=2, both cod)

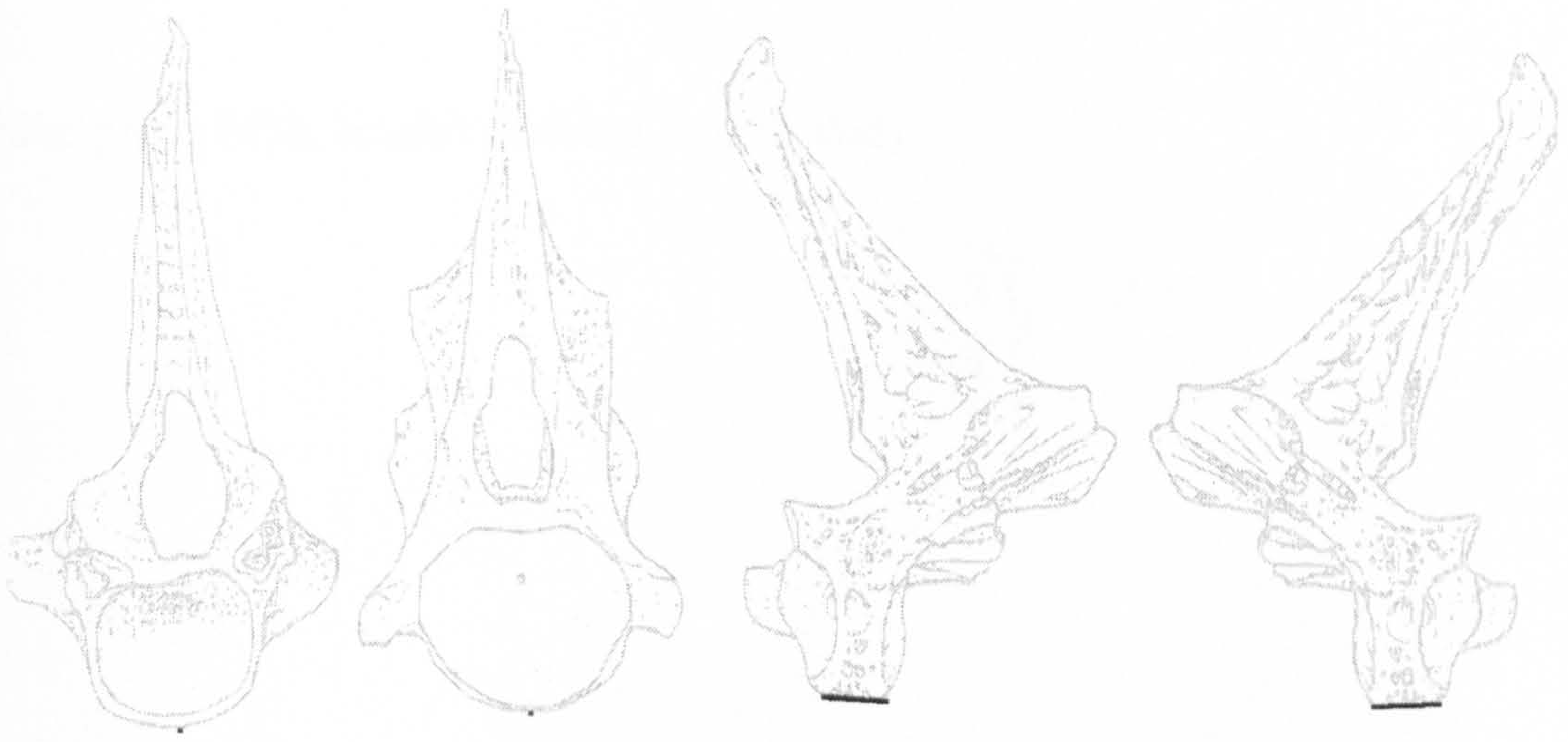


Phase group M3a, caudal vertebra 1 (n=2, both cod)

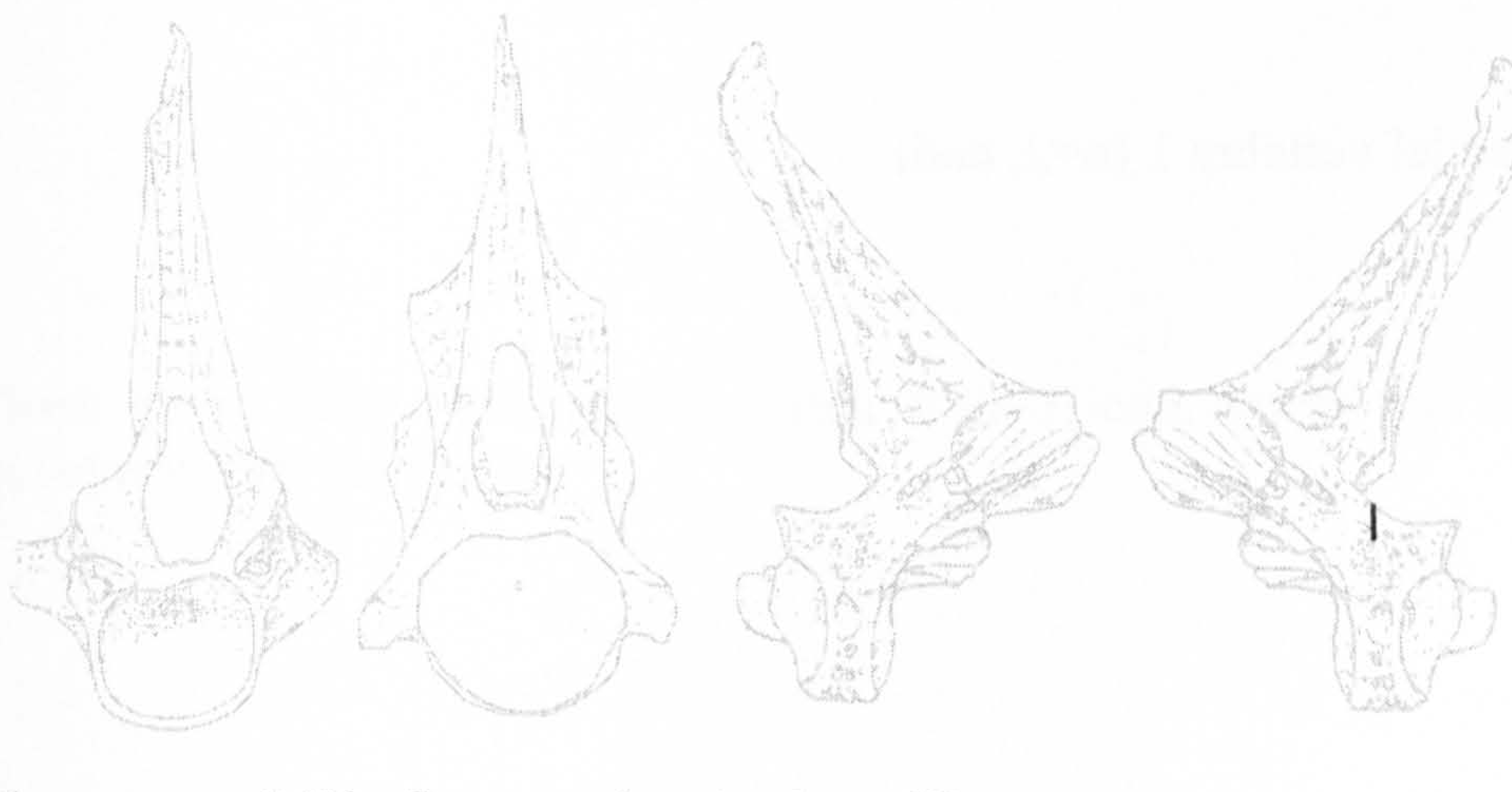
Phase group M3a, abdominal vertebra 1, not illustrated: cod ventral cut, transverse plane



Phase group M3a, abdominal vertebra 2 (n=1, ling)

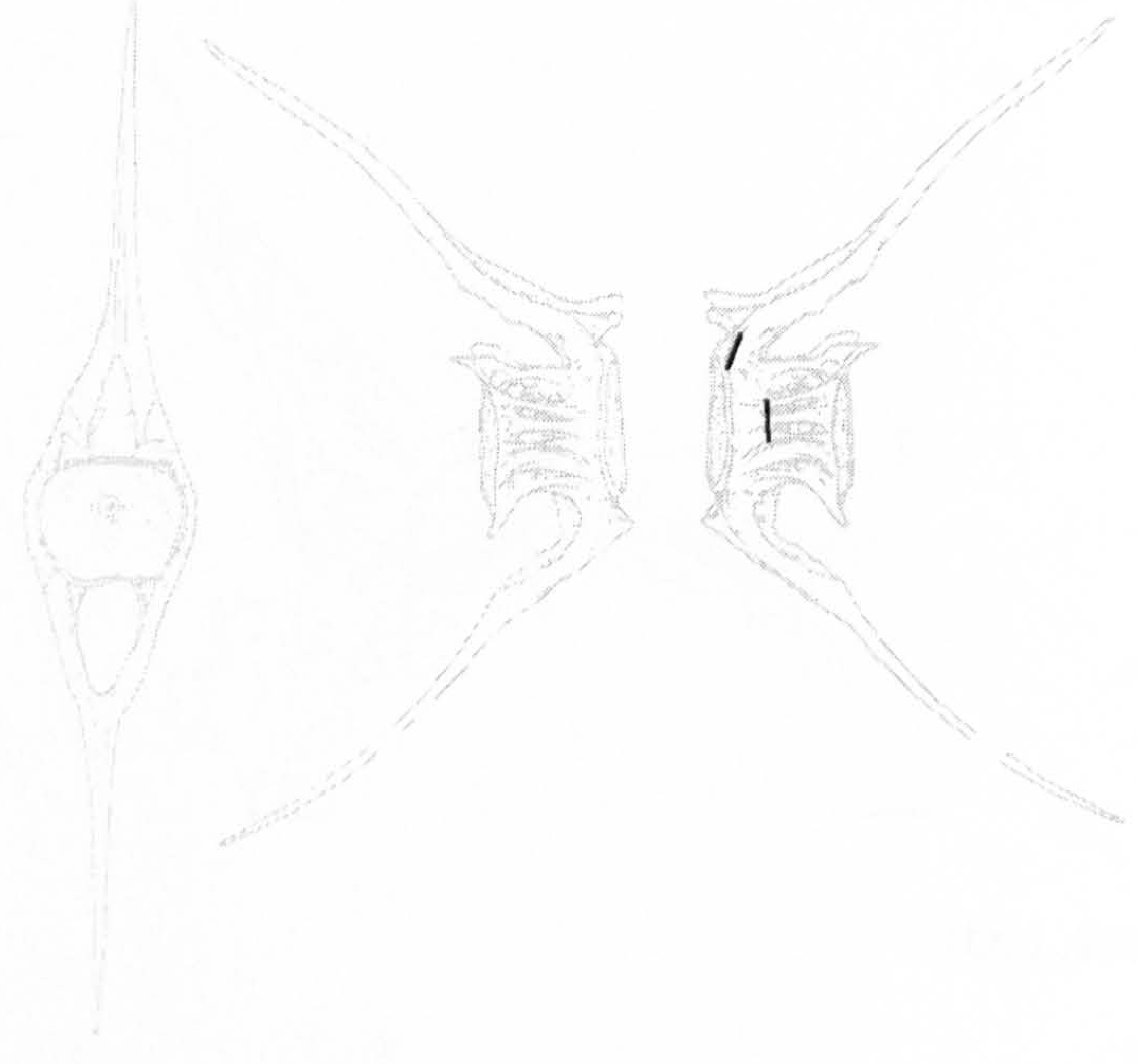


Phase group M3a, first vertebra (n=1, cod)

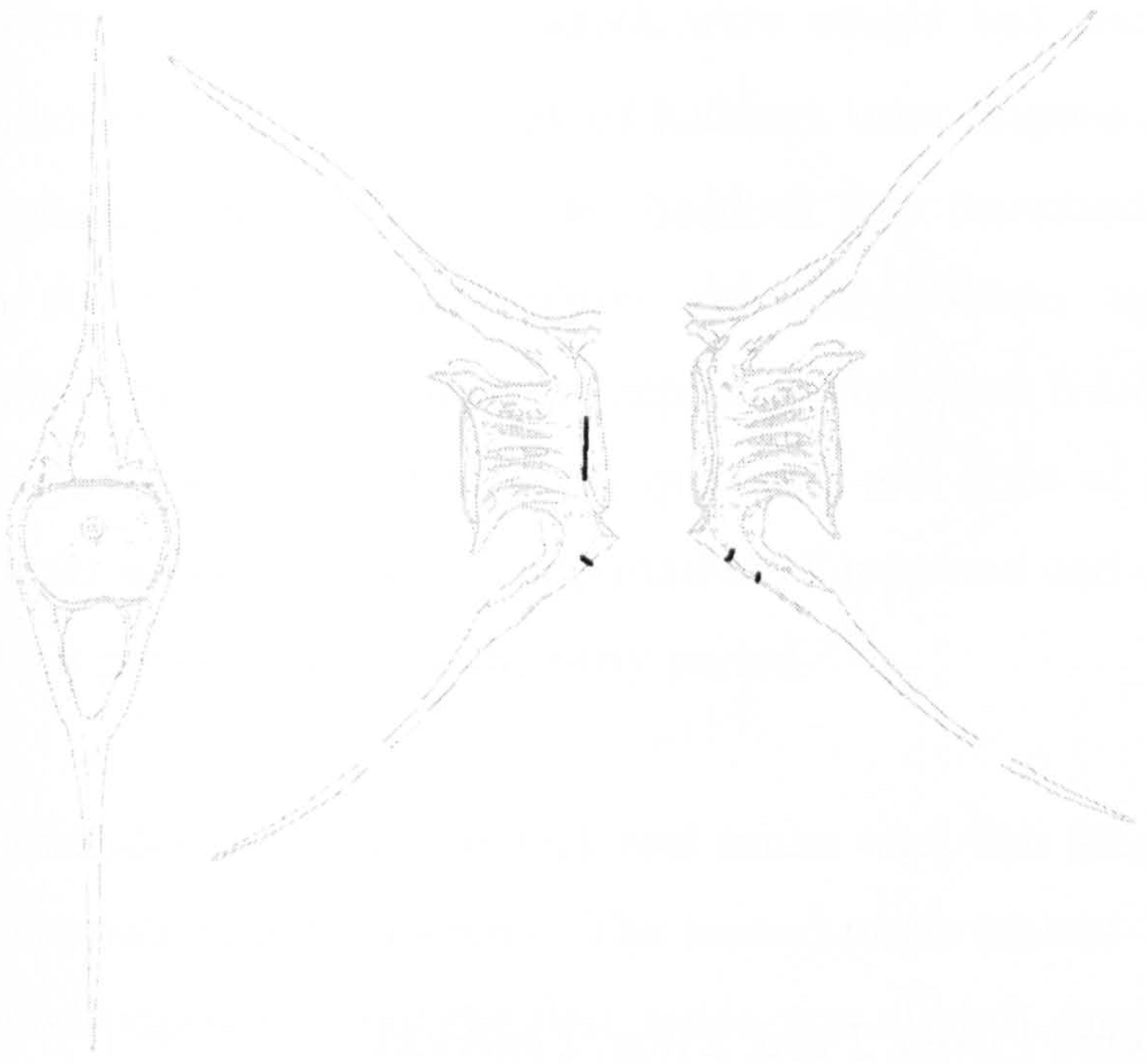


Phase group M3b, first vertebra (n=1, cod?)

Phase group M3b, abdominal vertebra 3 (n=1, cod)

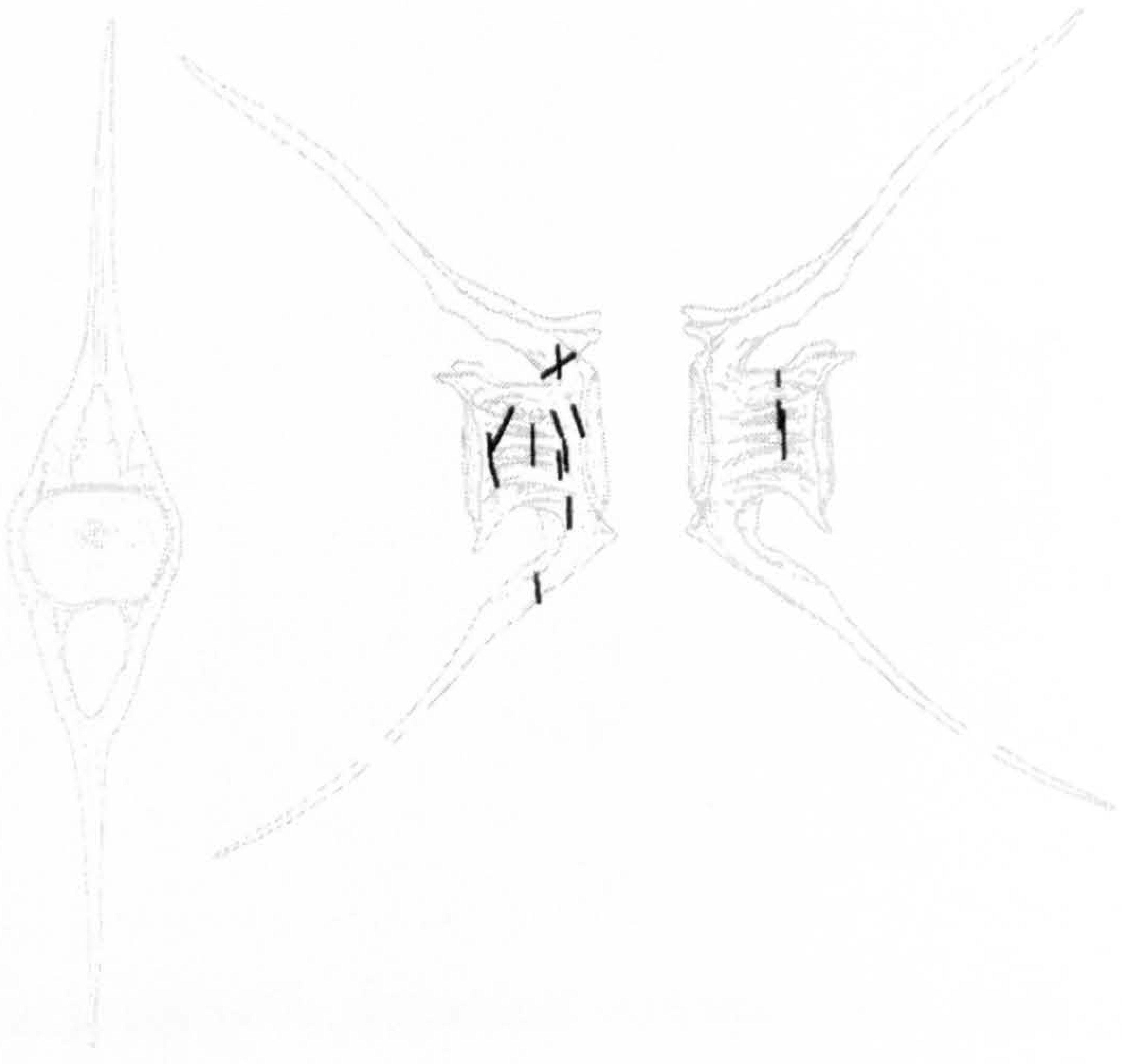


Phase group M3b, caudal vertebra 1 (n=2, cod)



Phase group M3b, caudal vertebra 2 (n=2, cod)

Phase group M3c, abdominal vertebra 3 (n=3, cod, saithe and ling; ling represent transverse cuts marked by *)



Phase group M3c, caudal vertebra 1 (n=6, 2 cod, 2 ling, 2 haddock)
Figure 4.51: Fish butchery diagrams, base images from Cannon (1987)

4.8 Discussion

Trade in processed fish is a recognised economic phenomenon of the Orkney earldom during the time Earl's Bu was occupied, as indicated in Chapter One. Given that Earl's Bu was probably a high status settlement, it would be unusual to not have some evidence for fish trade found in the zooarchaeological assemblage. Different element proportions can be used as evidence of fish trade, particularly an abundance or shortage of gadid cleithra, elements that accompany the prepared fish to the consumption site (Barrett 1997). Several lines of evidence have pointed to an increased proportion of cleithra that cannot be explained by recovery, preservation or taphonomic biases. Haddock cleithra definitely outnumber other elements in almost all phase groups, with an increase in quantity from the early phase group to the late ones. The haddock cleithrum is a robust element likely to be over-represented compared to all others for taphonomic reasons, but in contrast, cod cleithra are not nearly as robust, yet they are also over-represented in some phases. Some phase groups contain proportionally greater vertebrae than premaxillae and dentaries, thus providing further evidence of processed fish arriving without corresponding cranial elements attached. Butchery marks are consistent with this practice, and the proportions of other elements do not contradict this pattern. In addition, size data suggest an addition of 500-800mm and 800-1000mm total length processed haddock containing the cleithra without any accompanying cranial elements.

Therefore, although some haddock were caught and consumed whole at Earl's Bu, a considerable quantity of processed haddock were imported to the site, particularly in the later phase groups. The imported haddock then increased in size within the later period from 300-500mm to 500-800mm and 800-1000mm total length. The considerable quantities of cod fragments must represent numerous fish being caught and consumed on site. However, differences in the quantities and sizes of cod cleithra compared to other elements suggests a similar importation of prepared cod of 800-1000mm total length in the later period, but not in the early period.

The bimodality of cod, haddock and saithe total fish lengths suggest the exploitation of two separate fish populations. The second mode around 1000mm was consistent among the cod population, but the first mode was slightly smaller for the later phase groups (around 450mm) than seen in the early phase groups (around 600mm). Haddock size modes were around 500mm and 750mm, with a tendency towards increasing numbers of larger fish in the later phase groups. Saithe bimodality was centred around the 300-500 and 800-1000mm total length categories, while only >500mm total length ling were exploited. No great changes were seen through time, suggesting a stable fishing economy based around both deep water and more shore-based activities. The increasing proportions of prepared haddock, as represented primarily by the cleithra, do not contribute to the calculation of total fish lengths because the premaxilla and dentaries from these fish – the elements that are measured – remained at the processing site. Although there appears to be an increase in haddock fish sizes over time, much of this pattern is actually caused by increasing imports of prepared larger haddock. The butchery evidence for processing correspondingly increases in these late phase groups, providing further non-metrical confirmation of this trend. A small quantity of 500-800mm size butchered haddock ventral cleithra were found in the later phase and are difficult to explain. They may be evidence that some prepared haddock arrived at Earl's Bu, was temporarily stored, and then was exported again for another market.

Throughout all stages of the analysis, biases caused by differential recovery and preservation have been discussed and factored in to any conclusions. Recovery methods at Earl's Bu were problematic because it was at times difficult to differentiate between the hand collected and sieved assemblages, despite this being vital to any analysis of fish bone. A subset of entirely sieved bone and entirely hand collected bone was used to provide a pattern against which the main assemblage was compared; this permitted the nature of any biases to be identified and then applied to subsequent results. Preservation biases were easier to identify using a variety of taphonomic data, including texture and fragmentation. Each phase group was compared to every other, providing a list of well preserved and poorly preserved phase groups. All results discussed here take into account these biases, and in most cases the incorporation of taphonomic biases has strengthened these results, rather than weakened them.

Almost every analytical method used above confirmed the separation of phase groups by spatial units as well as time. Construction/collapse and feature deposits consistently appeared different from the main midden phases, implying that they were the result of different behavioural and taphonomic patterns (a conclusions also drawn from preliminary analysis of the mammal bone, see Chapter Eight). The difference between midden and redeposited midden was pronounced as well, and had they been grouped together into early and late, some of the patterning would have been lost. The fact that both early and late redeposited midden tended to be less fragmented and less affected by burning, rather than more as would be expected, suggests that equating M1 with R1 and M3 with R3 may be too simplistic. Significant differences in cod textures were observed between R3 and M3a, and significant differences in the percent completeness of all species were observed between R3 and both M3b and M3c. The species compositions of the later redeposited midden and both M3b and M3c were different by QC1 NISP and weight and QC2 NISP, though some similarities between the early M1 midden and redeposited R1 midden were observed. Cod element distributions were markedly different between R3 and the M3 phase groups, but fairly similar for R1 and M1, whereas haddock element distributions were substantially different for both early and late phase groups. In conclusion, there is not enough evidence to state conclusively that R1 and R3 were derived from M1 and M3, but the earlier deposits appear to be more similar than the later ones. The redeposited midden phase groups are therefore best viewed separately unless gross comparisons between early and late need to be made. Further conclusions regarding these phases will have to wait for preparation of the site publication.

In conclusion, the inhabitants of Earl's Bu consumed large quantities of cod and haddock, augmented by saithe, ling, and a small number of non-gadid species including eel and salmonids, and overall, the consumption of fish increased through time. Although many cod and some haddock were caught and brought to the site whole, additional haddock and cod were traded to the site ready-processed. This was more common towards the later period of the site than the earlier, suggesting an increase in trade occurred through time. Both deep water and inshore fisheries were exploited throughout all phase groups of the site, with a slight tendency towards smaller inshore fish through time. Compared to other sites, saithe caught at Earl's Bu were much larger, indicating a greater exploitation of deeper water saithe stocks; this may reflect the higher status of Earl's Bu, and will be investigated further in subsequent chapters. The high quantities of processed fish arriving at Earl's Bu can be correlated with its high status, as defined through textual associations, architecture and finds.

Chapter Five: Quoygrew Fish

The aim of this chapter is to present the results of the fish bone identified by the author. The emphasis will be placed on comparisons both between two main areas of the site – the shore-based fish midden and the inland farm mound (as introduced in Chapter Three) – as well as the variation between phases. The use of inter-site comparisons will be kept to a minimum in this chapter, but will be explored in more detail in Chapter Eight, following the presentation of the mammal and bird assemblages in the following chapters.

5.1 Recovery rates

Recovery for Area G (i.e. phases i to viiii) included hand collection, >4mm and 2-4mm, but Area A (i.e. phases 1.2, 2 and 7) was sieved entirely so had no hand collection. Because of the huge quantities of hand collected fish bone (about 120kg), and the biases caused by the hand collection of fish that need to be resolved during analysis (see Earl's Bu, Chapter Four for a précis of the problems involved), only >4mm and 2-4mm fractions were examined from Area G. Therefore, Areas A and G can easily be compared because both used similar recovery methods.

Fish suffer from severe recovery biases if only certain fractions are examined. Hand collection is extremely unreliable for fish bones and can lead to the over-emphasis of some elements, fish sizes and even fish species, while even recovery to >4mm can lead to a biased recovery of some elements and sizes (Wheeler and Jones 1989). Consequently, every 2-4mm fraction of each flotation sample used for fish identification was sorted and all identifiable bone was recorded. The coarse sieving samples from phases i and ii have no 2-4mm fraction, but the smaller number of fish bones from these phases meant both flotation and coarse samples needed to be considered to increase sample sizes. Thus there is a mismatch between the Area A and phase iii fish (matching and equal quantities of 2-4mm and >4mm fractions identified) and the phases i and ii samples (all >4mm samples, but only half of which have matching 2-4mm fractions). When this difference is important in quantification, the fractions used will be made explicit. For example, the graphs in Figure 5.1 showing fish textures use a darker colour to indicate the unmatched >4mm coarse results, as opposed to the lighter grey used for the complete and matched 2-4mm and >4mm.

Phase	Recovery	QC 4		QC 2		QC 1		QC 0 (unidentified)		TNB
Phase 1.2	2-4	1	2%	50	82%	10	16%			61
	4	3	0%	67	6%	48	4%	1048	90%	1166
	Total	4	0%	117	10%	58	5%	1048	85%	1227
Phase 2	2-4	23	4%	487	78%	113	18%			623
	4	40	0%	1267	10%	593	5%	10804	85%	12704
	Total	63	0%	1757	13%	706	5%	10807	81%	13333
Phase 7	2-4	1	4%	19	68%	8	29%			28
	4		0%	7	22%	1	3%	24	75%	32
	Total	1	2%	26	43%	9	15%	24	40%	60
Phase i	2-4	1	2%	39	81%	8	17%			48
	4		0%	46	12%	21	5%	331	83%	398
	Total	1	0%	85	19%	29	7%	331	74%	446
Phase ii	2-4	2	0%	678	82%	145	18%			825
	4	20	0%	2113	17%	887	7%	9459	76%	12479
	Total	22	0%	2791	21%	1032	8%	9459	71%	13304
Phase iii	2-4	4	0%	737	88%	93	11%			834
	4	44	0%	1264	7%	1030	6%	16179	87%	18517
	Total	48	0%	2001	10%	1123	6%	16180	84%	19352
Grand Total		139	0%	6777	14%	2957	6%	37849	79%	47722

Table 5.1: Identification by recovery method and quantification code (percentages of TNB for each recovery method)

5.2 Preservation

5.2.1 Texture

The fish bone textures are without the variation caused by mammal age profiles (see Chapter Six), and consequently they can provide a good illustration of spatial and temporal texture variation. Table 5.2 summaries the fish textures for the >4mm fraction. Phases 1.2, 2 and iii fish are predominately of texture 2 (good), but phases i and ii are poorly preserved. Significant differences in texture of the >4mm fraction were observed between phases ii and iii (greatest difference 0.229, Kolmogorov-Smirnov Z value 5.065, significance 0.000), phases i and iii (0.714, 3.239, 0.000), and even phases i and ii (0.509, 2.308, 0.000): phases 2 and iii were the best preserved, while phase i was the worst preserved. Texture scores for each of the three species of economic importance (cod, saithe and ling) are illustrated in Figure 5.1, Figure 5.2 and Figure 5.3. Because each species can have different economic and taphonomic influences, the textures for each need to be analysed separately. Using only the matching cod >4mm and 2-4mm dataset (i.e. only the light grey bars in Figure 5.1, Figure 5.2 and Figure 5.3), phase 2 had significantly better textures than phase ii (0.257, 3.525, 0.000), phase iii had significantly better textures than phase ii (0.252, 3.939, 0.000), and phase ii had significantly better textures than phase i (0.522, 1.368, 0.047). Using the similarly matching >4mm and 2-4mm dataset, but for saithe, phase iii had significantly better textures than phase ii (0.142, 1.472, 0.026), while phase 2 was not significantly different from phases ii or iii.

To summarise, fish textures were more variable than mammal textures (see Chapter Six), and were approximately correlated to duration of deposition, with phases 2 and iii having the best textures and phase i significantly worse textures. Cod and saithe both followed the general pattern.

Textures	Phase 1.2		Phase 2		Phase i		Phase ii		Phase iii		Grand Total	
1 (Excellent)			3	0%		0%	3	0%	13	1%	19	1%
2	36	71%	485	77%	1	5%	478	53%	804	75%	1804	67%
3	12	24%	132	21%	8	38%	366	41%	245	23%	763	28%
4 (Poor)	3	6%	13	2%	12	57%	56	6%	11	1%	95	4%
Total	51	100%	633	100%	21	100%	903	100%	1073	100%	2681	100%

Table 5.2: Fish texture by phase (>4mm)

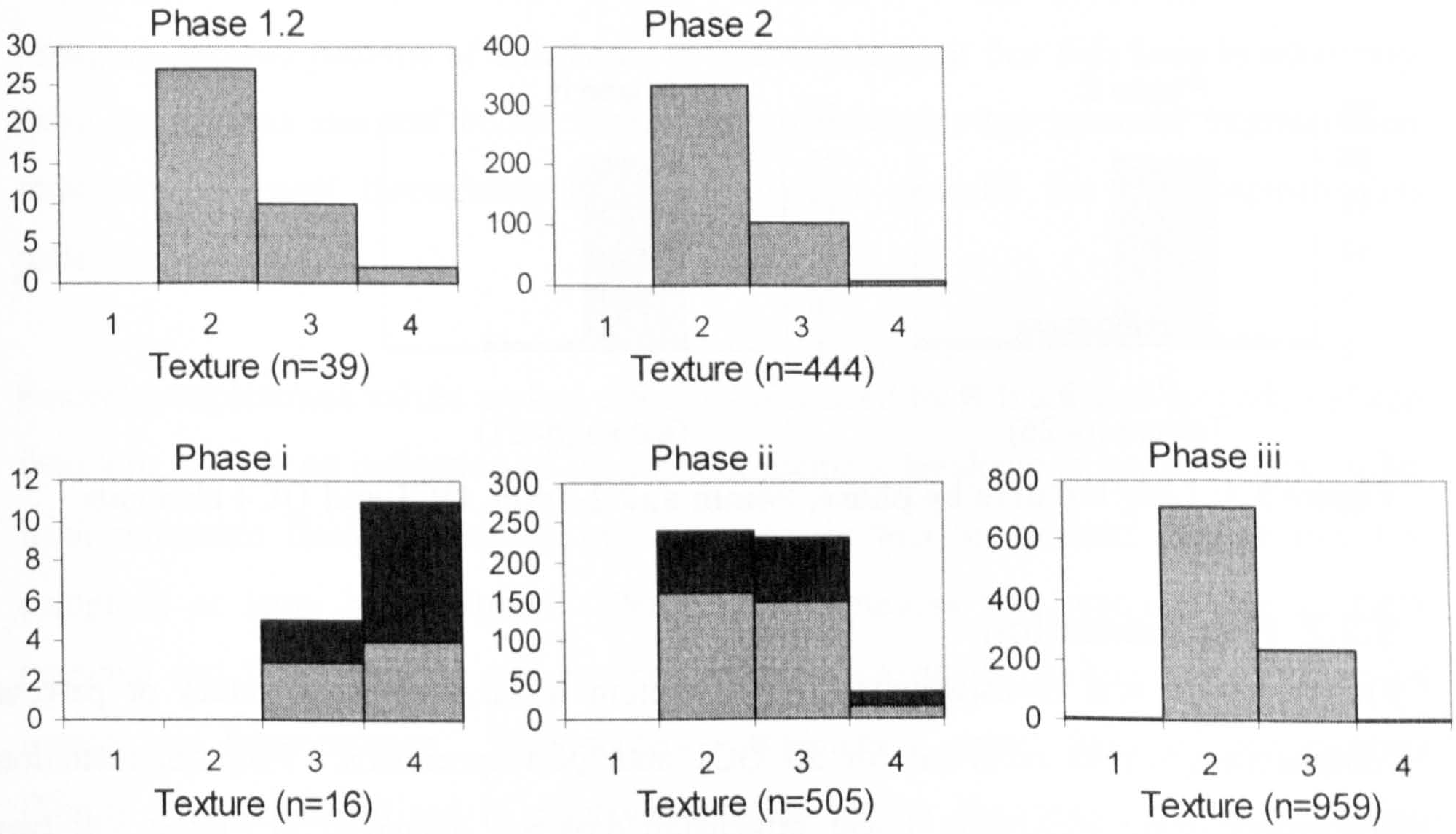


Figure 5.1: Cod textures by phase, >4mm and 2-4mm, QC1 and QC4 elements (darker grey indicates results from coarse >4mm samples without matching 2-4mm fraction)

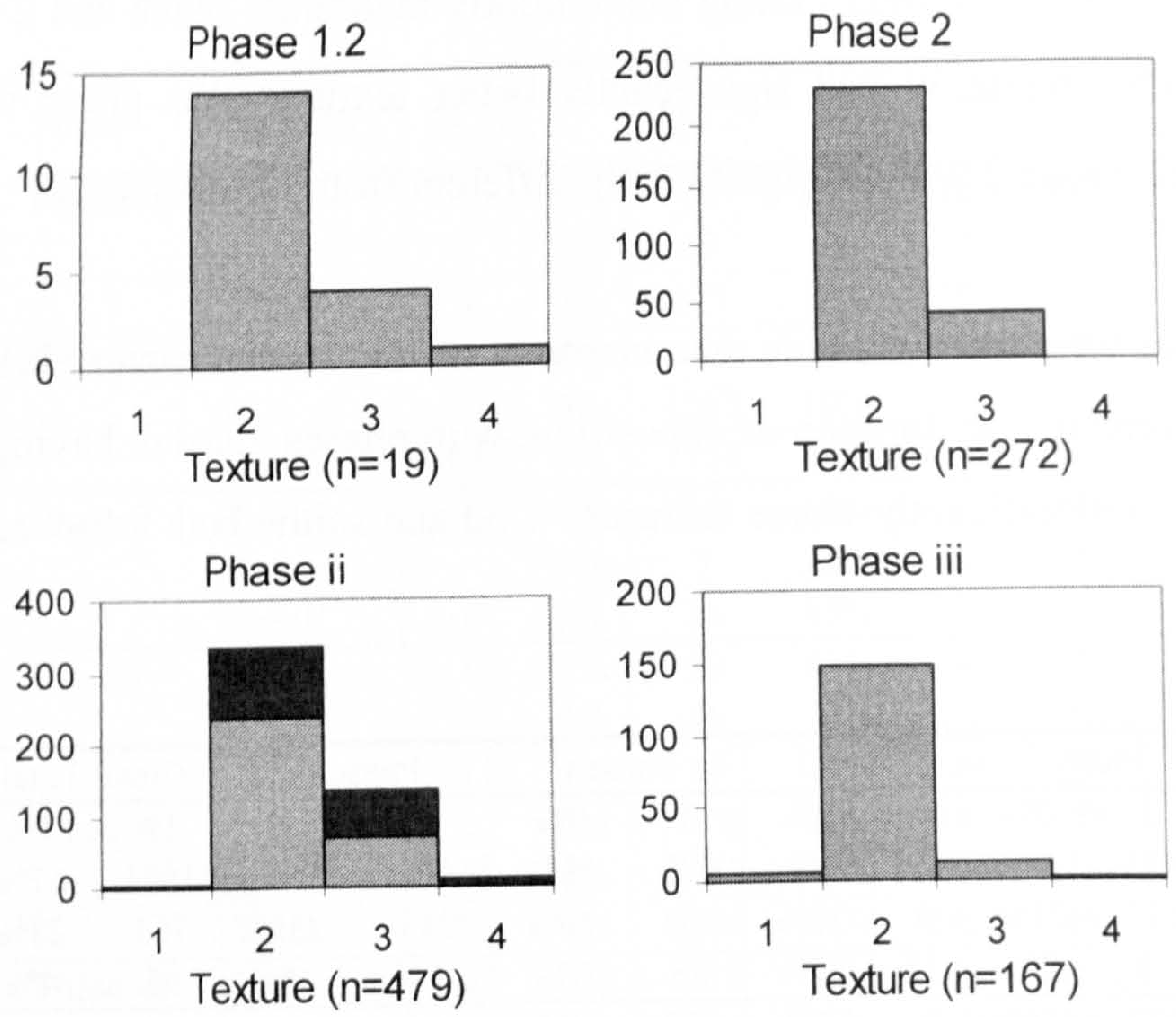


Figure 5.2: Saithe textures by phase, >4mm and 2-4mm, QC1 and QC4 elements (darker grey indicates results from coarse >4mm samples without matching 2-4mm fraction)

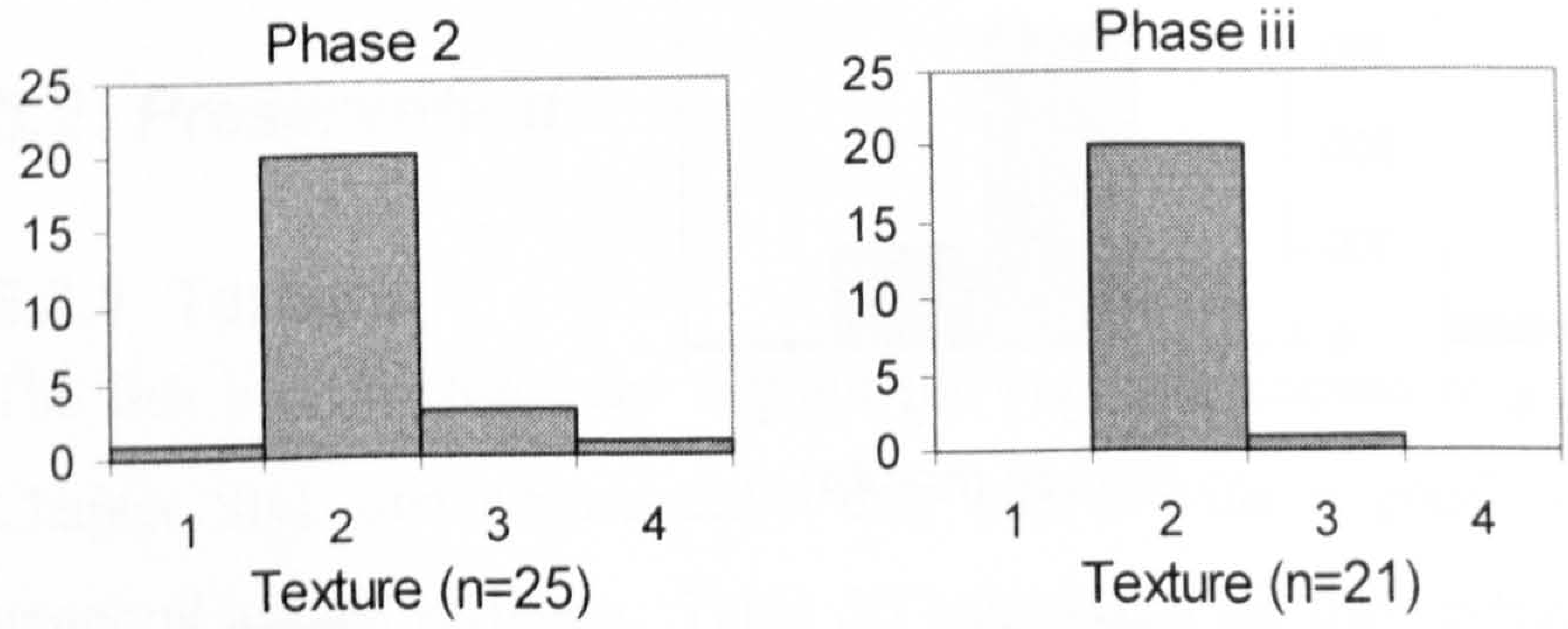


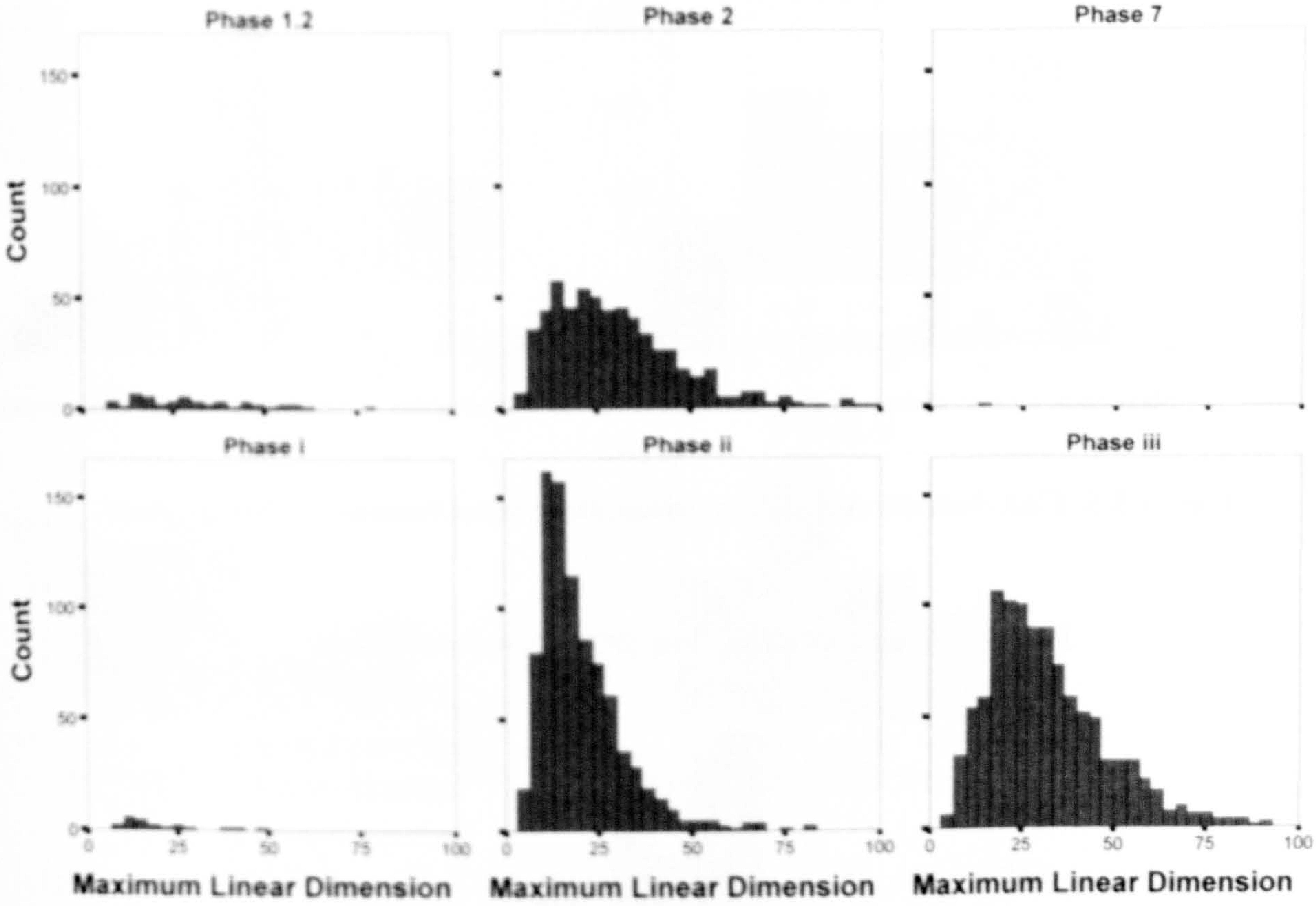
Figure 5.3: Ling textures by phase, >4mm and 2-4mm, QC1 and QC4 elements

5.2.2 Fragmentation

Fragmentation was investigated using maximum linear dimension values or percent completeness scores recorded for all QC1 and QC4 specimens. Fish fragmentation histograms using maximum linear dimension data are displayed in Figure 5.4; two groups are immediately apparent, with phases i and ii having very similar small modes around 12mm and phases 2 and iii displaying similar, larger modes around 18-20mm. These histograms could easily represent differences in species and age distributions, with the earlier phases possibly containing smaller fish compared with the later phases. The prevalence of values above 50mm for phases 2 and iii would support this hypothesis. Consequently, in order to get an idea of real differences in fragmentation between phases

– rather than differences in the species and age compositions in the assemblage in addition to fragmentation – one element from one species of a set age needs to be compared across phases. No one mammal element of one age group or fusion stage was present in sufficient quantity. However, a total of 124 cod dentaries from fish of 800-1000mm in length were found in phases 2, ii and iii, and because these dentaries were from cod of a similar age, they could be used to test the real variation in fragmentation between phases (Figure 5.5). The dentaries were the most commonly occurring element in that size category, and unfortunately none was found in phase i or 1.2. These dentaries indicate that the mean size increased from phase ii (25.9mm) to phases iii (37.8mm) and 2 (41.4mm). These differences proved to be significant (phases ii and iii: Mann-Whitney U 494.000, significance 0.001; phases ii and 2: 116.000, -2.776, 0.006). The evidence from cod dentaries reinforces the overall fragmentation pattern, indicating minimal influence of changing age and species profiles through the phases. Fish bones are more highly fragmented in the older deposits, while there was little difference in mammal bone fragmentation (see Chapter Six). This could indicate changing fishing strategies or changing disposal patterns of fish bone, or it could suggest that fish bone is inherently more fragile than mammal bone. Either way, it indicates that mammal fragmentation remained consistent throughout, but some factors changed the fish fragmentation patterning.

Percent completeness values are not directly influenced by fish age and species, and can therefore provide an indication of the rates of element breakage or usage. These differ from minimum linear dimension measurements in that an element can be tiny but complete, or large but fractured. Percent completeness was recorded for all QC1 mammal and fish elements, and can be used to augment the taphonomic evidence of texture and fragmentation. Fish percent completeness scores followed two patterns (Figure 5.6). Phases ii and iii displayed roughly similar distributions, both containing large quantities of 21-40% complete elements and small quantities of 81-100% complete elements. Phase 2, and to a lesser degree phase 1.2, contained higher quantities of 81-100% complete elements, and approximately equal quantities of 21-40%, 41-60% and 61-80% complete elements. Phases ii and iii were statistically different (greatest difference 0.091, Kolmogorov-Smirnov Z value 1.994, 0.001), phase ii having lower percent completeness scores than phase iii. Unsurprisingly, statistical tests proved that phase 2 had higher percent completeness scores than phase ii (0.249, 4.689, 0.000) and phase iii (0.158, 3.056, 0.000). These results match both the mammal percent completeness scores, and the results of the maximum linear dimension distributions for both mammal and fish. Individual summaries by phase for the three major economic species, cod, saithe and ling, are provided in Figure 5.7, Figure 5.8 and Figure 5.9. The overall pattern of percent completeness regardless of species is similar to that of cod alone. Using only the matching cod >4mm and 2-4mm dataset from flotation samples, phase 2 is significantly more complete than phase iii (0.165, 2.880, 0.000) and phase iii is significantly more complete than phase ii (0.109, 1.704, 0.006). Using the same matching >4mm and 2-4mm dataset for saithe, phase 2 is again more complete than phase iii, but not significantly, although phase iii *is* significantly more complete than phase ii (0.222, 2.313, 0.000). The difference between phases ii and iii is much more extreme in the saithe dataset than observed for the cod, suggesting that there was a substantial change in the economic or taphonomic patterning between these phases that impacted considerably upon the saithe.



Phase 1.2
Count: 51
Mean: 31.1
Phase i
Count: 21
Mean: 19.7

Phase 2
Count: 633
Mean: 30.3
Phase ii
Count: 907
Mean: 20.2

Phase 7
Count: 1
Mean: 16.5
Phase iii
Count: 1074
Mean: 31.7

Figure 5.4: Fish maximum linear dimension histograms for QC1 and QC4 elements (in mm, all >4mm)

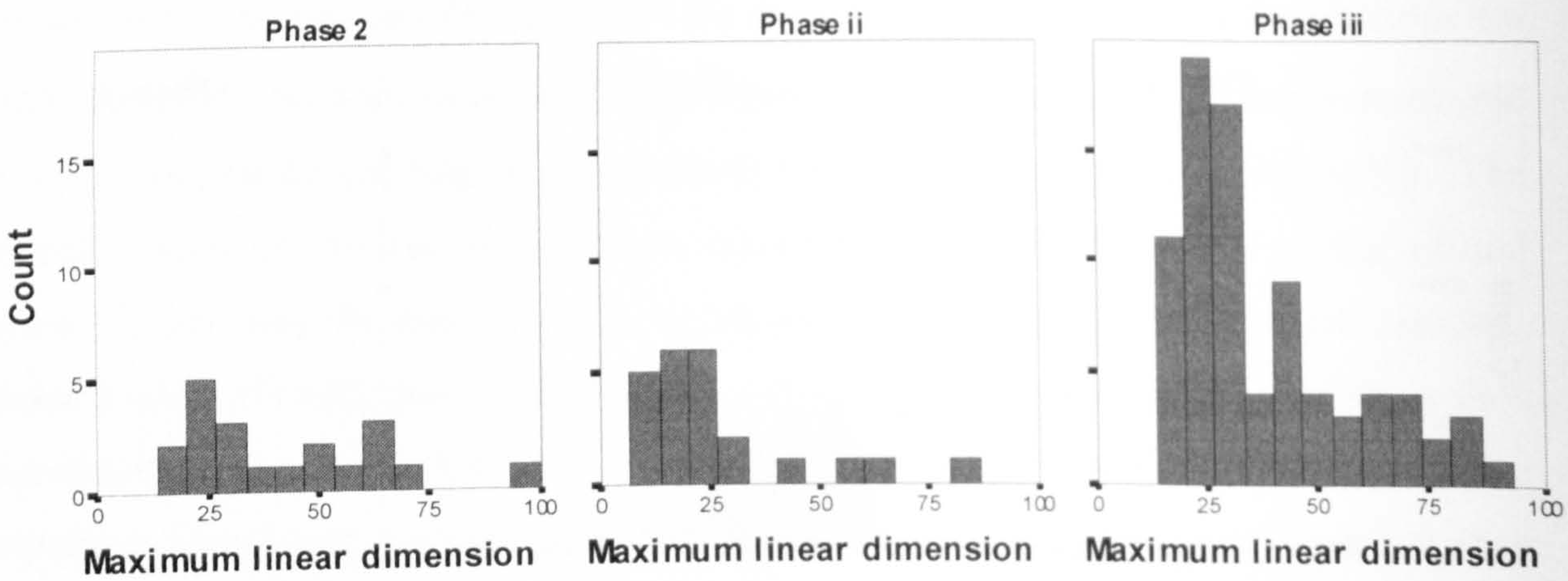


Figure 5.5: Cod dentary maximum linear dimension measurements (in mm)

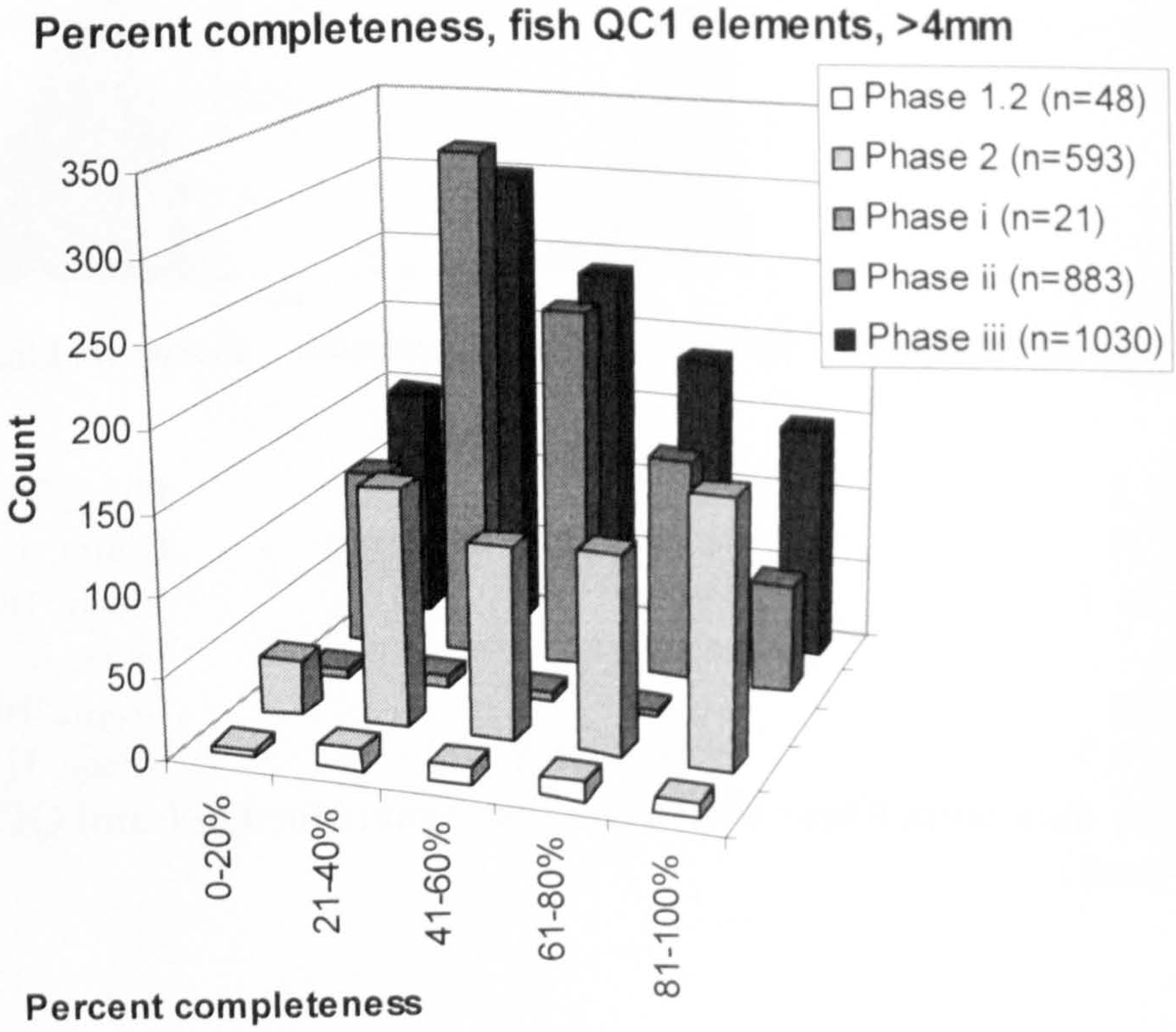


Figure 5.6: QC1 fish percent completeness

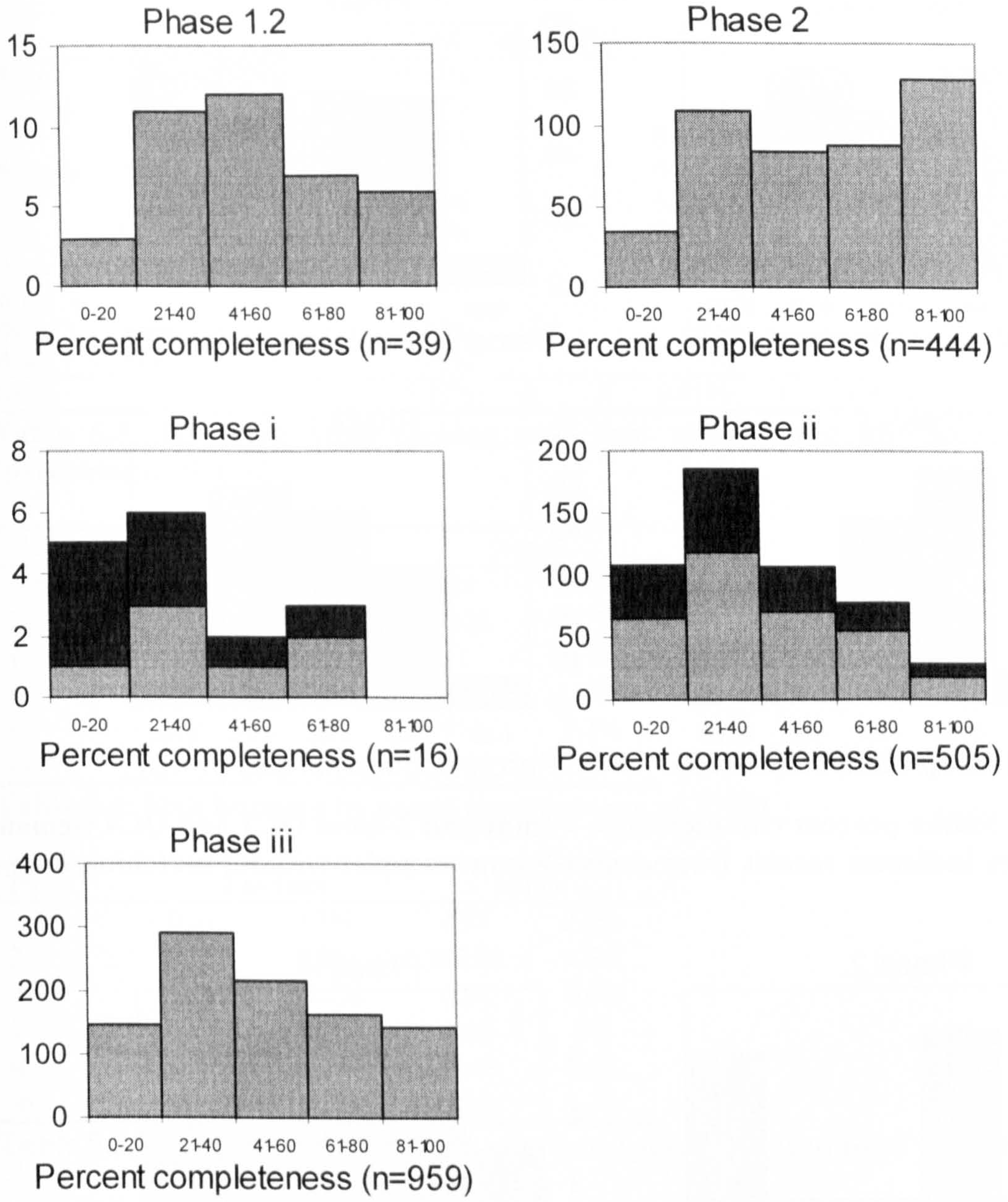


Figure 5.7: Cod percent completeness, >4mm and 2-4mm QC1 and QC4 elements (darker grey indicates results from coarse >4mm samples without matching 2-4mm fraction)

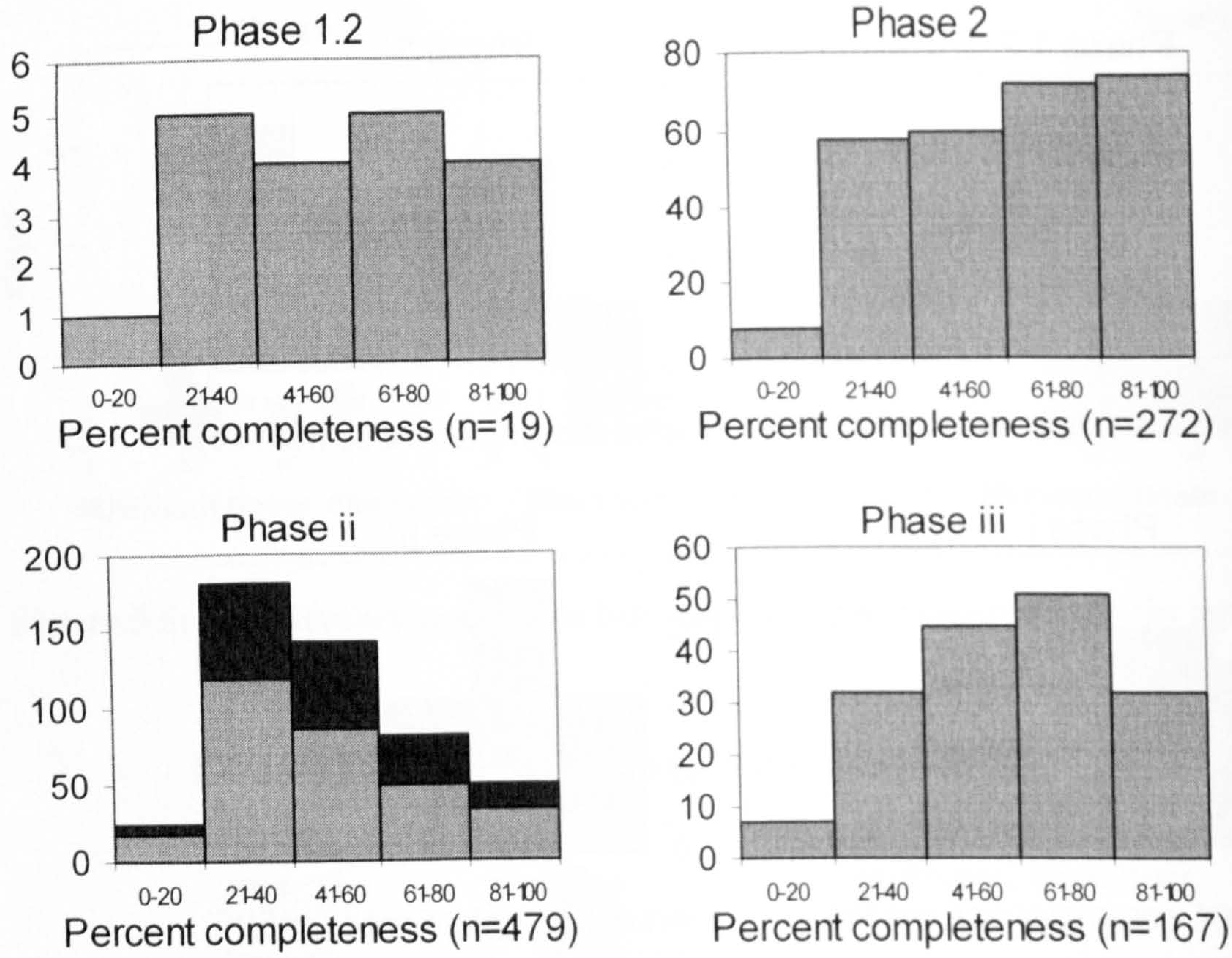


Figure 5.8: Saithe percent completeness, >4mm and 2-4mm QC1 and QC4 elements (darker grey indicates results from coarse >4mm samples without matching 2-4mm fraction)

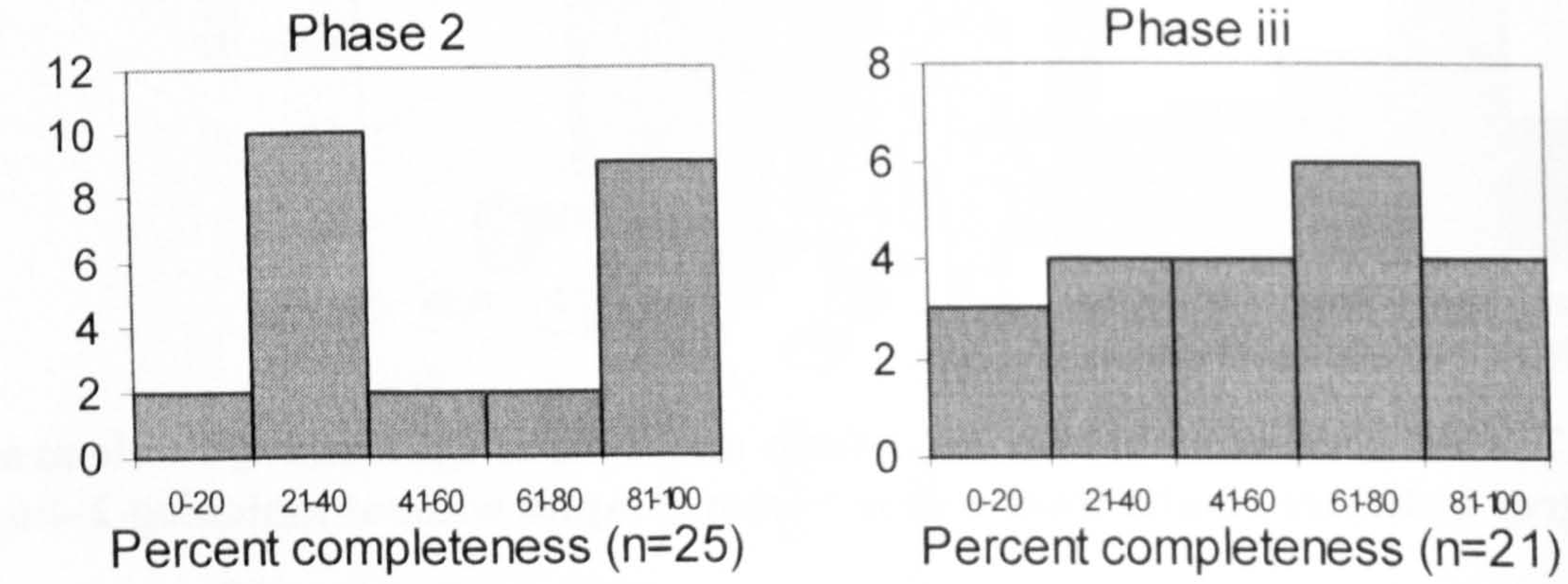


Figure 5.9: Ling percent completeness, >4mm and 2-4mm QC1 and QC4 elements

5.2.3 Other taphonomic alterations

Table 5.3 summarises frequencies of carnivore activity (gnawing and acid etching), rodent gnawing, and root etching on all mammal and fish bone. Carnivore gnawing was the most common alteration, being found throughout the assemblage at a consistently low frequency. None of these various modifications would have provided anything but a minimal influence on the surviving assemblage.

Phases	Recovery	Carnivore gnawing			Acid etching			Rodent gnawing		Root etching		
		Mam.	Fish	Total	Mam.	Fish	Total	Mam.	Total	Mam.	Fish	Total
Phase i	>4mm	1		0.13%								
Phase ii	>4mm	7		0.03%								
	Hc	90		2.28%	1		0.03%	1	0.03%	2		0.05%
Phase iii	2-4					3	0.34%					
	>4mm	19	1	0.08%	2	1	0.01%				1	
	Hc	89		1.37%	3		0.05%			4		0.06%
Phase iii/viii	Hc	1		0.76%						2		1.53%
Phase 2	>4mm	3	1	0.03%								
Phase 7	>4mm	1		1.02%								
Totals		211	2	0.28%	6	4	0.01%	1	0.00%	8	1	0.01%

Table 5.3: Gnawing, acid etching and root etching for all mammal and fish (percentages of TNB)

Phase	2 - 4mm		>4mm	
1.2	1	1.6%	59	5.1%
2	24	3.8%	1103	8.7%
7	6	21.4%	1	3.1%
i	1	2.1%	46	11.6%
ii	22	2.7%	916	7.3%
iii	16	1.9%	1346	7.3%

Table 5.4: Fish burning by count (percentages of TNB)

Phase	2 to 4mm		>4mm	
1.2	0.01	1.3%	4.57	2.7%
2	0.41	4.3%	100.98	4.6%
7	0.13	36.1%	0.04	1.6%
i	0.05	6.3%	3.05	6%
ii	0.31	1.9%	77.19	4.6%
iii	0.22	1.9%	115.31	3.1%

Table 5.5: Fish burning by weight in grams (percentages of total weight)

5.2.4 Taphonomic summary

- fish textures in order from best to worst: all of Area A and iii together, phase ii, then phase i
- fish fragmentation in order from largest and most complete, to smallest and most fragmented: phase 2, phase iii, phase ii, phase i
- the fish from phases 2 and iii were fairly similar for most of the taphonomic variables explored, but the percent completeness scores showed marked differences, despite having similar fragmentation patterning
- saithe indicated a considerable change in element fragmentation between phase ii (very fragmented) to phases iii and 2 (much more complete), much more pronounced than in the cod dataset

5.3 Summary of species

A total of 9836 fish elements were identified to 56 species or species groupings, from an assemblage of about 47,000 fish fragments. Table 5.6 provides a summary of the fish identified by phase, quantified by basic NISP data and recovery methods. Percentages indicate the proportion of the identified subset represented by each species. The fish assemblage was dominated by gadid (cod) family fish that comprised about 94.2% of the identified fish bones, unsurprising given the chronology and location of Quoygrew. Other families found in moderate quantities include needlefishes or sauries (2.6%), herring (0.6%), dogfish (0.5%), flatfish (0.5%) and sand eels (0.4%). The comprehensive sampling strategy and standardised 2mm and 4mm recovery has permitted a wide variety of fish species and elements to be recovered, with the result that a few species were found that were rarely identified in previous archaeological assemblages from the Northern Isles. The fish are discussed in more detail below (see section 5.4 for element distribution, 5.5 for fish sizes and measurements, section 5.6 for butchery evidence and section 5.3.2 for a discussion of the minor species).

Common name	Phase i						Phase ii						Phase iii		Phase 1.2		Phase 2		Phase 7		Grand Total	
	>4mm without matching 2-4mm		Total matching >4mm and 2-4mm		Total		>4mm without matching 2-4mm		Total matching >4mm and 2-4mm		Total		Total matching >4mm and 2-4mm		Total matching >4mm and 2-4mm		Total matching >4mm and 2-4mm		Total matching >4mm and 2-4mm			
Dogfish Families			2	2.4	2	1.7	14	1.1	19	0.8	33	0.9	11	0.3			1	0.0			47	0.5
Dogfish Family			2	2.4	2	1.7	1	0.1			1	0.0									3	0.0
Spurdog							1	0.1	3	0.1	4	0.1									4	0.0
Ray Family									1	0.0	1	0.0									1	0.0
Eel							1	0.1	1	0.0	2	0.1					2	0.1			4	0.0
Conger Eel													1	0.0			2	0.1			3	0.0
Herring Family									24	1.0	24	0.6	20	0.6			9	0.4			53	0.5
Salmon and Trout Family																			1	2.8	1	0.0
Bib									1	0.0	1	0.0									1	0.0
Cod	18	60.0	18	21.2	36	31.3	405	31.3	614	24.3	1019	26.7	1712	54.0	68	38.2	1048	41.6	2	5.6	3885	39.5
Cod Family	1	3.3	1	1.2	2	1.7	4	0.3	37	1.5	41	1.1	57	1.8	4	2.2	46	1.8	4	11.1	154	1.6
Cod/ Saithe/ Pollack	3	10.0	6	7.1	9	7.8	69	5.3	159	6.3	228	6.0	147	4.6	6	3.4	102	4.0	3	8.3	495	5.0
Five Bearded Rockling									4	0.2	4	0.1	10	0.3			8	0.3			22	0.2
Four Bearded Rockling									4	0.2	4	0.1	7	0.2	1	0.6	3	0.1			15	0.2
Haddock			1	1.2	1	0.9	1	0.1	1	0.0	2	0.1	2	0.1			5	0.2			10	0.1
Ling			1	1.2	1	0.9	6	0.5	4	0.2	10	0.3	65	2.0	2	1.1	52	2.1			130	1.3
Pollack							36	2.8	30	1.2	66	1.7	15	0.5			1	0.0			82	0.8
Poor-cod									2	0.1	2	0.1									2	0.0
Rockling									1	0.0	1	0.0	10	0.3			8	0.3			19	0.2
Saithe	8	26.7	47	55.3	55	47.8	710	54.9	1359	53.8	2069	54.2	1002	31.6	72	40.4	1176	46.7	24	66.7	4398	44.7
Saithe/ Pollack							13	1.0			13	0.3									13	0.1
Three-bearded Rockling									3	0.1	3	0.1	11	0.3			5	0.2			19	0.2
Torsk									3	0.1	3	0.1	4	0.1	2	1.1					9	0.1
Whiting									2	0.1	2	0.1	3	0.1			1	0.0			6	0.1
Hake									1	0.0	1	0.0	1	0.0							2	0.0
Garfish							1	0.1	67	2.7	68	1.8									68	0.7
Needlefishes/Sauries			5	5.9	5	4.3	24	1.9	145	5.7	169	4.4	6	0.2			5	0.2	1	2.8	186	1.9

Grey Gurnard									1	0.0	1	0.0									1	0.0
Gurnard Family									8	0.3	8	0.2	1	0.0							9	0.1
Tub Gurnard															1	0.6					1	0.0
Bullhead													1	0.0							1	0.0
Bull-rout									1	0.0	1	0.0	8	0.3							9	0.1
Sea Scorpion													3	0.1			1	0.0			4	0.0
Sea Scorpion Family							1	0.1	2	0.1	3	0.1	8	0.3			3	0.1			14	0.1
Seabass Family							1	0.1	1	0.0	2	0.1									2	0.0
Atlantic Horse-mackerel/ Scad									1	0.0	1	0.0	1	0.0	2	1.1					4	0.0
Ballan Wrasse							2	0.2	2	0.1	4	0.1	1	0.0			1	0.0			6	0.1
Cuckoo Wrasse																	1	0.0			1	0.0
Wrasse Family									1	0.0	1	0.0									1	0.0
Eelpout Family													5	0.2	2	1.1					7	0.1
Viviparous Eelpout													6	0.2	1	0.6	7	0.3	1	2.8	15	0.2
Snake Blenny									1	0.0	1	0.0	3	0.1	4	2.2	1	0.0			9	0.1
Butterfish							1	0.1	2	0.1	3	0.1	3	0.1			10	0.4			16	0.2
Wolf-fish																	9	0.4			9	0.1
Sand Eel Family									4	0.2	4	0.1	22	0.7	3	1.7	10	0.4			39	0.4
Dragonet			1	1.2	1	0.9			1	0.0	1	0.0	2	0.1							4	0.0
Mackerel Family									1	0.0	1	0.0									1	0.0
Flatfish Order									3	0.1	3	0.1			1	0.6	1	0.0			5	0.1
Turbot Family													1	0.0	1	0.6					2	0.0
Dab									1	0.0	1	0.0									1	0.0
Flounder																	1	0.0			1	0.0
Halibut Family			1	1.2	1	0.9	1	0.1	8	0.3	9	0.2	18	0.6	8	4.5	1	0.0			37	0.4
Lemon Sole													3	0.1							3	0.0
Flounder/ Plaice							2	0.2	1	0.0	3	0.1	2	0.1							5	0.0
Totals	30	100	85	100	115	100	1294	100	2524	100	3818	100	3172	100	178	100	2520	100	36	100	9839	100

Table 5.6: Fish QC1, 2 and 4 NISP and %NISP

5.3.1 Major species

Figure 5.10 and Figure 5.11 provide a graphical representation of the major gadid species, quantified separately using QC1 and QC2 elements. These data are then displayed by weight in Figure 5.12 and Figure 5.13, illustrating the difference between counts and weights for each of the major gadid species. The problem of the 'missing' 2-4mm samples from phase ii is solved by displaying two sets of results for this phase. The first shows only the matching >4mm and 2-4mm fractions, while the second shows all data, regardless of sample type. Phases i and 2 are very small compared to phases ii, iii and 2 so are not included in these figures, though they are discussed where relevant later. These figures illustrate the overwhelming predominance of cod and saithe in the assemblage, plus ling and pollack, both gadid species found in small quantities at Quoygrew, as well as the undifferentiated 'cod/ saithe/ pollack' and general 'gadid' identifications. These two final categories were used when it was not possible to identify the specimen fully to species, because there are similarities between the cod, saithe and pollack vertebrae that make this difficult if the specimen has lost diagnostic features. Each of the quantification methods explores a different area of the fish skeleton: QC1 elements are from the cranium and appendicular skeleton, while QC2 elements are from the vertebral column. Element variation is examined in more detail below (section 5.5).

Cod was the most prevalent species when counting cranial and appendicular elements, but when quantifying vertebrae, saithe were most common. Cod were by far the most common species by weight, indicating that most of the saithe were much smaller (and therefore lighter). The difference in prevalence of cod QC1 elements versus saithe QC2 elements could reflect the numbers of vertebrae per individual (cod typically have from 46 to 56 vertebra per fish, saithe from 50 to 58 and ling from 60 to 66 (Barrett 1997, 631)), or could reveal a real absence of cod vertebrae or saithe crania. Even if all QC2 'cod/ saithe/ pollack' and 'gadid' specimens were actually cod, there are far fewer QC2 elements. This is investigated in greater detail below (see 5.4 for element variation and 5.5 for fish sizes). Saithe were generally more common in the earlier phases (i and ii) than in the later ones, while cod were more common in phase iii, and in the area A phases.

Gadids not identified to species were found in the highest quantities in the earlier phases. This reflects the poorer preservation of these phases, with less opportunity for positive identification than in the later well preserved and less fragmented phases. Ling were present in small quantities in all phases, but at very low quantities, while pollack was only found in any quantity in phases ii and iii. Ling quantities appear larger by weight, but this is because most ling bones were extremely large and therefore heavy. Haddock were found in very small quantities, but unlike Earl's Bu, were not a major species of economic importance and are thus discussed with minor gadids, in section 5.3.2; these differences will be discussed in greater detail in Chapters Eight and Nine.

The ratio of gadids to non gadids is investigated in Figure 5.15, showing the importance of all gadid species at Quoygrew. The earliest phases, i and ii, have approximately 7 gadid specimens for every one non-gadid (using the matched subset of >4mm and 2-4mm samples), while phase 2 has over 35 gadid specimens to each non-gadid. It is unsurprising that phases i and ii are similar, given that variation within the gadids is also low, but the difference between phases 1.2 and 2 is harder to explain. These two phases had very similar proportions of cod, saithe and ling, as shown in Figure 5.15, yet phase 1.2 has a relatively higher proportion of identifiable non-gadids. These included halibut family, snake blenny and sand eel family fish. This patterning cannot be the result of taphonomic factors, because preservation and fragmentation was similar between the two phases, but this variation is likely to result from the small sample size of phase 1.2. Section 5.3.2 will discuss the varying proportions of non-gadid species in more detail.

The proportions of the various gadid species are investigated in Figure 5.15, which uses basic NISP data regardless of element type, but only from the matching subset of >4mm and 2-4mm samples. This figure shows the predominance of saithe over cod in all but phase iii, where cod was most common. Phases 1.2 and 2 are very similar, with almost equal quantities of saithe and cod and low levels of ling or less securely identified gadids. Phases i and ii are also similar, though with slightly decreasing levels of saithe through time. Phase iii stands out in contrast to all other phases, because the proportions of cod and saithe show a reversal of the general trend. Element distributions and fish sizes will be used to explore this pattern in more detail below. The taphonomic pattern is well illustrated, because the earliest phases contain the highest proportions of *gadus/pollachius* and gadid, and they are the phases with the highest degree of fragmentation.

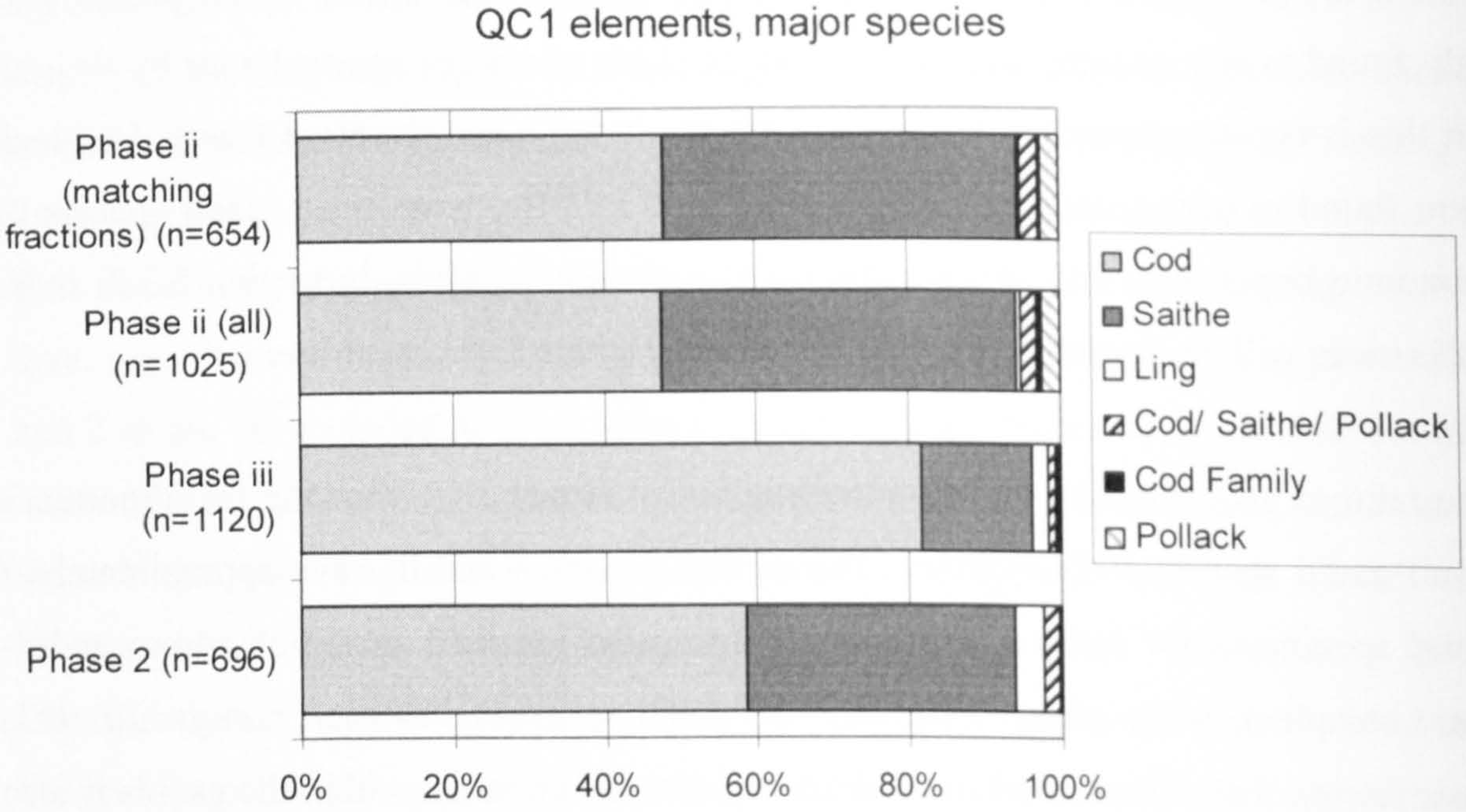


Figure 5.10: Fish QC1 NISP, major species

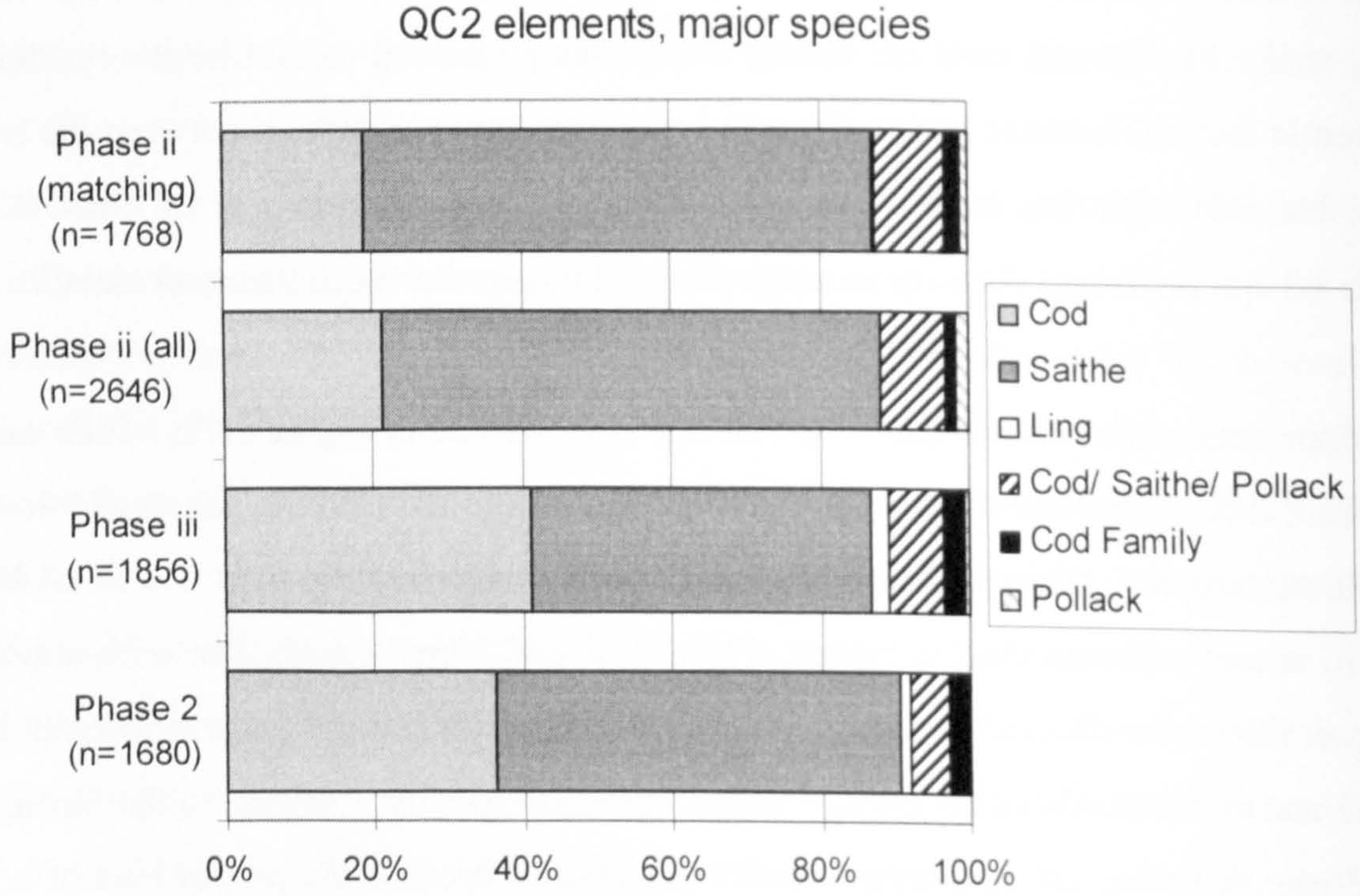


Figure 5.11: Fish QC2 NISP, major species

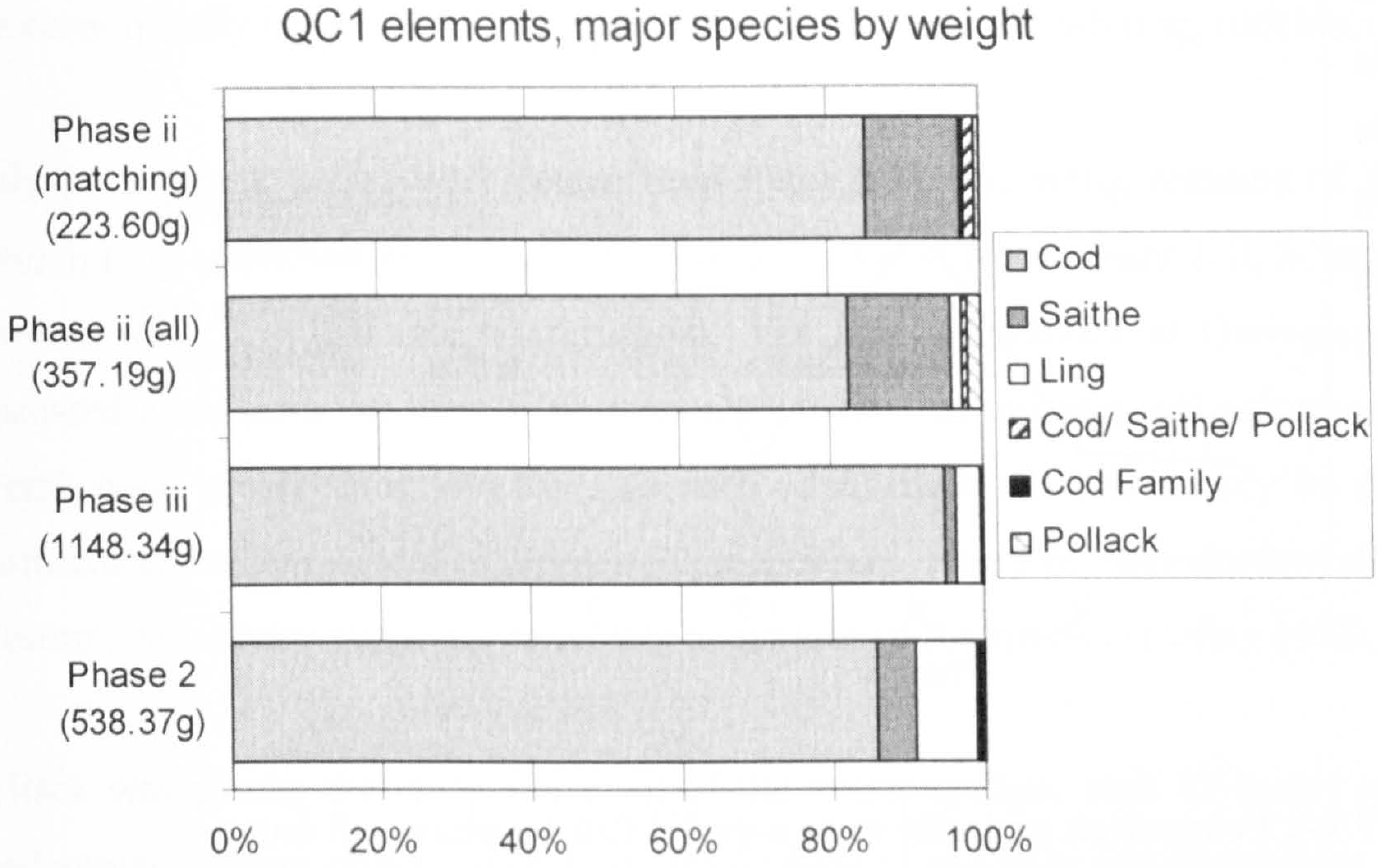


Figure 5.12: Fish QC1 by weight, major species

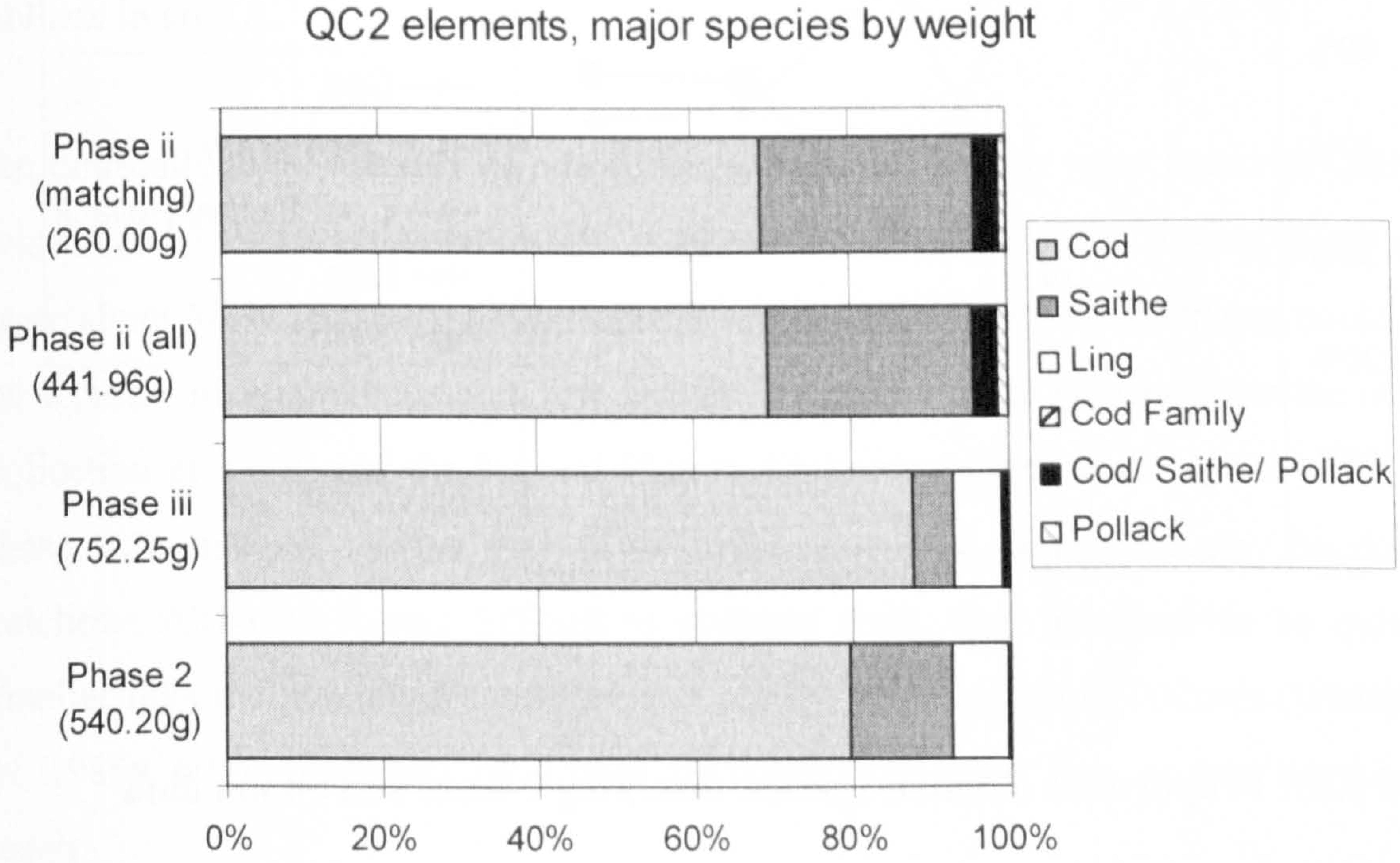


Figure 5.13: Fish QC2 by weight, major species

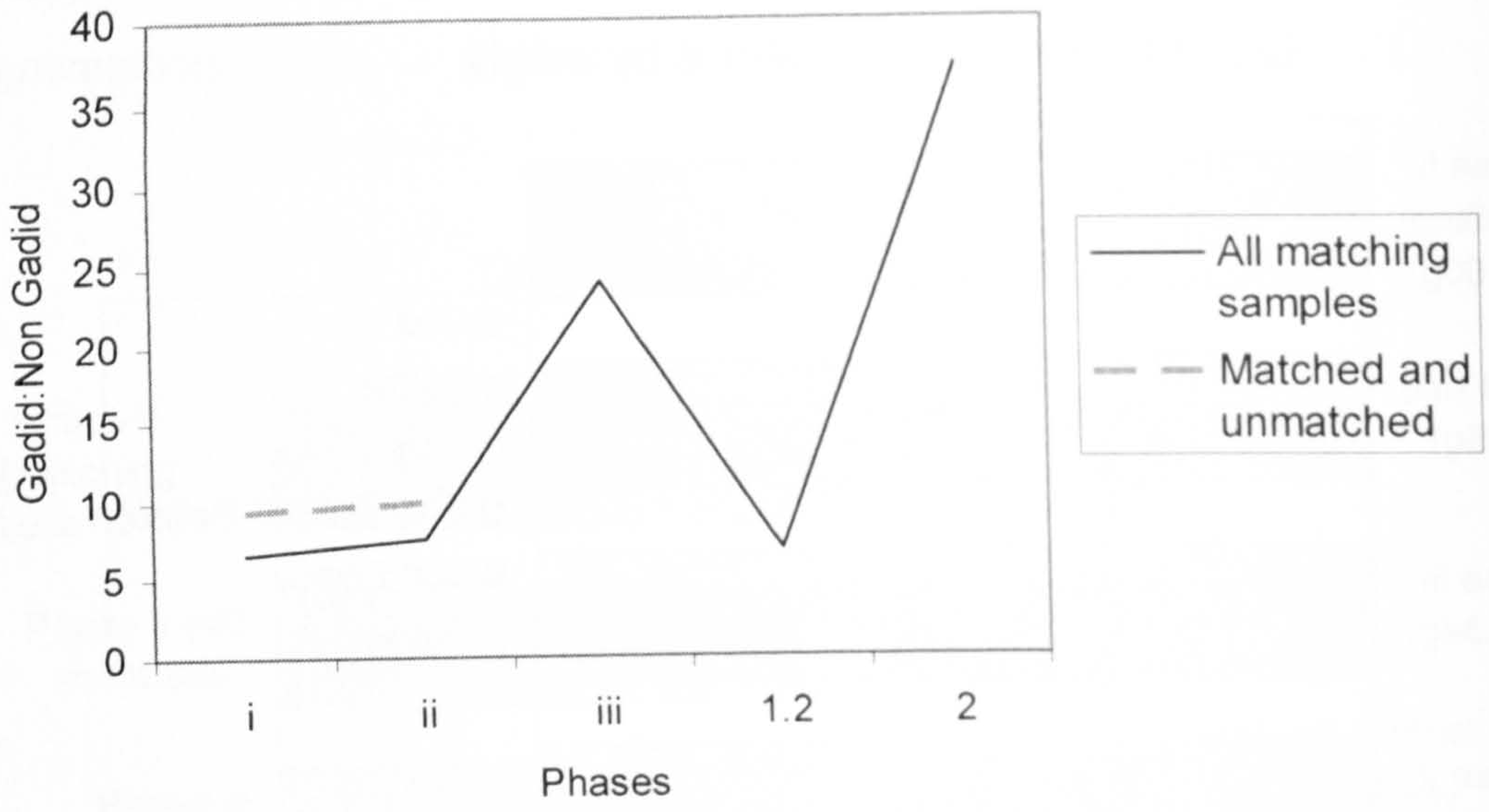


Figure 5.14: Proportion of gadid to non-gadid fish by phase, all data

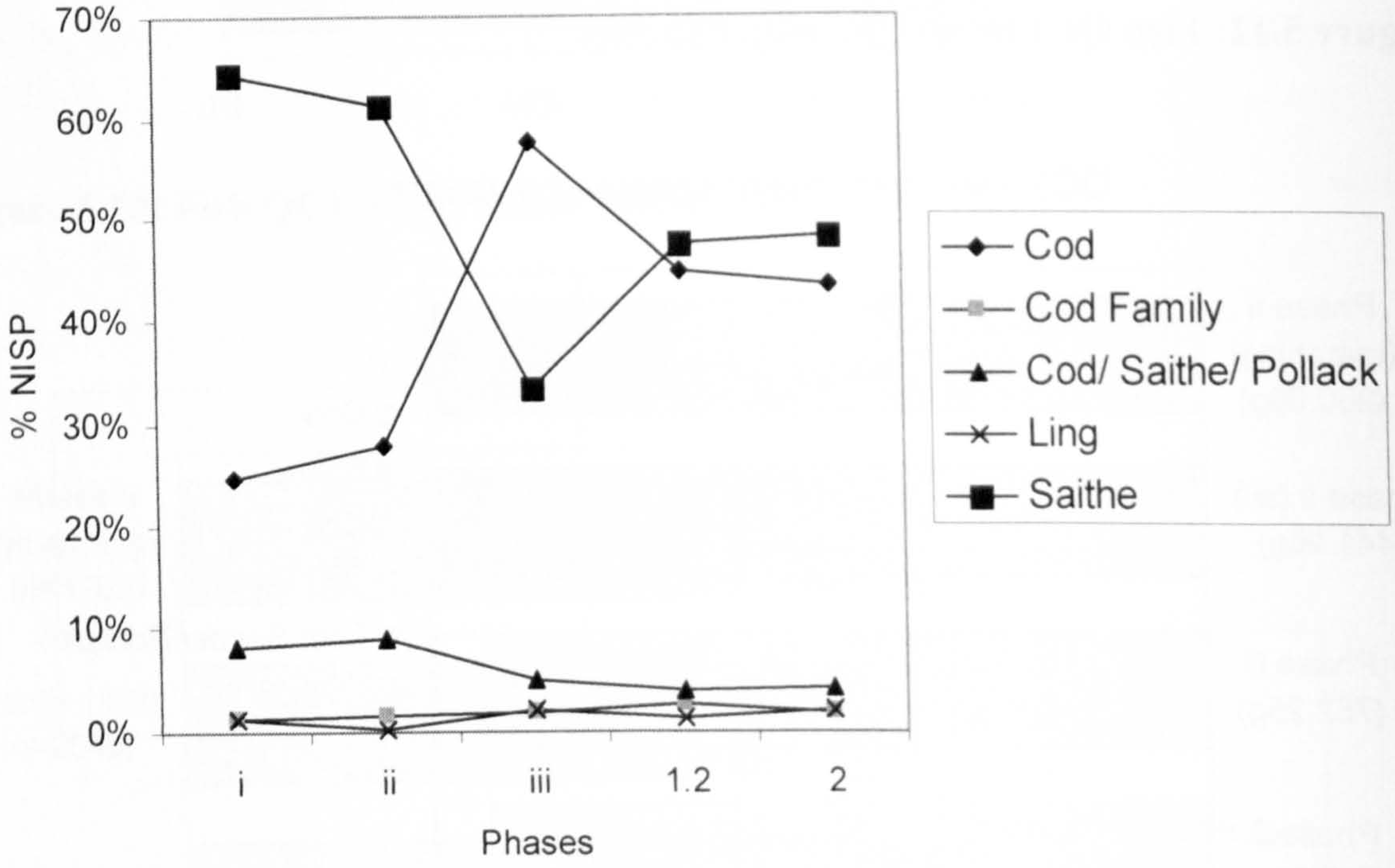


Figure 5.15: Proportions of gadid species, matching 2-4mm and >4mm data

5.3.2 Minor species

Table 5.7 summarises the minor fish species by phase and element, and notes any fish sizes or taphonomic alterations where recorded. As discussed above, the phases with the highest proportions of non-gadids were phases i, ii and 1.2, while phases iii and 2 contained much lower proportions of non-gadids (see Figure 5.14). Of course, there were also minor gadid species that were grouped under gadid, but which were not discussed in any detail because of the small quantities recorded. These include haddock (an economically important fish species at Earl's Bu), pollack, whiting, rocklings, etc.

Only 10 haddock bones were found from Quoygrew, including remains of fish 300-500mm long and 500-800mm long; they were recovered from phases i, ii, iii and 2. One vertebra was burnt and one was crushed. The lack of haddock at Quoygrew will be discussed elsewhere, but there is no reason to doubt that this is a real pattern, given the overall good preservation and the ease with which haddock can usually be identified. Furthermore, recent evidence suggests haddock are found off the northwest coast of Westray, which may suggest a deliberate avoidance of the species (Colley 1988, Fig. 7).

Pollack was among the more numerous of the minor species, with 82 bones recovered, predominantly from phase ii with some from phase iii and only one from phase 2. These included vertebrae and cranial elements from fish of 300 to 1000mm in length. Given that preservation was best in phase 2, we can assume that there was a real absence of pollack in area A.

An unusually large quantity of needlefish/sauries and garfish were found at Quoygrew, with over 250 found, predominantly in phases i and ii. For both phases, these species were about 5-6% of the entire identified assemblage (see Table 5.6) These could not all be securely identified because a few crucial fish species were missing from the reference collection at York, and the Natural History Museum collection did not contain any of these extra species. These may have been accidentally caught, or may be deliberate catches. Although it was difficult to estimate sizes, they appeared to be quite a bit smaller than the maximum range for this family, which is about 900mm (Whitehead *et al.* 1986a, 605). They may have been gut contents of larger fish, or may have been by-catch.

Inshore fishing undoubtedly took place at Quoygrew, given the large quantity of small saithe recovered (see section 5.5.2). A number of other fish species were probably caught as a by-product of this fishery, or were deliberately targeted, including the rocklings, the wrasse and the cottids, all of which were found in small quantities (Barrett *et al.* 1999, 367).

Flatfish were found in small numbers throughout the farm mound and the fish midden. These low quantities suggest they were not a deliberately exploited species, or if they were, it was on a very small scale. These may have been incidentally caught while fishing for gadid species. The few gurnard family identifications may also represent accidental catches while fishing for large gadids (Barrett *et al.* 1999, 367).

The dogfish family was probably deliberately exploited on a small scale, and are known to have been an economically useful species in early modern Westray (Izat 1791-99, 261). Most of these identifications were in the farm mound.

The one identification of salmon and trout family fish in phase 7 probably reflects both the tendency of this family towards poor preservation (Wheeler and Jones 1989), and the lack of economic importance of this family at the site. Only four eel bones were identified at Quoygrew, from both the farm mound and fish midden. As both salmonids and eels were commonly caught in fresh water, their near absence suggests the emphasis at Quoygrew was upon sea-based fisheries.

Small quantities of herring were found in phases ii and iii (about 20 in each phase), but few were found in phase 2. There is no evidence to suggest herring were of economic significance despite their contemporary importance in England (Barrett *et al.* 2004b) and the Western Isles (Cerón-Carrasco 2005); similar conclusions were drawn at Earl's Bu (see Chapter Four). These few herring may have been gut contents from the larger fish. The smaller gadids may have entered the assemblage in the same way (Barrett *et al.* 1999, 364). The sand eel family fish might have been gut contents of the larger fish as well, or they may have been gut contents of birds, because along with other small fish, they are a common foodstuff for marine species of birds (Johnston 1999, 177-82).

Species or family	Phase	Quantity vertebrae	Other elements and notes
Dogfish Families	i	2	
	ii	33	
	iii	11	
	2	1	
Dogfish Family	i	2	
	ii	1	
Spurdog Family			1 spine
Spurdog	ii	3 and 1 tentative id	
Ray Family	ii	1	
	2		1 tooth
Eel	ii	2	
	2	1 and 1 tentative id	1 vertebra crushed
Conger Eel	iii	1	
	2	1	1 opercular
Herring Family	ii	23 and 1 tentative id	
	iii	20	
	2	9	
Salmon & Trout Family	7	1	Charred
Bib	ii		1 vomer, 300-500mm length
Five-bearded Rockling	ii	2 and 2 tentative id	
	iii	10	
	2	7	1 ceratohyal 150-300mm length fish, 1 epihyal
Four Bearded Rockling	ii	4	
	iii	7	
	1.2	1	
	2	3	
Haddock	i	1	
	ii	1	1 vertebra crushed, 1 maxilla 300-500mm length
	iii	2	
	2	3	1 vertebra calcined, 1 ceratohyal 300-500mm length, 1 quadrate 500-800mm length
Pollack	ii	40	1 basioccipital 300-500mm, 1 ceratohyal, 4 dentaries (2 300-500mm, 2 500-800mm lengths), 2 maxillae (1 300-500mm, 1 500-800mm length), 1 palatine 500-800mm length, 2 parasphenoids (1 500-800mm, 1 800-1000mm length), 1 posttemporal 500-800mm, 7 premaxillae (2 300-500mm, 5 500-800mm lengths), 3 quadrates (2 300-500mm, 1 500-800mm lengths), 4 vomers (1 300-500mm, 3 500-800mm lengths)
	iii	11	1 articular 300-500mm length, 1 basioccipital 300-500mm length, 1 palatine 500-800mm length, 1 parasphenoid 500-800mm length
	2		1 parasphenoid 500-800mm length
Poor-cod	ii	2	
Rockling	ii	1	
	iii	9 and 1 tentative id	
	2	6	1 cleithrum 150-300mm length, 1 premaxilla <150mm length
Three-bearded Rockling	ii	2	
	iii	11	2 vertebrae charred
	2	5	
Torsk	ii	3	
	iii	2	1 opercular 500-800mm length, 1 preopercular 500-800mm length
	1.2	2	
Whiting	ii	1	1 tentative vomer 500-800mm length
	iii	3 and 2 tentative ids	
	2	1	
Hake	ii	1	
	iii	1	
Garfish	ii	68	1 vertebra crushed
Needlefishes/ Sauries	i	5	
	ii	169	2 vertebrae charred, 1 crushed
	iii	6	
	7	1	
Grey Gurnard	ii	1	
Gurnard Family	ii	8	
	iii	1	
Tub Gurnard	1.2	1	
Bullhead	iii	1	
Bull-rout	ii	1	
	iii	8	
Sea Scorpion	iii	3	
	2	1	
Sea Scorpion Family	ii	3	
	iii	8	

	2	2	2 charred vertebrae, 1 opercular 150-300mm length
Seabass	ii	1	1 ceratohyal 300-500mm length
Atlantic Horse-mackerel/ Scad	ii	1	
	iii	1 tentative id	1 vertebra acid etched
	1.2	1 and 2 tentative id	
Ballan Wrasse	ii	2	1 maxilla 300-500mm length, 1 quadrate 500-800mm length
	iii		1 quadrate 500-800mm length
	2	1	
Cuckoo Wrasse	2	1	
Wrasse Family	ii		1 dentary 300-500mm length
Eelpout Family	iii	5	1 crushed vertebra
	1.2	2	
Viviparus Eelpout	iii	6	
	1.2	1	
	2	7	
	7	1	
Butterfish	ii	3	
	iii	3	
	2	8	2 parasphenoids both >150mm
Wolf-fish	2	9	
Sand Eel Family	ii	4	
	iii	22	
	1.2	3	
	2	10	
Dragonet	i	1	
	ii	1	
	iii	1 and 1 tentative id	
Mackerel Family	ii	1	
Turbot Family	iii	1	
	1.2	1	
Dab	ii	1	
Flounder	2		1 quadrate 500-800mm length
Flounder/ Plaice	ii	3	
	Iii	2	
Halibut Family	i	1	
	ii	9	
	iii	18	
	1.2	8	
	2	1	
Lemon Sole	iii	3	
Flatfish Order	ii	3	
	1.2	1	
	2	1	
Snake Blenny	ii	1	
	iii	3	
	1.2	4	
	2	1	

Table 5.7: Summary of minor fish species

5.4 Element variation

Proportions of elements within each species can indicate variation in body-part usage, as well as reflecting taphonomic differences in fracture and fragmentation for each element. During the identification process, elements were grouped into three quantification codes (QC) as discussed in the methodology chapter: QC1 elements are cranial and appendicular, QC2 elements are vertebral, and QC4 elements are unusual or rare, and at Quoygrew are mainly otoliths (fish ear 'bones' made of calcium carbonate and useful for reconstructing fish sizes). Two main methods of quantification are used in the following section: NISP (number of identified specimens) and MNE (minimum number of elements). NISP values for the midline elements have been doubled to allow easy comparison with the elements that naturally occur in pairs in the body. MNE was calculated by comparing the number of occurrences of each diagnostic zone, using the maximum value recorded for left or right when elements occurred in pairs. To overcome the problem of some samples not having any 2-4mm fraction, a darker colour is used to display the MNE results obtained using only the unmatched >4mm fraction, and the lighter bars show the difference between the total MNE minus the values displayed using the darker bars (see Figure 5.16 and Figure 5.17).

Table 5.8, Table 5.10 and Table 5.12 display QC1 and QC4 NISP for each of the three species, with all elements ranked by phase, and Table 5.16, Table 5.18 and Table 5.20 display QC2 NISP for each of the three species. Corresponding MNE data are presented in Table 5.9, Table 5.11 and Table 5.13 for QC1 and QC4 elements, and Table 5.17, Table 5.19 and Table 5.21 for QC2 elements. Figure 5.16, Figure 5.17 and Figure 5.18 graphically display the NISP results for QC1 and QC4 elements for cod, saithe and ling, Figure 5.19, Figure 5.20 and Figure 5.21 show similar results for QC2 elements, and both are combined to display the MNE results by species and phase, in Figure 5.23, Figure 5.24 and Figure 5.25. Rank orders for elements are provided because they are a quick method of determining the prevalence of certain elements over others. Values for single-occurring elements have been doubled to more easily compare with paired elements.

Cod element variation is least in phase 2, with most elements present in similar quantities, which is probably a reflection of the excellent preservation and low fragmentation of this phase. Even elements like the cod scapula, easily fragmented beyond recognition, were recorded in comparable quantities to other more robust elements. In contrast, phases ii and iii have substantially more variation in quantities, probably indicative of the relatively poorer preservation. The ranking of the scapula across the phases is a good indicator of taphonomic variation, because in phase 2 it ranks 13th, but in phases ii and iii it ranks last. Other element ranks can be explained by a similar process, including the infrapharyngeal, which easily fragments into small pieces that although recognisable, do not form at least half of a diagnostic zone, and as such are not recorded. The cod infrapharyngeal ranks 4th in the well-preserved phase 2, yet is 11th in phase iii and 15th in phase ii. Other elements that fit this taphonomic pattern include otoliths and preoperculars.

The variation in element proportions was examined using Spearman's Rho tests of statistical significance, which compared the rank order of QC1 and QC4 elements (tested together) in all phases. The results for cod are shown in Table 5.14, and indicate that significant correlations in rank were found between phases ii and iii, and between phases iii and 2. These significances are likely the result of a combination of butchery patterning (see below) and taphonomic variation; it is difficult to isolate one from the other. It is unsurprising that phases ii and 2 have different rankings, given that the latter is significantly better preserved than the former.

The presence, absence, or unusual size patterning of the set of elements from the appendicular skeleton (including the cleithrum, supracleithrum and scapula), as well as the posttemporal, can be indicative of the production and trade of dried fish (be it local or long-range) (Barrett 1997, 616). Cod cleithra are ranked 8th in phase 2, tied for 5th place with four other elements in phase iii, and 9th in phase ii. The supracleithra are ranked 10th in phase 2 and 11th in phases ii and iii. The scapulae are ranked 13th in phase 2 and last in phase ii and iii. The cod cleithrum and, to a greater degree, scapula are both very fragile and easily fragmented, so would be expected to appear in smaller quantities and lower rankings in phases ii and iii, because they are not as well preserved as phase 2. The cleithra have some of the lowest percent completeness scores of all elements, indicating they fragment more readily than others. However, the pattern we observe is not completely taphonomic, because the highest rank would be expected for phase 2 given the better preservation of that phase, but is not observed. The cleithrum MNE results give a different and potentially more accurate picture, as they control for the identification of multiple fragments of single cleithra: the cleithrum is the second *least* common element in phase 2 (despite its excellent preservation) and yet in phase iii, its ranking is slightly above average. The greatest difference in cod QC1 elements was between the ranking of the posttemporal in phase ii (ranked third) and phase 2 (ranked last); MNE data reinforce this difference. This pattern may be partly taphonomic: the posttemporal is a fairly robust element that can be easily identified despite fragmentation in the earlier phases, yet in phase 2, the increased preservation and ease of identification of all elements makes the posttemporal decrease in importance. Nevertheless, this element may also stay attached to the appendicular skeleton and thus be removed from site in dried fish. The posttemporal is tied with the cleithrum for the second least common element in phase 2 by MNE, and both are second only to the penultimate vertebra, an extremely difficult element to identify accurately between cod and saithe. The supracleithra evidence is ambiguous, but given the insights provided by the other elements, this is not problematic.

Variation in vertebrae fit this emerging pattern. In phases ii and iii, anterior and posterior cod vertebrae are found in approximately equal numbers, once MNE has been calculated (Figure 5.23). However, in phase 2 a different pattern emerged: the abdominal vertebrae groups one and two both appeared in larger quantities than the other vertebral groups. This is a slight but clear pattern that is not found in any other phase, and is unlikely to be taphonomic: could this be indicative of higher quantities of anterior abdominal vertebrae without matching posterior vertebrae? If so, this could be evidence for fish trade operating in phase 2, with small quantities of cod dried, prepared, and removed from Quoygrew. This could explain the lower quantities of cleithra in phase 2 despite the taphonomic results indicating quantities should increase, and the higher than usual proportions of anterior abdominal vertebrae, which in effect indicate lower than usual quantities of posterior vertebrae – all of which would be removed with the prepared fish. Evidence for this is slight, but is corroborated by the small quantities of butchery evidence (see below, section 5.6). Nevertheless, the vast majority of the cod caught near Quoygrew was consumed whole on site; other sites with fish processing evidence also have quantities of fish consumed whole (e.g. Hoffman *et al.* 2000; Krivogorskaya *et al.* 2005).

Another conceivable explanation for the higher proportion of cod anterior abdominal vertebrae in phase 2 could be related to taphonomy: phase 2 is better preserved than any other phase. Vertebrae are sometimes recorded as *gadus/pollachius* if they cannot be positively identified to cod or saithe, and thus if preservation is poor, the use of this category will increase. Figure 5.22 shows the NISP of *gadus/pollachius* vertebrae for all phases. The anterior abdominal vertebrae identifications are at a low quantity throughout the phases, with no particular change from phases ii and iii to phase 2: therefore the apparent increase of anterior abdominal vertebrae in phase 2 is not the result of a decrease in use of the *gadus/pollachius* category. If we were to assume all *gadus/pollachius* vertebrae in phase 2 were actually cod, then this would slightly increase the proportion of the caudal vertebrae, but not so much that the pattern observed using MNE would change. Obviously not all of the *gadus/pollachius* category are actually cod, so therefore the pattern in phase 2 is likely to be real, and not related to differential identification of cod, saithe and *gadus/pollachius* through the phases.

Saithe can be dried for trade in a like manner to cod, as is also detectable by unusual proportions or size distributions of some elements. The supracleithrum was ranked 11th in phase ii by NISP, then decreased to 13th in phase iii and 15th in phase 2 (Table 5.10). This element is moderately robust, and because 2-4mm samples were examined, sieving biases do not influence the count of smaller sized saithe supracleithra. These rankings thus probably reflect the quality of preservation in each phase. The saithe scapula is easily fragmented and thus is unlikely to be found, particularly in the earlier phases with poorer preservation. Only four saithe scapulae were recovered in total. In general, the saithe cleithrum is as fragile as the cod cleithrum. It is ranked 15th, 16th or 17th in all phases by either MNE or NISP. While this might be suggestive of prepared fish being exported and therefore decreasing the quantities of cleithra left at Quoygrew, the size distributions of saithe are smaller than those usually exploited for this process (Perdikaris 1999; see section 5.5.2). The near absence of butchery marks supports this theory (see section 5.7.5). An alternative explanation for the low proportions of saithe cleithra would be if they were often recorded as *gadus/pollachius* or gadid, but this was not the case. Thus the under-representation of cleithra remains unexplained, unless it relates to the small size of many of the saithe, which may be correlated with poorer recovery potential for this particular element once fragmented (see further below). If this lack of cleithra had been the result of preparation and removal of dried saithe, then lower than usual quantities of posterior vertebrae might be expected (as observed for cod in phase 2). However, posterior vertebrae actually outnumber anterior vertebrae in each of phases ii, iii and 2. The high proportion of saithe vertebrae compared to cranial and appendicular elements found in phases ii, iii and 2 is similarly perplexing, but may imply that they were easier to identify to species. Overall, the element distributions for saithe are probably the result of other taphonomic processes and recovery biases rather than butchery.

The variation in saithe elements was also examined by applying Spearman's Rho significance tests on the rank of QC1 and QC4 elements (Table 5.15). All of the major phases are significantly similar to each other – that is, phases ii, iii and 2 all have statistically similar rank orders of elements. Unlike cod, it is therefore likely that throughout the use of the middens in Area A and G, saithe were consumed in similar ways, presumably as whole fish. There are slight taphonomic differences through time, particularly as the fish bone from phase ii is more poorly preserved, but these differences had a minimal effect on the rank order of elements.

The difference between the cod and saithe results may be due to a combination of butchery and preservation issues. The saithe were much smaller, which influences the likelihood that they were consumed whole, locally, but also raises the possibility that each species followed a different taphonomic pathway. Saithe tended to be better preserved than cod (compare the percent completeness of QC1 and QC4 elements for cod and saithe, as shown in Figure 5.7 and Figure 5.8). For phases ii and iii, saithe were significantly more complete than cod (phase ii: greatest difference 0.176, Kolmogorov-Smirnov Z value 2.517, significance 0.000; phase iii: 0.254, 2.205, 0.000). For phase 2, saithe were also more complete than cod, but not significantly so (0.115, 1.204, 0.110). The lack of significant variation in saithe element patterning may thus result from both the consumption of whole fish across the site, and the better preservation of their smaller bones.

Ling quantities were low so any comparison of element and size distributions across phases was difficult. Figure 5.18 illustrates the NISP and MNE for the largest phases, iii and 2. It is difficult to determine if any parts of the body were over- or under-represented. There is a definite peak of abdominal vertebrae group one in phase 2, but it is difficult to argue that this is evidence of stockfish production, because cranial and appendicular elements were not recovered in sufficient quantity to look for patterning. The cleithrum is among the most frequently occurring cranial and appendicular elements in phase 2, which makes dried fish production unlikely, but this could also reflect the fact that cleithra are more robust in ling than cod or saithe (although less so than in haddock).

In summary, there was a slight indication that dried cod were produced and removed from the site in phase 2 alone. Conversely, whole saithe were probably consumed at Quoygrew. Ling were not recovered in sufficient quantity to draw conclusions in these regards.

Element Output	Phase i		Phase ii				Phase iii		Phase 1.2		Phase 2		Totals	
	Matching 2-4mm and >4mm	All	Matching 2-4mm and >4mm	Rank	All	Rank	All	Rank	All	Rank	All	Rank	All	Rank
Articular		1	10	*15*	15	*17*	65	*5*	4	*5*	32	*5*	117	*9*
Basioccipital (x2)			12	*13*	18	*16*	36	*15*		*14*	20	*13*	74	*16*
Ceratohyal			10	*15*	23	*10*	65	*5*	1	*11*	19	*16*	108	*11*
Cleithrum			18	*9*	28	*9*	65	*5*		*14*	28	*8*	121	*8*
Dentary			26	*5*	42	*5*	106	*1*		*14*	32	*5*	180	*3*
Hyomandibular			9	*17*	20	*13*	32	*16*		*14*	18	*17*	70	*17*
Infrapharyngeal	1	2	15	*11*	19	*15*	53	*11*	2	*8*	33	*4*	109	*10*
Maxilla	2	2	21	*7*	35	*7*	73	*4*	2	*8*	23	*10*	135	*5*
Opercular			21	*7*	29	*8*	30	*18*	4	*5*	17	*18*	80	*15*
Palatine	1	1	12	*13*	21	*12*	52	*12*	5	*3*	21	*12*	100	*13*
Parasphenoid (x2)		6	36	*2*	56	*2*	86	*2*	12	*1*	32	*5*	192	*1*
Posttemporal		1	35	*3*	53	*3*	55	*10*		*14*	16	*19*	125	*7*
Premaxilla	1	2	23	*6*	38	*6*	65	*5*	5	*3*	24	*9*	134	*6*
Preopercular			9	*17*	14	*18*	32	*16*	3	*7*	20	*13*	69	*18*
Quadrate	2	4	33	*4*	52	*4*	62	*9*	1	*11*	39	*1*	158	*4*
Scapula			6	*19*	8	*19*	20	*19*		*14*	20	*13*	48	*19*
Supracleithrum			16	*10*	22	*11*	37	*14*	1	*11*	23	*10*	83	*14*
Vomer (x2)			52	*1*	64	*1*	86	*2*	6	*2*	34	*3*	190	*2*
Otolith			14	*12*	20	*13*	43	*13*	2	*8*	36	*2*	101	*12*
Totals	7	16	328		508		959		39		444		1966	

Table 5.8: Cod QC1 and QC4 NISP by element and phase, combined >4mm and 2-4mm unless stated

	Phase i		Phase ii		Phase iii	Phase 1.2	Phase 2
	Matching 2-4mm and >4mm	All	Matching 2-4mm and >4mm	All	All	All	All
Articular		1	5	7	32	3	16
Basioccipital			4	7	16		10
Ceratohyal			5	13	29	1	8
Cleithrum			6	8	27		7
Dentary			9	14	29		14
Hyomandibular			5	10	22		9
Infrapharyngeal	1	2	7	8	29	1	15
Maxilla	2	2	9	14	36	1	14
Opercular			12	15	15	3	10
Palatine	1	1	7	11	28	3	13
Parasphenoid		3	12	15	24	5	12
Posttemporal		1	12	18	25		7
Premaxilla	1	1	13	20	30	4	12
Preopercular			3	5	9	2	8
Quadrate	2	4	14	22	25	1	19
Scapula			4	5	13		13
Supracleithrum			7	10	19	1	13
Vomer			19	22	31	3	17
Otolith			8	11	26	2	21

Table 5.9: Cod QC1 and QC4 MNE by element and phase, combined >4mm and 2-4mm unless stated

	Phase i	Phase ii				Phase iii		Phase 1.2	Phase 2		Grand Total	
	All	Matching 2-4mm and >4mm	Rank	All	Rank	All	Rank	All	All	Rank	All	Rank
Articular	1	24	*7*	44	*4*	9	*10*	1	16	*8*	71	*7*
Basioccipital (x2)	0	40	*1*	68	*1*	18	*3*	2	26	*3*	114	*2*
Ceratohyal		15	*11*	16	*13*	10	*9*	5	11	*15*	42	*12*
Cleithrum		8	*15*	9	*16*	3	*17*		8	*17*	20	*17*
Dentary	1	24	*7*	40	*6*	9	*10*	2	15	*11*	67	*8*
Hyomandibular	1	14	*13*	35	*9*	12	*8*	1	16	*8*	65	*9*
Infrapharyngeal	1	15	*11*	18	*12*	4	*14*	1	15	*11*	39	*13*
Maxilla		29	*4*	44	*4*	15	*5*		13	*13*	72	*6*
Opercular		12	*14*	15	*14*	1	*19*		3	*18*	19	*18*
Palatine		6	*16*	15	*14*	8	*12*		16	*8*	39	*13*
Parasphenoid (x2)	4	32	*3*	56	*2*	28	*1*	6	32	*1*	126	*1*
Posttemporal		24	*7*	31	*10*	14	*6*	1	19	*7*	65	*9*
Premaxilla	1	33	*2*	52	*3*	14	*6*		23	*5*	90	*4*
Preopercular		5	*17*	9	*16*	4	*14*		12	*14*	25	*16*
Quadrate	1	25	*6*	39	*8*	16	*4*		22	*6*	78	*5*
Scapula			*19*	0	*19*	2	*18*		2	*19*	4	*19*
Supracleithrum	1	22	*10*	29	*11*	6	*13*	2	11	*15*	49	*11*
Vomer (x2)	2	26	*5*	40	*6*	26	*2*	0	30	*2*	98	*3*
Otolith	1	2	*18*	2	*18*	4	*14*	2	26	*3*	35	*15*
Totals	11	307		480		167		19	272		949	

Table 5.10: Saithe QC1 and QC4 NISP, by element and phase, combined >4mm and 2-4mm unless stated

	Phase i		Phase ii		Phase iii	Phase 1.2	Phase 2
	Matching 2-4mm and >4mm	All	Matching 2-4mm and >4mm	All	All	All	All
Articular	1	1	10	18	7	1	8
Basioccipital			19	33	9	1	12
Ceratohyal			8	8	5	3	7
Cleithrum			3	4	2		4
Dentary	1	1	11	22	6	2	8
Hyomandibular	1	1	9	21	7	1	10
Infrapharyngeal	1	1	8	8	4	1	8
Maxilla			17	22	8		9
Opercular			6	9	1		2
Palatine			4	8	6		9
Parasphenoid	2	2	14	21	12	2	14
Posttemporal			14	17	8	1	9
Premaxilla	1	1	18	32	7		13
Preopercular			5	5	2		7
Quadrate	1	1	13	21	8		14
Scapula					1		2
Supracleithrum	1	1	13	17	4	2	7
Vomer	1	1	11	16	10		14
Otolith	1	1	1	1	2	1	14

Table 5.11: Saithe QC1 and QC4 MNE, by element and phase, combined >4mm and 2-4mm unless stated

Elements	Phase ii All NISP	Phase ii Matching >4mm and 2-4mm NISP	Phase iii NISP	Phase 1.2 NISP	Phase 2 NISP	Total	Rank order
Articular					1	1	*14*
Basioccipital (x2)						0	*18*
Ceratohyal	1				1	2	*9*
Cleithrum	1				4	5	*5*
Dentary			3		5	8	*1*
Hyomandibular			1			1	*14*
Infrapharyngeal			1		1	2	*9*
Maxilla	1		3		1	5	*5*
Opercular			1		1	2	*9*
Palatine			1		2	3	*8*
Parasphenoid (x2)			6		2	8	*1*
Posttemporal				1		1	*14*
Premaxilla	2		4		1	7	*4*
Preopercular	1	1		1		2	*9*
Quadrate	1	1	1		3	5	*5*
Scapula					1	1	*14*
Supracleithrum			1		1	2	*9*
Vomer (x2)			4		4	8	*1*
Otolith						0	*18*
Totals	7	2	21	2	25	55	

Table 5.12: Ling QC1 and QC4 NISP by phase and element, combined >4mm and 2-4mm unless stated

	Phase ii All	Phase iii All	Phase 1.2 All	Phase 2 All
Articular				1
Basioccipital				
Ceratohyal	1			1
Cleithrum	1			3
Dentary		2		3
Hyomandibular	1			
Infrapharyngeal		1		1
Maxilla	1	2		1
Opercular		1		1
Palatine		1		1
Parasphenoid		2		1
Posttemporal			1	
Premaxilla	2	2		1
Preopercular	1		1	
Quadrate	1	1		2
Scapula				1
Supracleithrum		1		1
Vomer		1		2
Otolith				

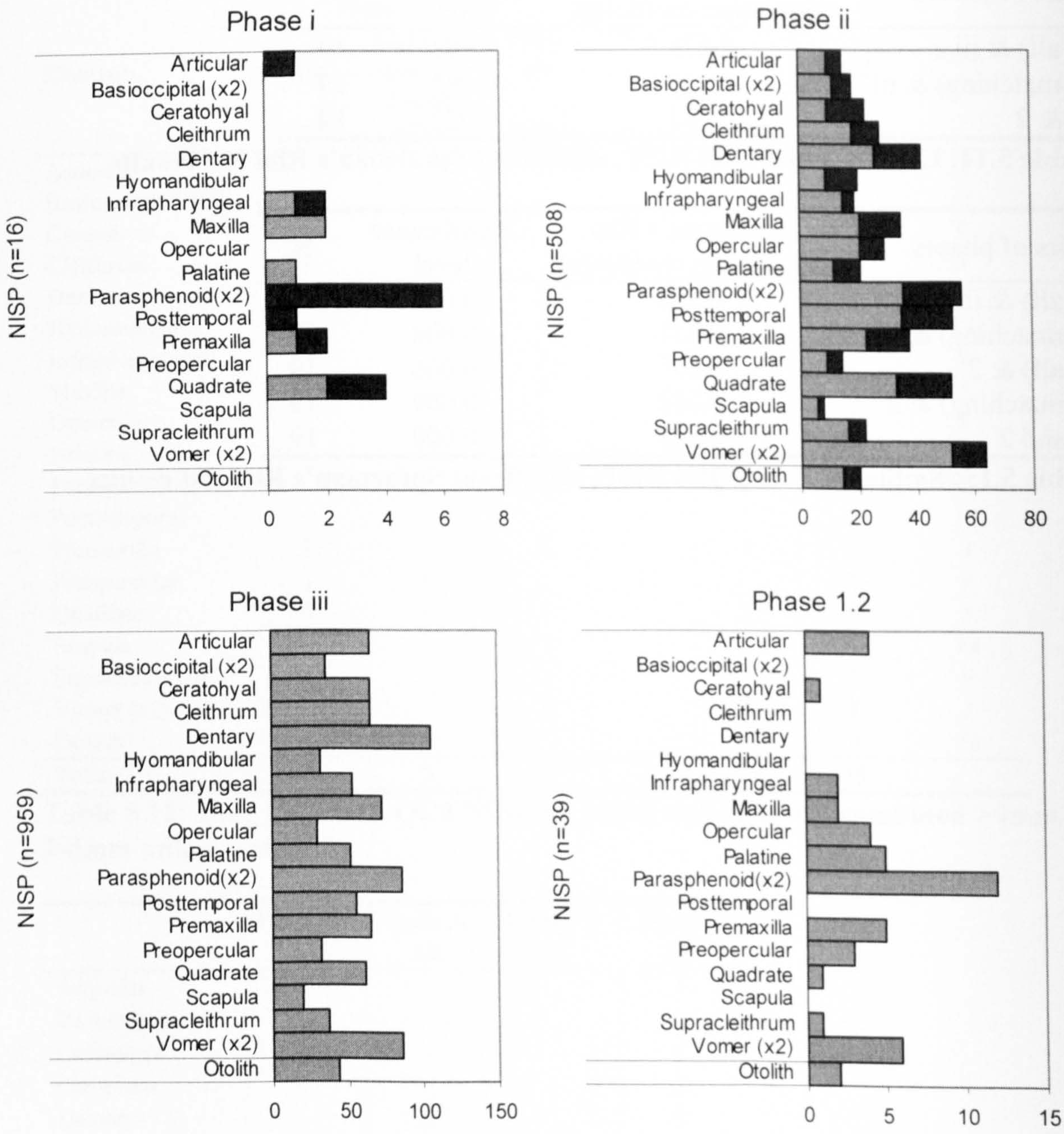
Table 5.13: Ling QC1 and QC4 MNE by phase and element, combined >4mm and 2-4mm unless stated

Pairs of phases	Spearman's Rho correlation coefficient	Significance level	N
ii (all) & iii	0.675	0.002	19
ii (matching) & iii	0.640	0.003	19
iii & 2	0.523	0.022	19

Table 5.14: Cod QC1 and QC4 NISP, significant Spearman's Rho test results

Pairs of phases	Spearman's Rho correlation coefficient	Significance level	N
ii (all) & iii	0.835	0.000	19
ii (matching) & iii	0.851	0.000	19
ii (all) & 2	0.605	0.006	19
ii (matching) & 2	0.582	0.009	19
iii and 2	0.753	0.000	19

Table 5.15: Saithe QC1 and QC4 NISP, significant Spearman's Rho test results


Phase i
NISP (n=16)
Articular
Basioccipital (x2)
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid(x2)
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer (x2)
Otolith
0
2
4
6
8
Phase ii
NISP (n=508)
Articular
Basioccipital (x2)
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid(x2)
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer (x2)
Otolith
0
20
40
60
80
Phase iii
NISP (n=959)
Articular
Basioccipital (x2)
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid(x2)
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer (x2)
Otolith
0
50
100
150
Phase 1.2
NISP (n=39)
Articular
Basioccipital (x2)
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid(x2)
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer (x2)
Otolith
0
5
10
15

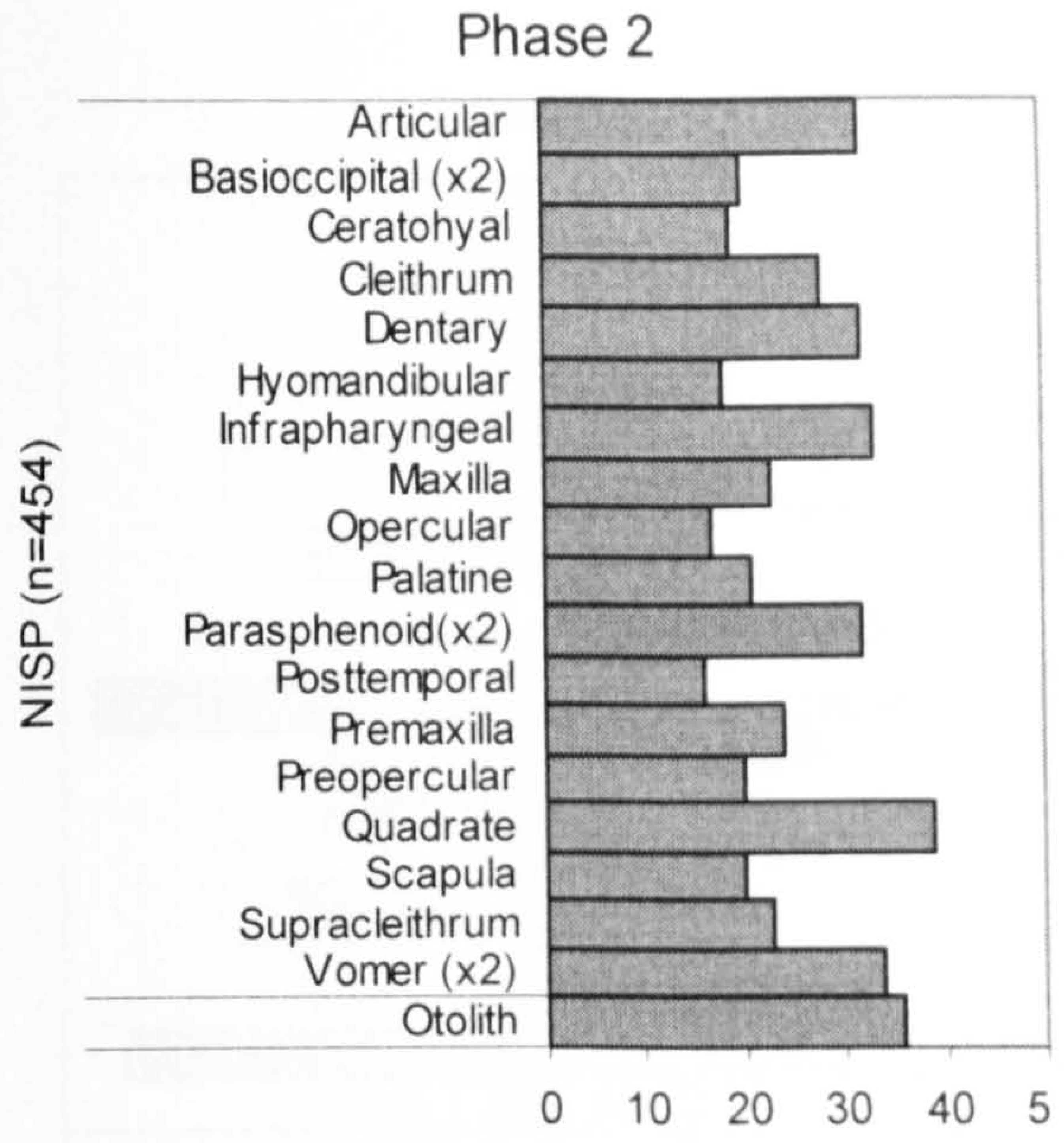


Figure 5.16: Cod QC1 and QC4 NISP, midline elements doubled for NISP but n is actual total (light grey for matching >4mm and 2-4mm, dark grey for unmatched >4mm)

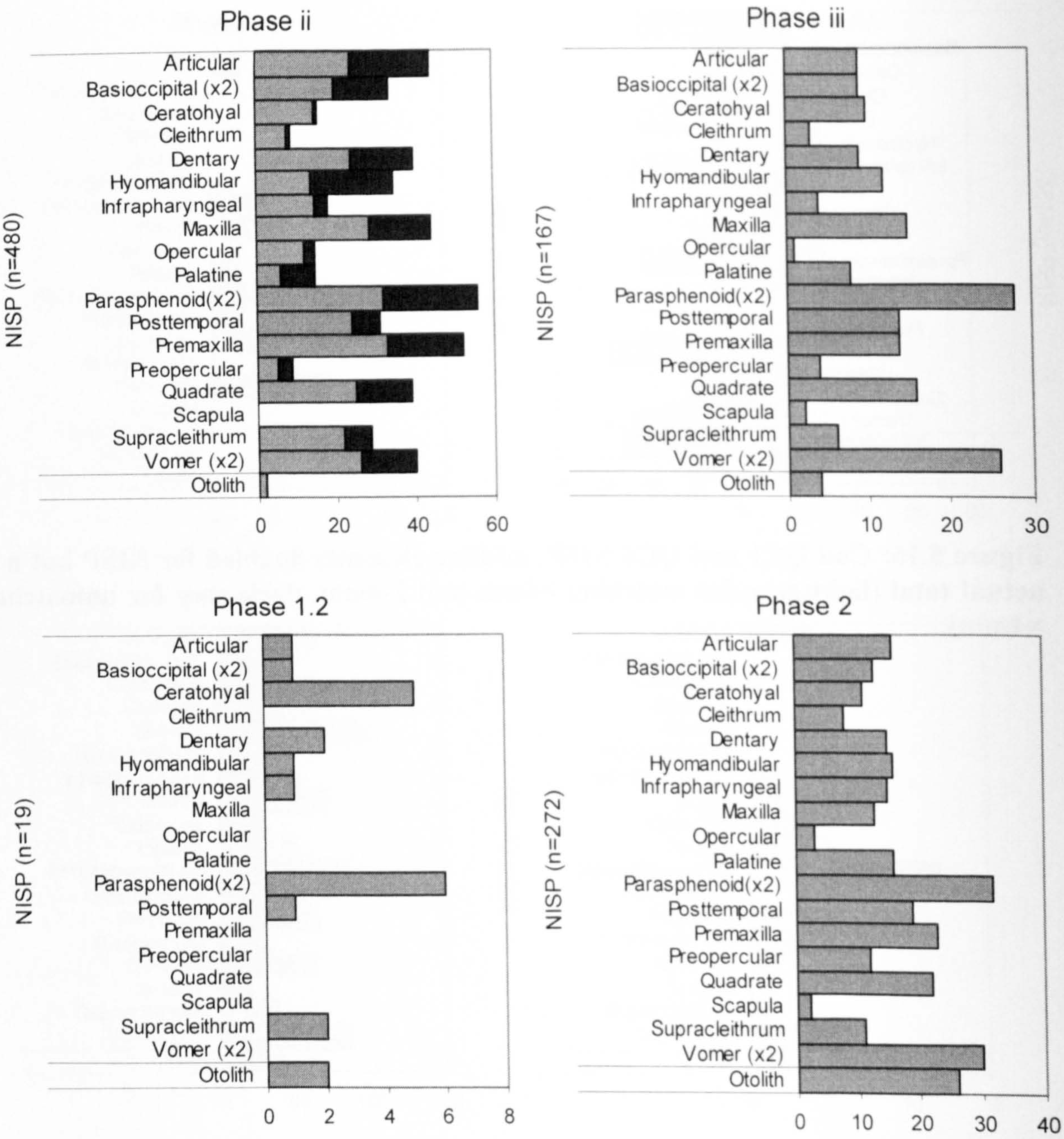


Figure 5.17: Saithe QC1 and QC4, midline NISP elements doubled but n is actual total (light grey for matching >4mm and 2-4mm, dark grey for unmatched >4mm)

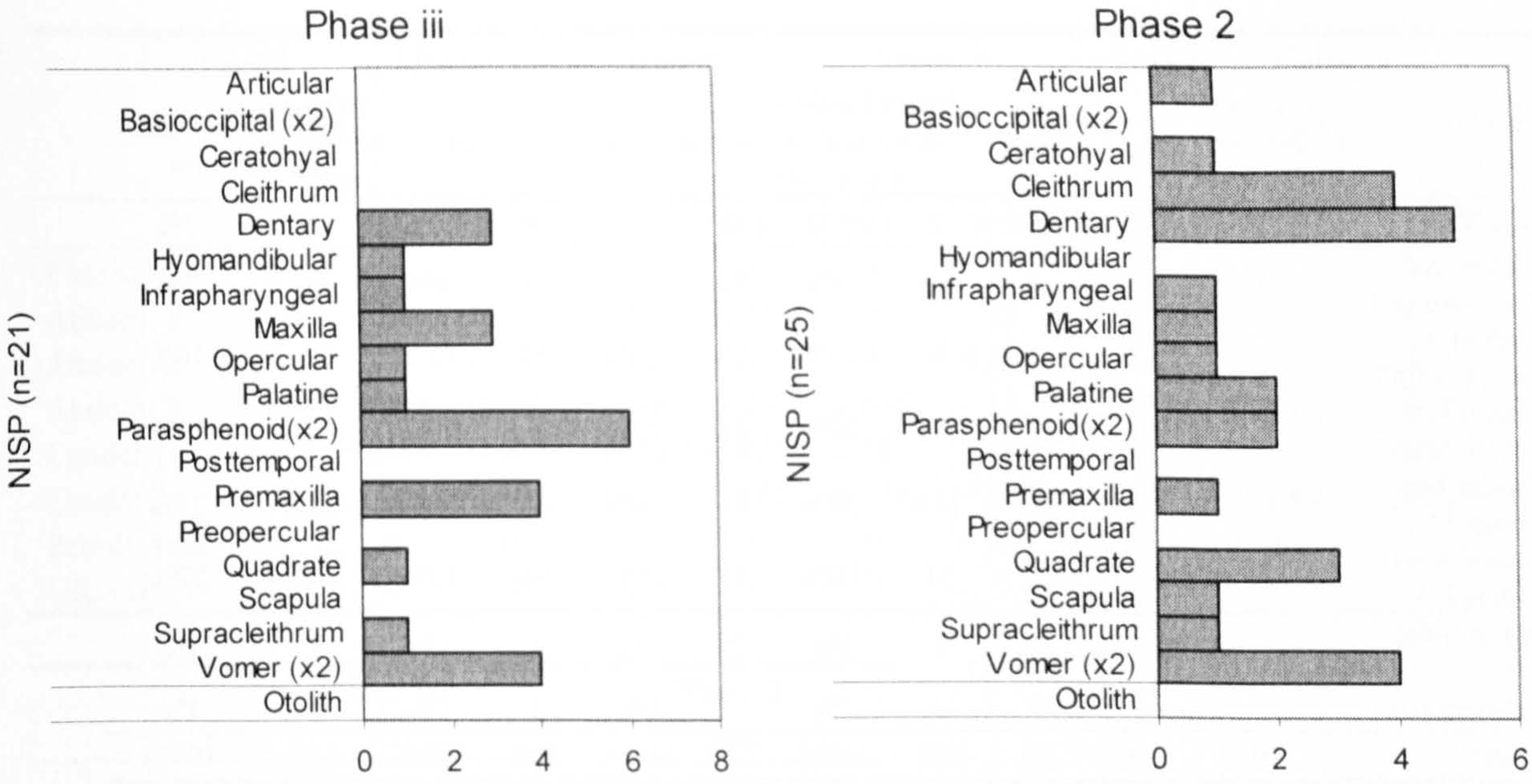


Figure 5.18: Ling QC1 and QC4 NISP, midline elements doubled for NISP but n is actual total

	Phase i			Phase ii						Phase iii	
Elements	Matching 2-4 mm and >4mm	>4 mm only	Total	Matching 2-4mm and >4mm		>4mm only		Total		Matching 2-4mm and >4mm	
First Vert.		1	1	2	1%	2	1%	4	1%	12	2%
Abdominal Vert. Group 1	3	1	4	25	9%	23	10%	48	9%	56	7%
Abdominal Vert. Group 2		1	1	36	13%	23	10%	59	12%	73	10%
Abdominal Vert. Group 3	1	1	2	58	20%	46	21%	104	20%	141	19%
Caudal Vert. Group 1	6	4	10	110	38%	81	36%	191	38%	249	33%
Caudal Vert. Group 2		1	1	51	18%	45	20%	96	19%	205	27%
Penultimate Vert.			0	1	0%	2	1%	3	1%	8	1%
Ultimate Vert.			0	3	1%		0%	3	1%	8	1%
Totals	10	9	19	286	100%	222	100%	508	100%	752	100%

	Phase 1.2		Phase 2			
Elements	Matching 2-4mm and >4mm		Matching 2-4mm and >4mm		Total	
First Vertebra	1	3%	8	1%	26	1%
Abdominal Vertebra Group 1	1	3%	61	10%	170	9%
Abdominal Vertebra Group 2	3	10%	61	10%	197	10%
Abdominal Vertebra Group 3	2	7%	87	14%	336	18%
Caudal Vertebra Group 1	12	41%	193	32%	655	34%
Caudal Vertebra Group 2	10	34%	180	30%	492	26%
Penultimate Vertebra			6	1%	17	1%
Ultimate Vertebra			8	1%	19	1%
Totals	29	100%	604	100%	1912	100%

Table 5.16: Cod QC2 NISP

	Phase i				Phase ii				Phase iii	
	Matching 2-4mm and >4mm		All		Matching 2-4mm and >4mm		All		All	
	min	max	min	max	min	max	min	max	min	max
First vert.	0	0	1	0	2	0	4	0	12	0
Abdom. 1	0.75	0	1	0	6.25	0	12	0	14	0
Abdom. 2	0	0	0.167	0.083	6	3	9.833	4.917	12.167	6.083
Abdom. 3	0.125	0.018	0.25	0.036	7.25	1.036	13	1.857	17.625	2.518
Caudal 1	0.375	0.087	0.625	0.144	6.875	1.587	11.938	2.755	15.563	3.591
Caudal 2	0	0	0.052	0.014	2.681	0.716	5.053	1.347	10.789	2.877
Penult. vert.	0	0	0	0	1	0	3	0	8	0
Ult. vert.	0	0	0	0	3	0	3	0	8	0

	Phase 1.2		Phase 2	
	All		All	
	min	max	min	max
First vert.	1	0	8	0
Abdom. 1	0	0	15.25	0
Abdom. 2	0.5	0.25	10.167	5.083
Abdom. 3	0.25	0.036	10.875	1.554
Caudal 1	0.75	0.173	12.063	2.784
Caudal 2	0.526	0.140	9.474	2.526
Penult. vert.	0	0	6	0
Ult. vert.	0	0	8	0

Table 5.17: Cod QC2 MNE

Elements	Phase i			Phase ii			Phase iii	Phase 1.2	Phase 2	Totals
	Matching 2-4mm and >4mm	>4 mm only	Total	Matching 2-4mm and >4mm	>4mm only	Total	Matching 2-4mm and >4mm	Matching 2-4mm and >4mm	Matching 2-4mm and >4mm	
First Vertebra				18 (2%)	10 (2%)	28 (2%)	12 (1%)	2 (4%)	17 (2%)	59 (2%)
Abdominal Vertebra Group 1	4 (11%)		4 (9%)	85 (8%)	61 (11%)	146 (9%)	58 (7%)	7 (13%)	72 (8%)	287 (8%)
Abdominal Vertebra Group 2	8 (22%)	3	11 (25%)	121 (12%)	84 (16%)	205 (13%)	78 (9%)	7 (13%)	110 (12%)	411 (12%)
Abdominal Vertebra Group 3	12 (33%)	3	15 (34%)	334 (32%)	158 (30%)	492 (31%)	332 (40%)	18 (34%)	339 (38%)	1196 (35%)
Caudal Vertebra Group 1	6 (17%)		6 (14%)	305 (29%)	126 (24%)	431 (27%)	211 (25%)	15 (28%)	191 (21%)	854 (25%)
Caudal Vertebra Group 2	6 (17%)	2	8 (18%)	188 (18%)	94 (18%)	282 (18%)	142 (17%)	4 (8%)	171 (19%)	607 (18%)
Penultimate Vertebra				1 (0%)		1 (0%)	1 (0%)		3 (0%)	5 (0%)
Ultimate Vertebra							1 (0%)		1 (0%)	2 (0%)
Totals	36	8	44	1052	533	1585	835	53	904	3421

Table 5.18: Saithe QC2 NISP

	Phase i				Phase ii				Phase iii	
	Matching 2-4mm and >4mm		All		Matching 2-4mm and >4mm		All		All	
	min	max	min	max	min	max	min	max	min	max
First vert.	0	0	0	0	18	0	28	0	12	0
Abdom. 1	1	0	1	0	21.25	0	36.5	0	14.5	0
Abdom. 2	1.6	0.4	2.2	0.55	24.2	6.05	41	10.25	15.6	3.9
Abdom. 3	0.8	0.2	1	0.25	22.267	5.567	32.8	8.2	22.133	5.533
Caudal 1	0.429	0.071	0.429	0.071	21.786	6.048	30.786	5.131	15.071	2.512
Caudal 2	0.353	0.047	0.471	0.063	11.059	1.475	16.588	2.212	8.353	1.114
Penult. vert.	0	1	0	0	1	0	1	0	1	0
Ult. vert.	0	0	0	0	0	0	0	0	1	0

	Phase 1.2		Phase 2	
	All		All	
	min	max	min	max
First vert.	2	0	17	0
Abdom. 1	1.75	0	18	0
Abdom. 2	1.4	0.35	22	5.5
Abdom. 3	1.2	0.3	22.6	5.65
Caudal 1	1.071	0.179	13.643	2.274
Caudal 2	0.235	0.031	10.059	1.341
Penult. vert.	0	0	3	0
Ult. vert.	0	0	1	0

Table 5.19: Saithe QC2 MNE

Element Output	Phase i	Phase ii			Phase iii		Phase 2		Totals	
	Matching 2-4mm and >4mm	Matching 2-4mm and >4mm	>4mm only	Total	Matching 2-4mm and >4mm		Matching 2-4mm and >4mm			
First Vertebra					1	2%			1	1%
Abdominal Vertebra Group 1					6	14%	1	4%	7	9%
Abdominal Vertebra Group 2					12	27%	2	7%	14	19%
Abdominal Vertebra Group 3					6	14%	13	48%	19	25%
Caudal Vertebra Group 1					3	7%	3	11%	6	8%
Caudal Vertebra Group 2	1	2	1	3	12	27%	7	26%	23	31%
Penultimate Vertebra							1	4%	1	1%
Ultimate Vertebra					4	9%			4	5%
Totals	1	2	1	3	44	100%	27	100%	75	100%

Table 5.20: Ling QC2 NISP

	Phase i				Phase ii				Phase iii	
	Matching 2-4mm and >4mm		All		Matching 2-4mm and >4mm		All		All	
	min	max	min	max	min	max	min	max	min	max
First vert.	0	0	0	0	0	0	0	0	1	0
Abdom. 1	0	0	0	0	0	0	0	0	1.5	0
Abdom. 2	0	0	0	0	0	0	0	0	2	1
Abdom. 3	0	0	0	0	0	0	0	0	0.375	0.054
Caudal 1	0	0	0	0	0	0	0	0	0.12	0.005
Caudal 2	0.083	0.008	0.083	0.008	0.167	0.015	0.25	0.023	1	0.091
Penult. vert.	0	0	0	0	0	0	0	0	0	0
Ult. vert.	0	0	0	0	0	0	0	0	4	0

	Phase 1.2		Phase 2	
	All		All	
	min	max	min	max
First vert.	0	0	0	0
Abdom. 1	0	0	4	0
Abdom. 2	0	0	0.333	0.167
Abdom. 3	0	0	0.813	0.116
Caudal 1	0	0	0.12	0.005
Caudal 2	0	0	0.583	0.053
Penult. vert.	0	0	1	0
Ult. vert.	0	0	0	0

Table 5.21: Ling QC2 MNE

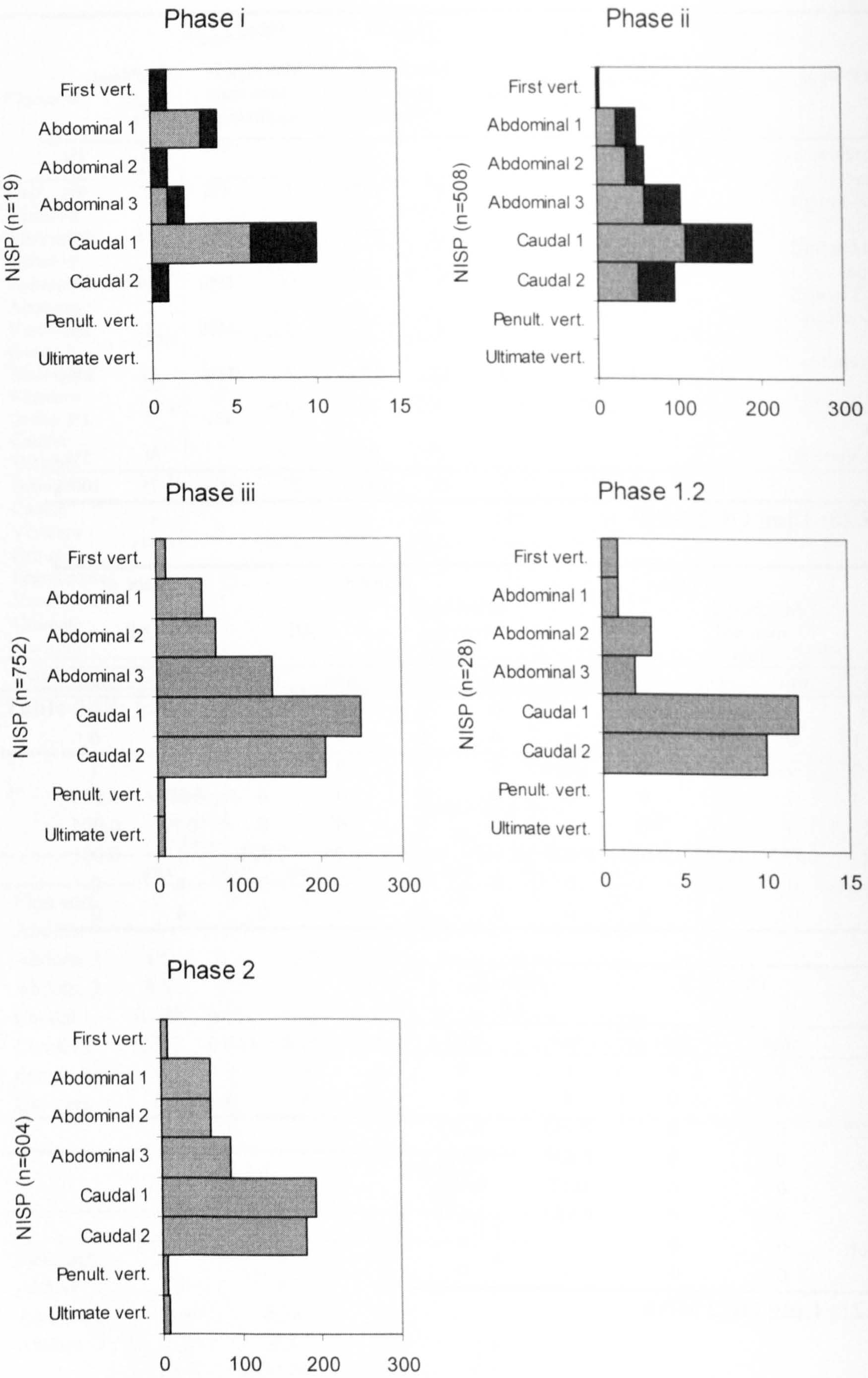


Figure 5.19: Cod QC2 NISP by phase

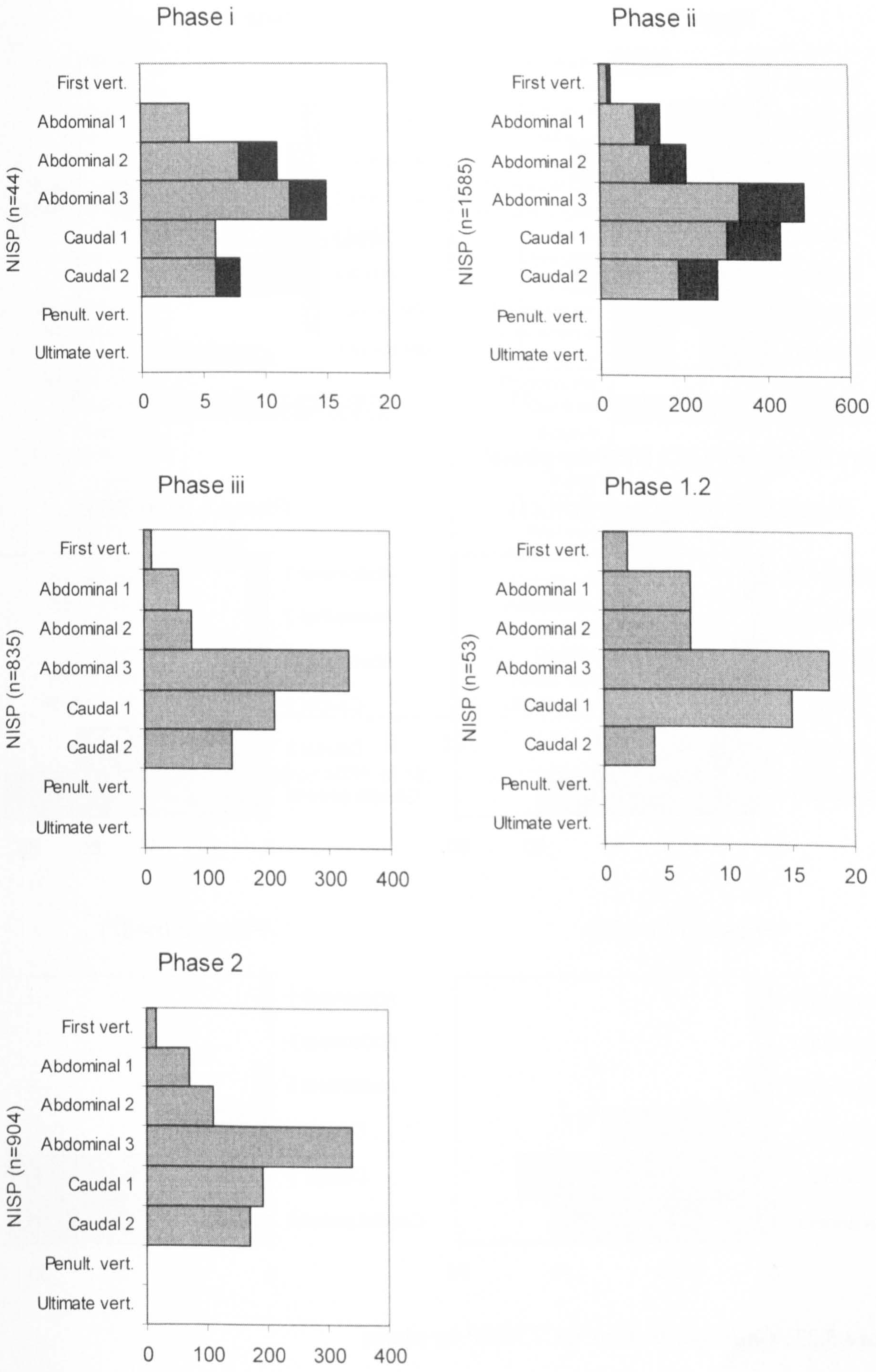


Figure 5.20: Saithe QC2 NISP by phase

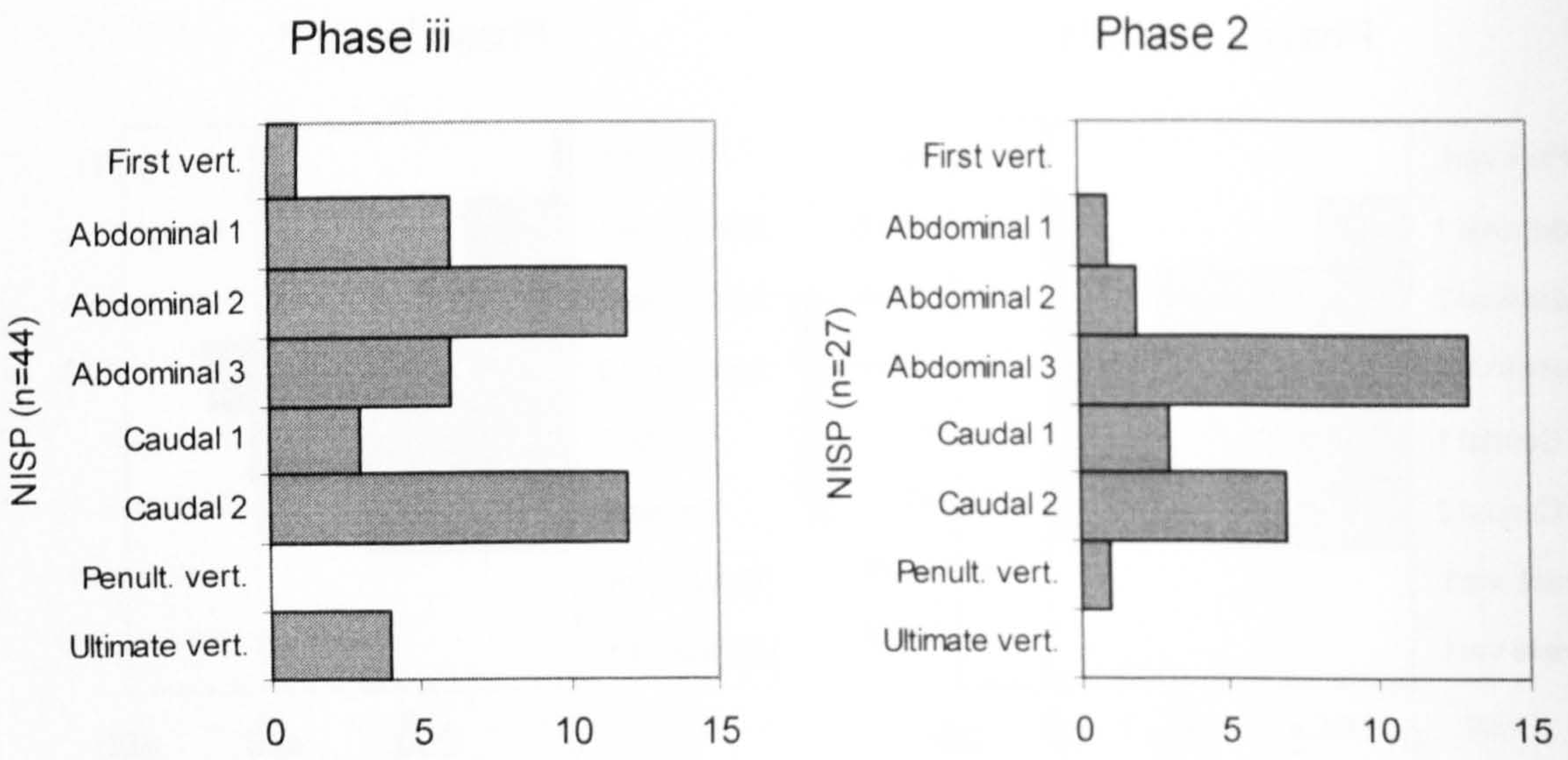


Figure 5.21: Ling QC2 NISP by phase

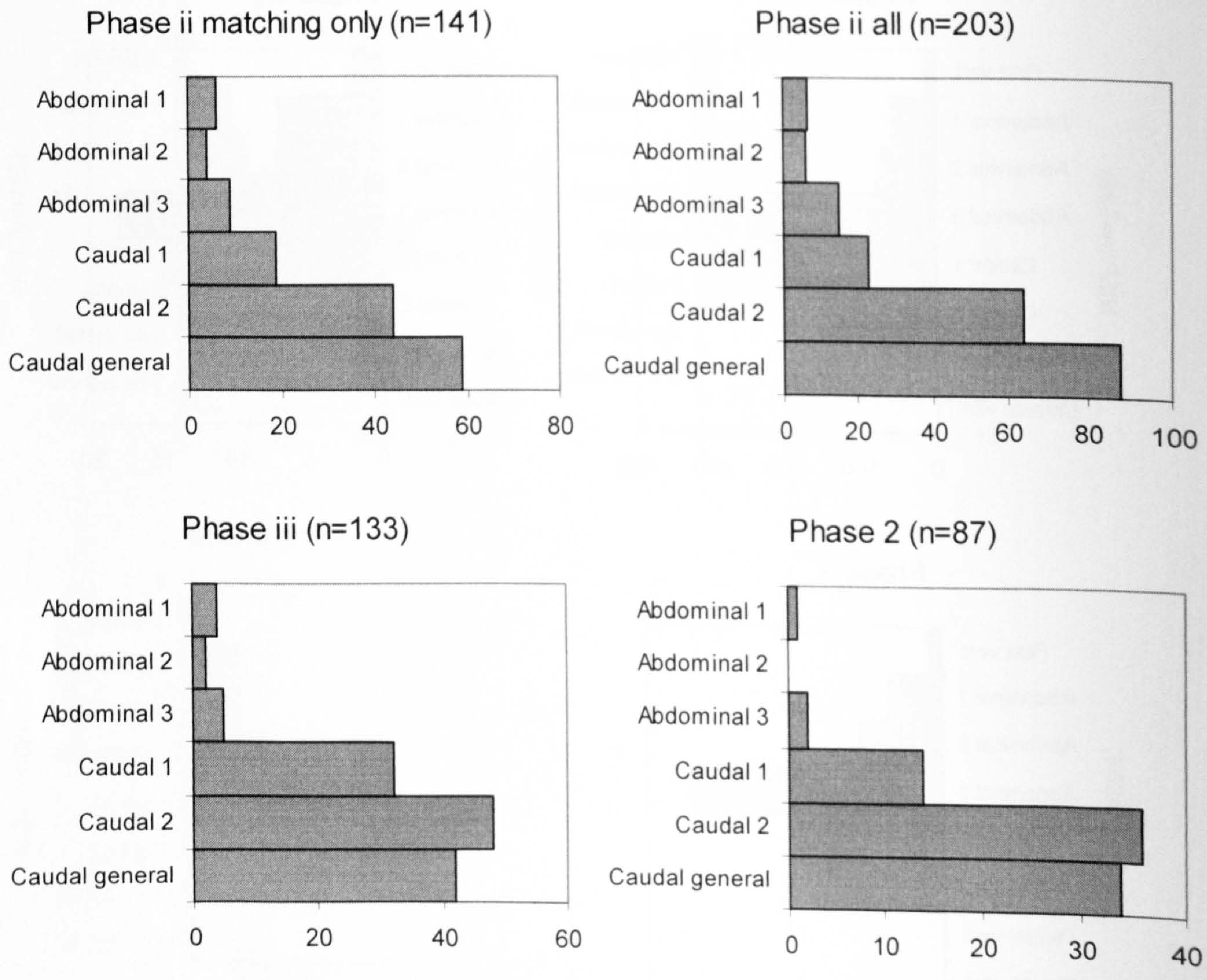
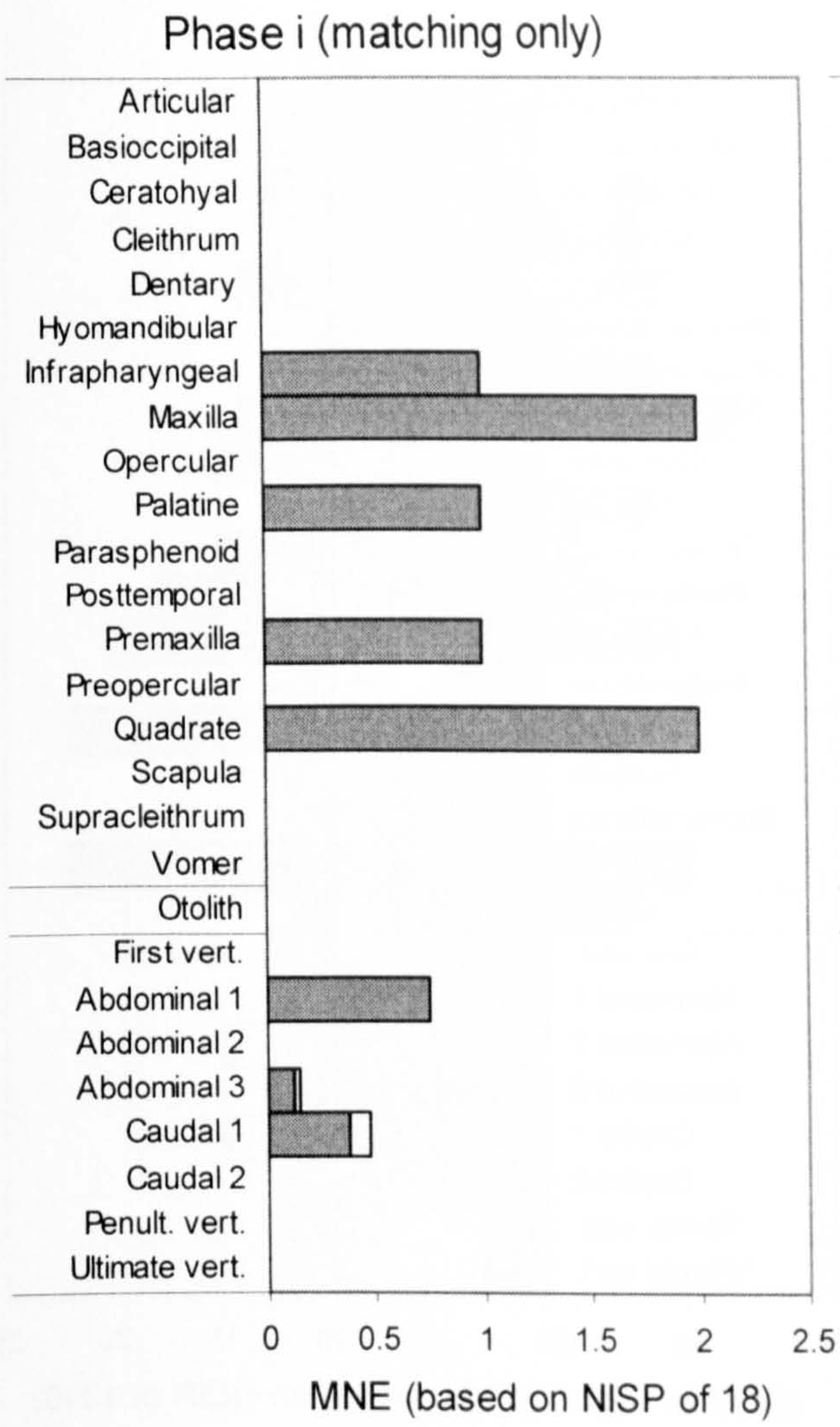
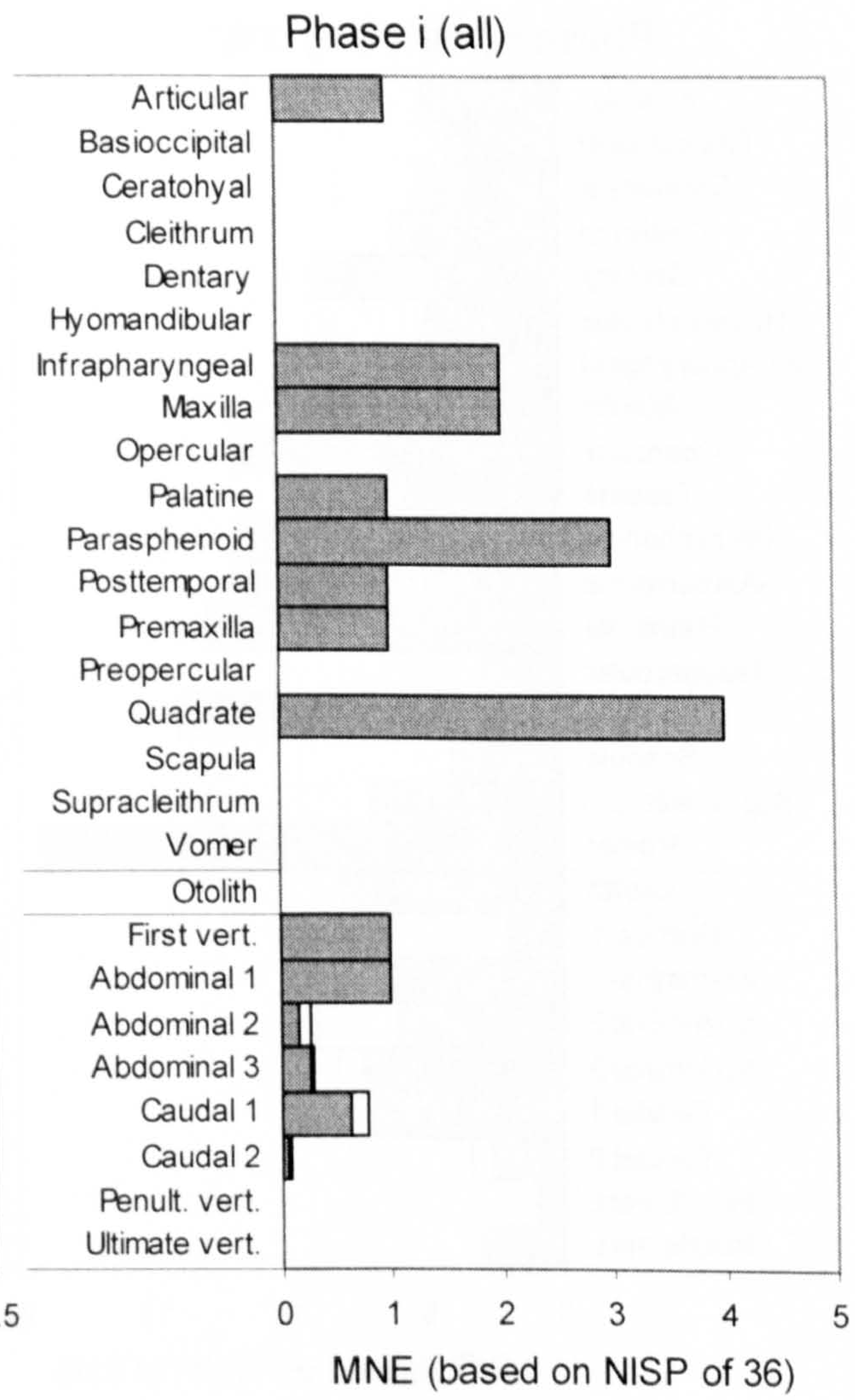
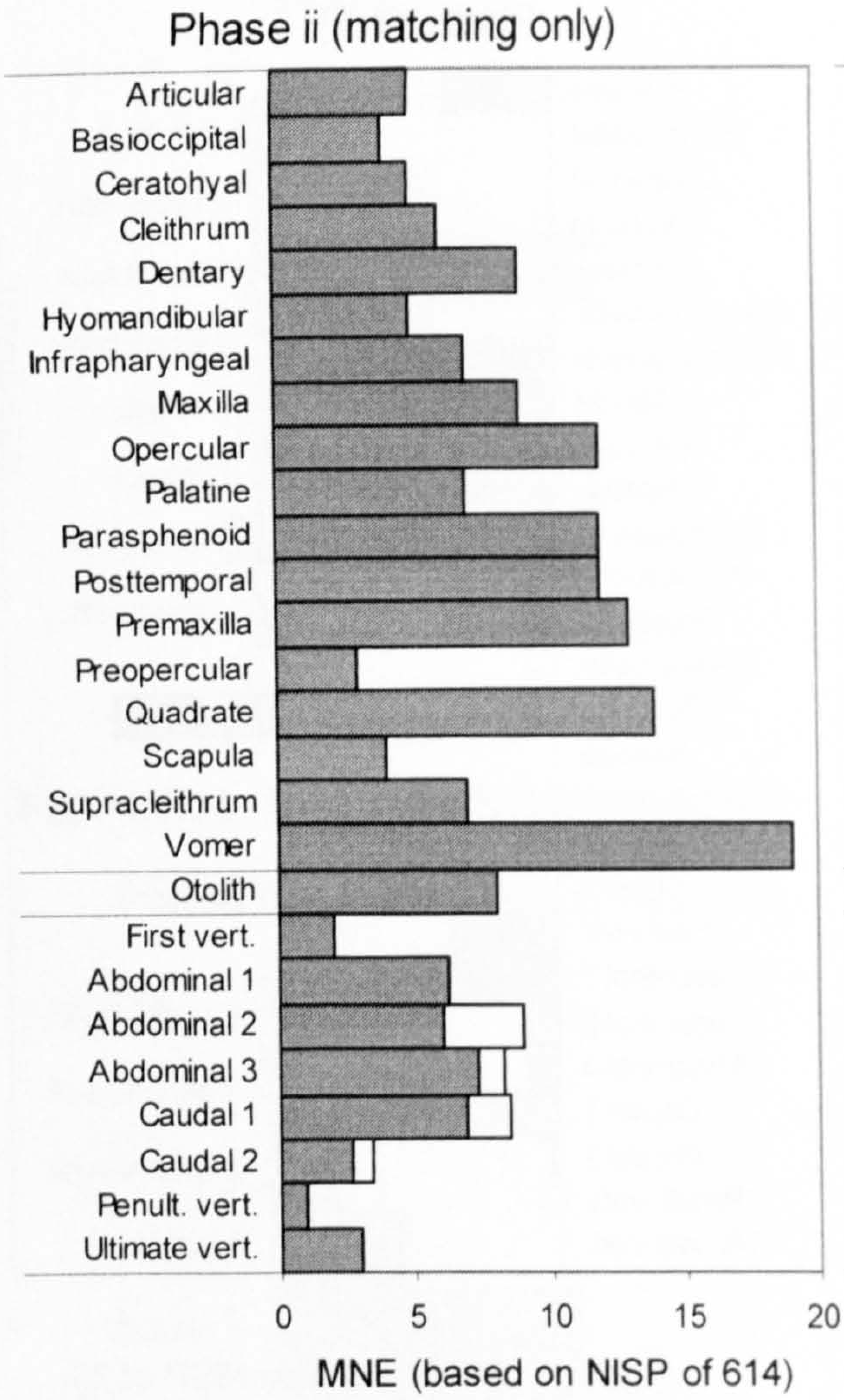
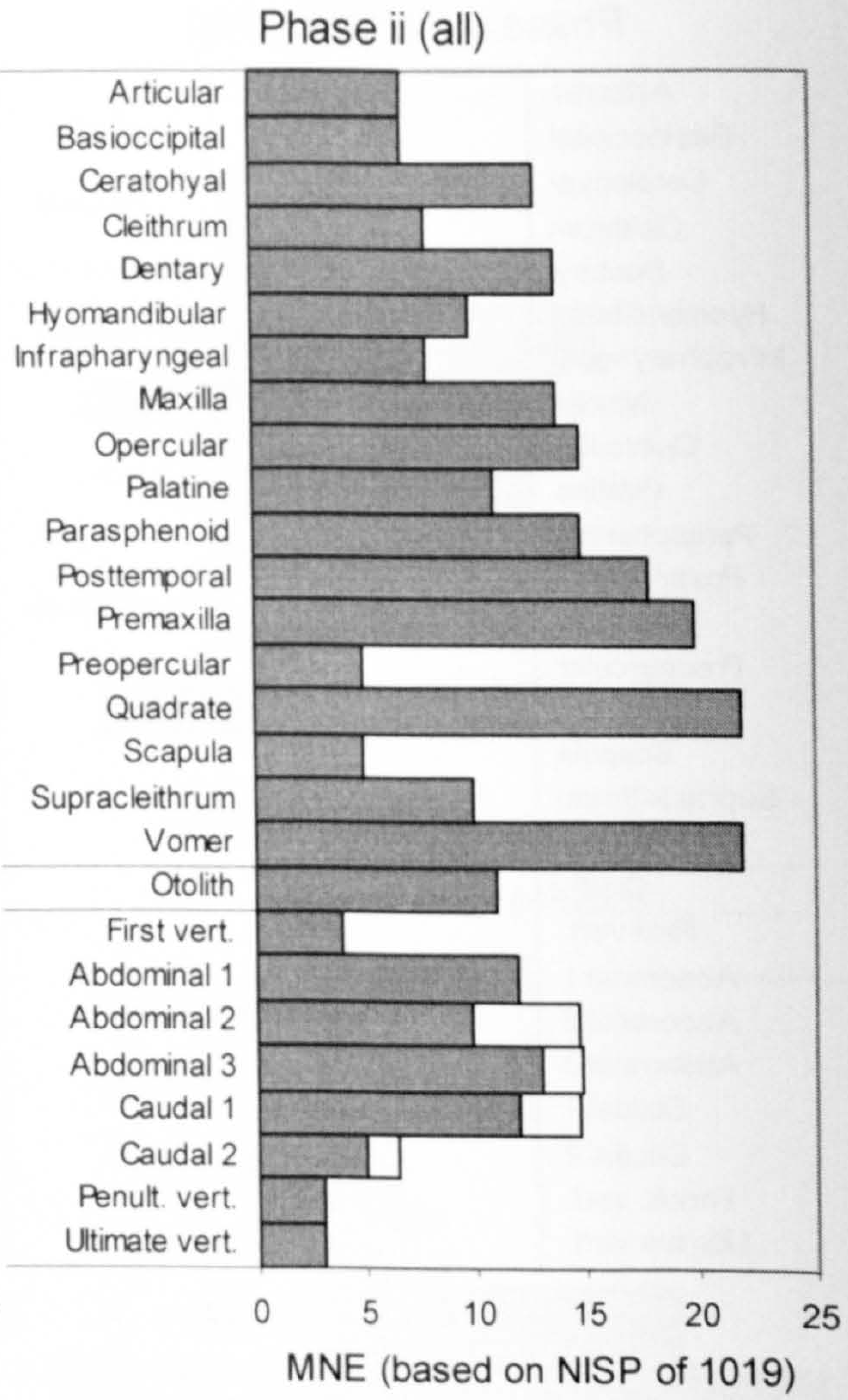


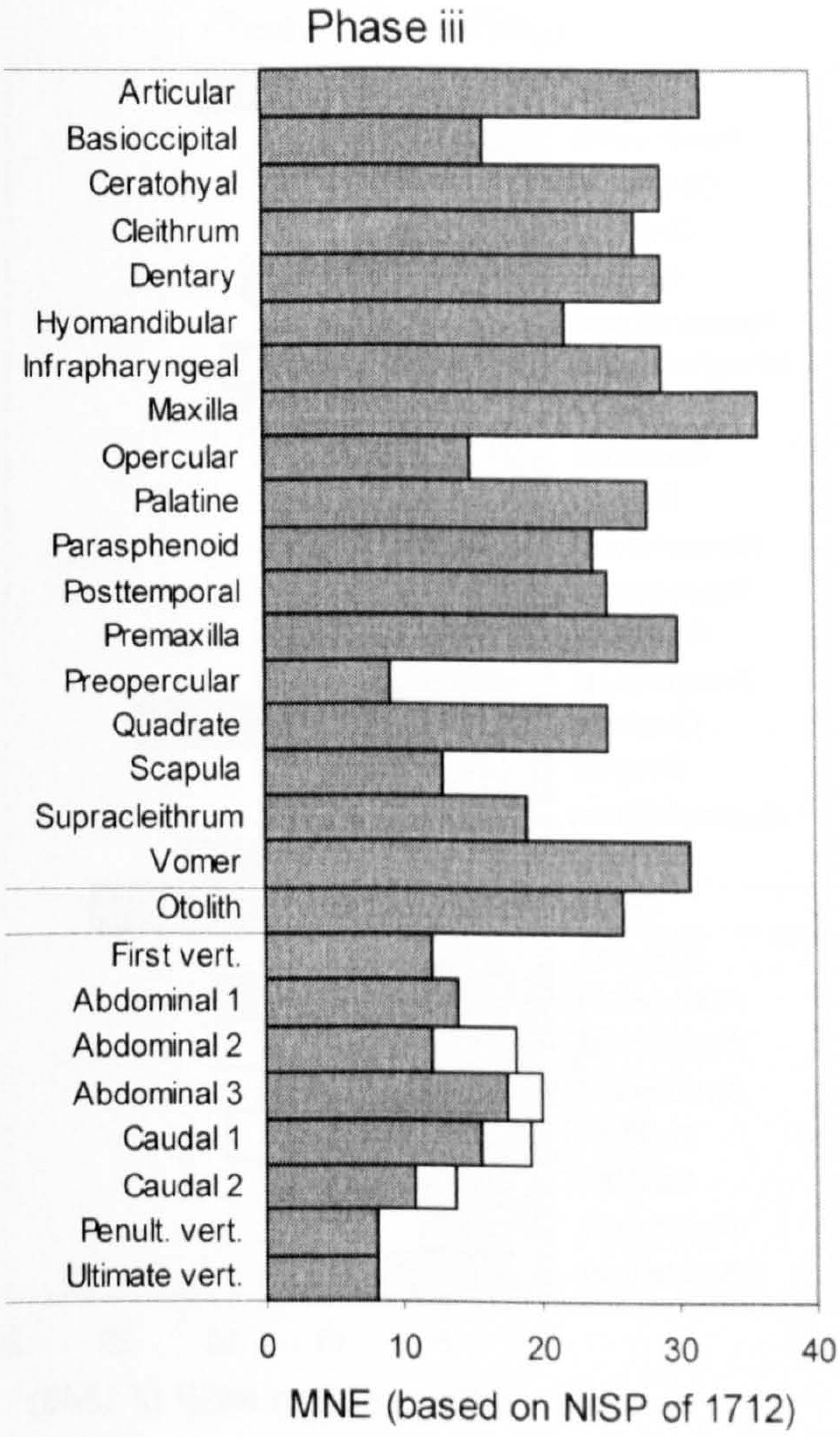
Figure 5.22: ***Gadus/pollachius*** **QC2 NISP by phase**


Phase i (matching only)
Articular
Basioccipital
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer
Otolith
First vert.
Abdominal 1
Abdominal 2
Abdominal 3
Caudal 1
Caudal 2
Penult. vert.
Ultimate vert.
0
0.5
1
1.5
2
2.5
MNE (based on NISP of 18)


Phase i (all)
Articular
Basioccipital
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer
Otolith
First vert.
Abdominal 1
Abdominal 2
Abdominal 3
Caudal 1
Caudal 2
Penult. vert.
Ultimate vert.
0
1
2
3
4
5
MNE (based on NISP of 36)


Phase ii (matching only)


Phase ii (all)


Phase iii
Articular
Basioccipital
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer
Otolith
First vert.
Abdominal 1
Abdominal 2
Abdominal 3
Caudal 1
Caudal 2
Penult. vert.
Ultimate vert.
0
10
20
30
40
MNE (based on NISP of 1712)

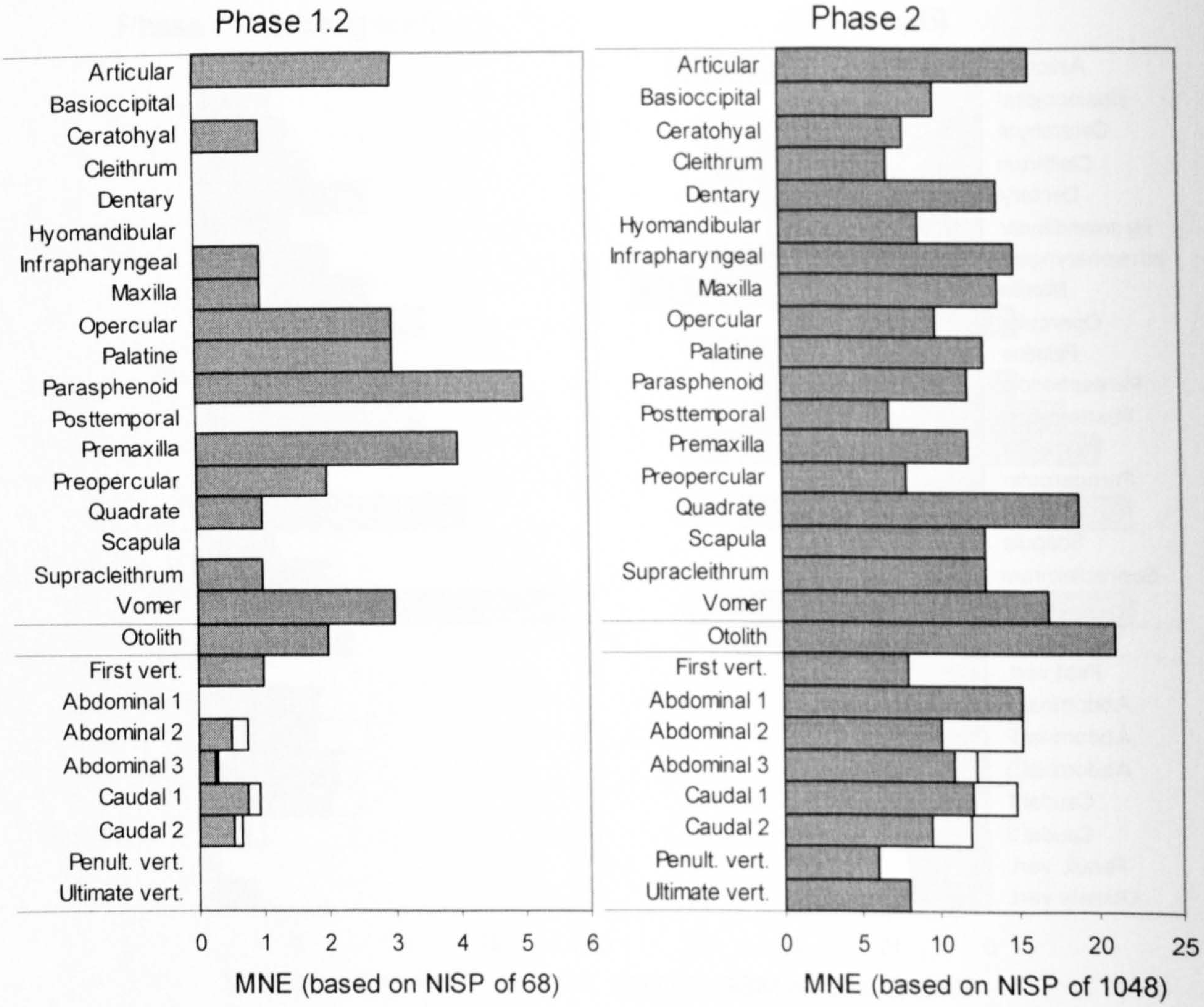
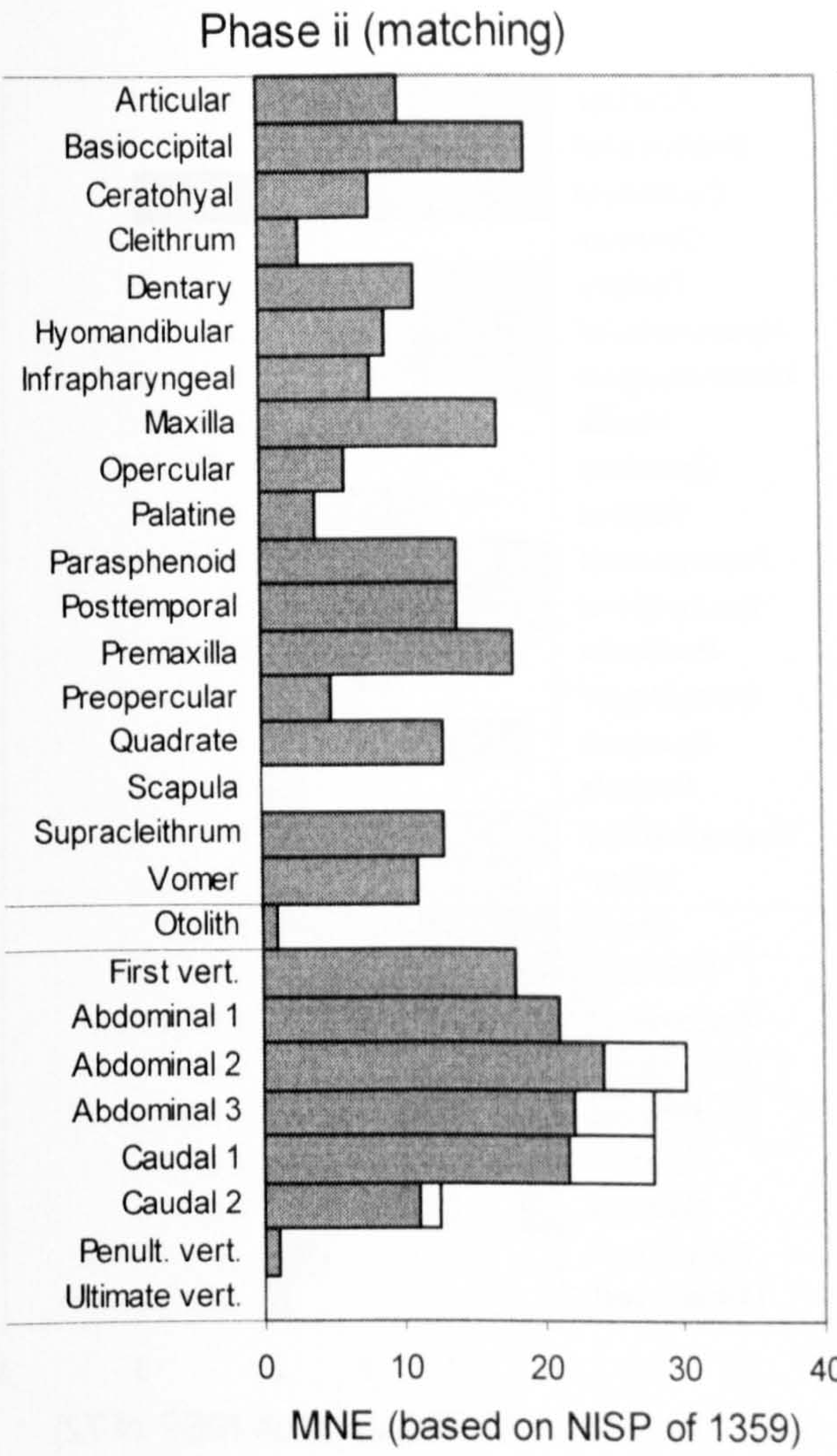
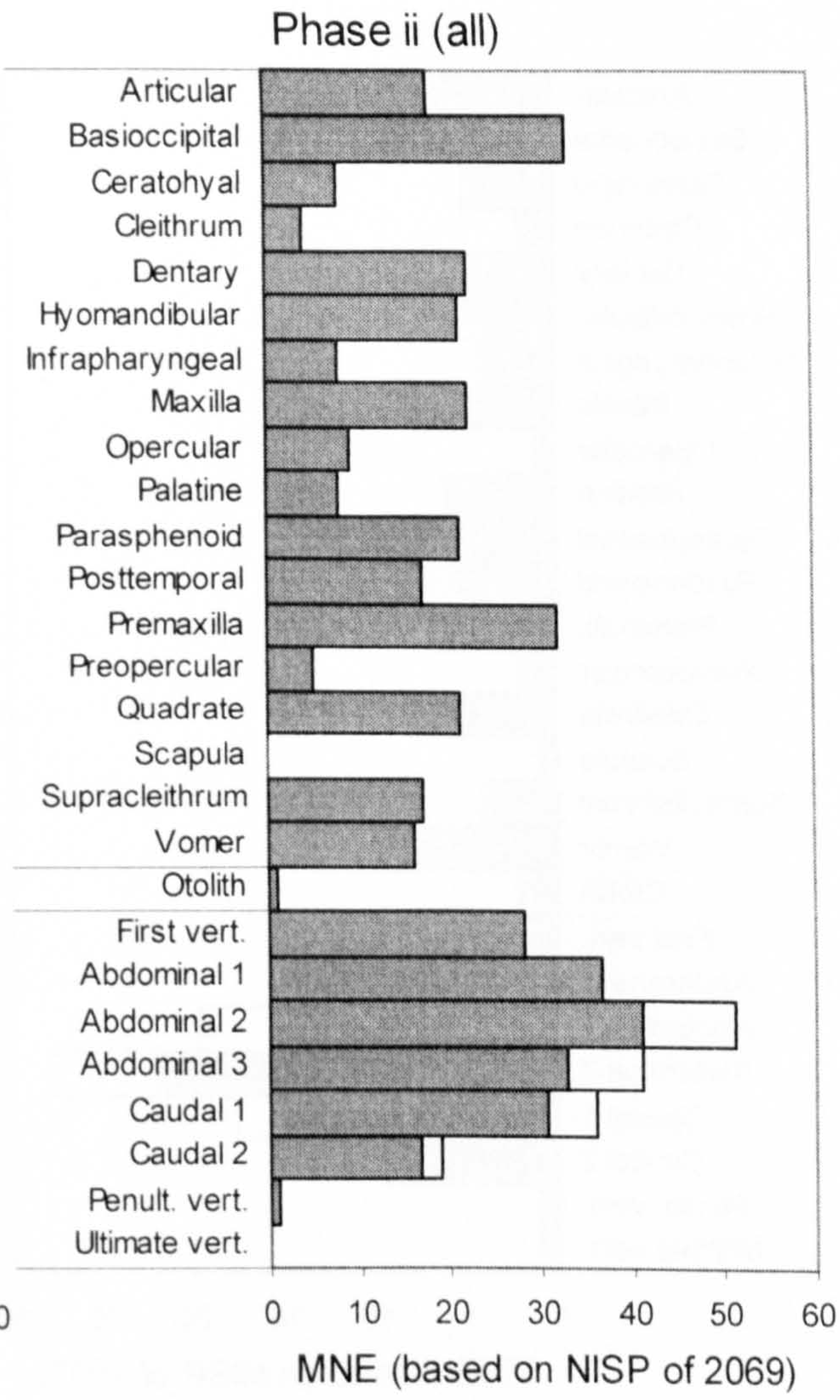
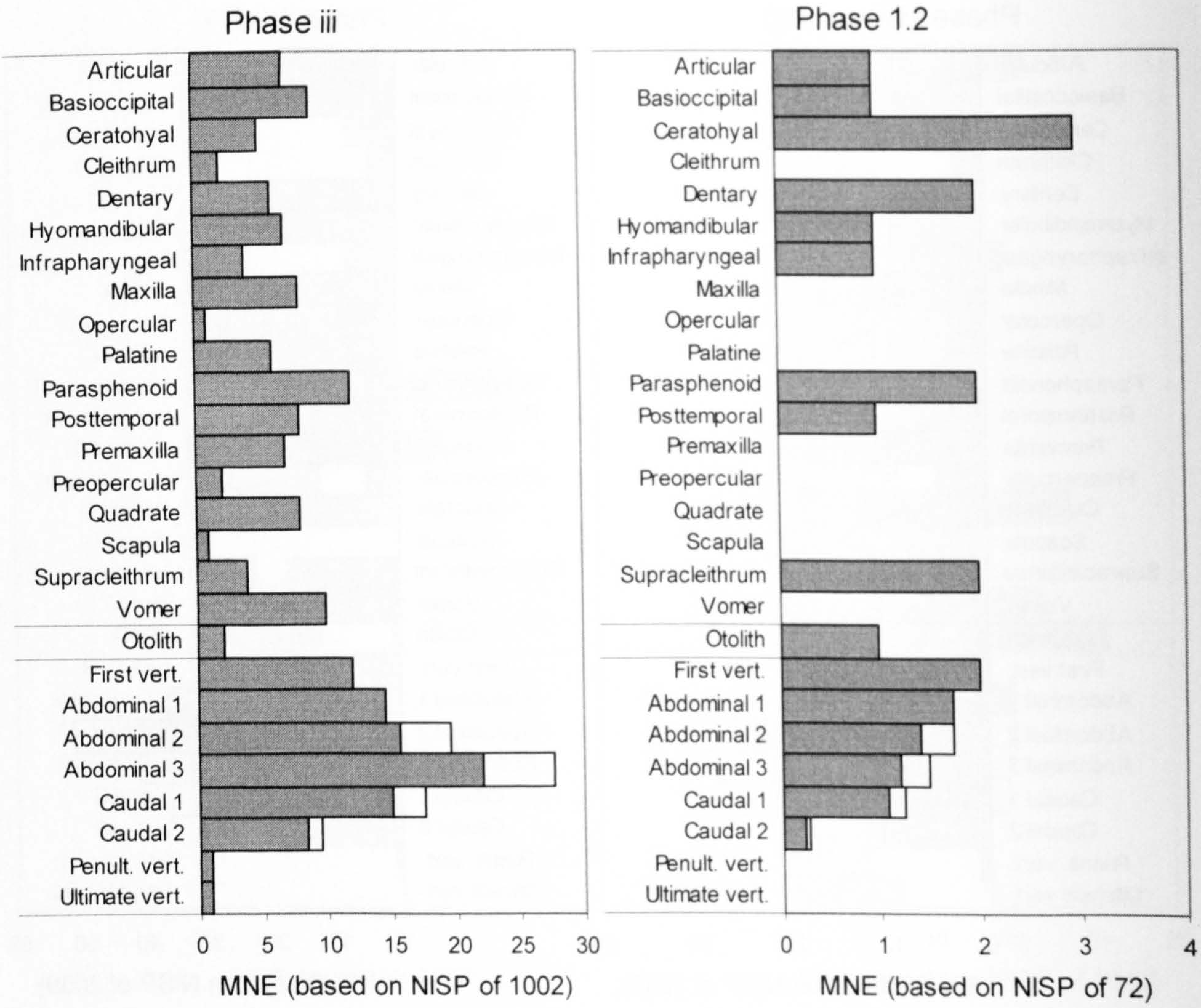


Figure 5.23: Cod MNE


Phase ii (matching)


Phase ii (all)


Phase iii
Phase 1.2
Articular
Basioccipital
Ceratohyal
Cleithrum
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Posttemporal
Premaxilla
Preopercular
Quadrate
Scapula
Supracleithrum
Vomer
Otolith
First vert.
Abdominal 1
Abdominal 2
Abdominal 3
Caudal 1
Caudal 2
Penult. vert.
Ultimate vert.
0
5
10
15
20
25
30
MNE (based on NISP of 1002)
0
1
2
3
4
MNE (based on NISP of 72)

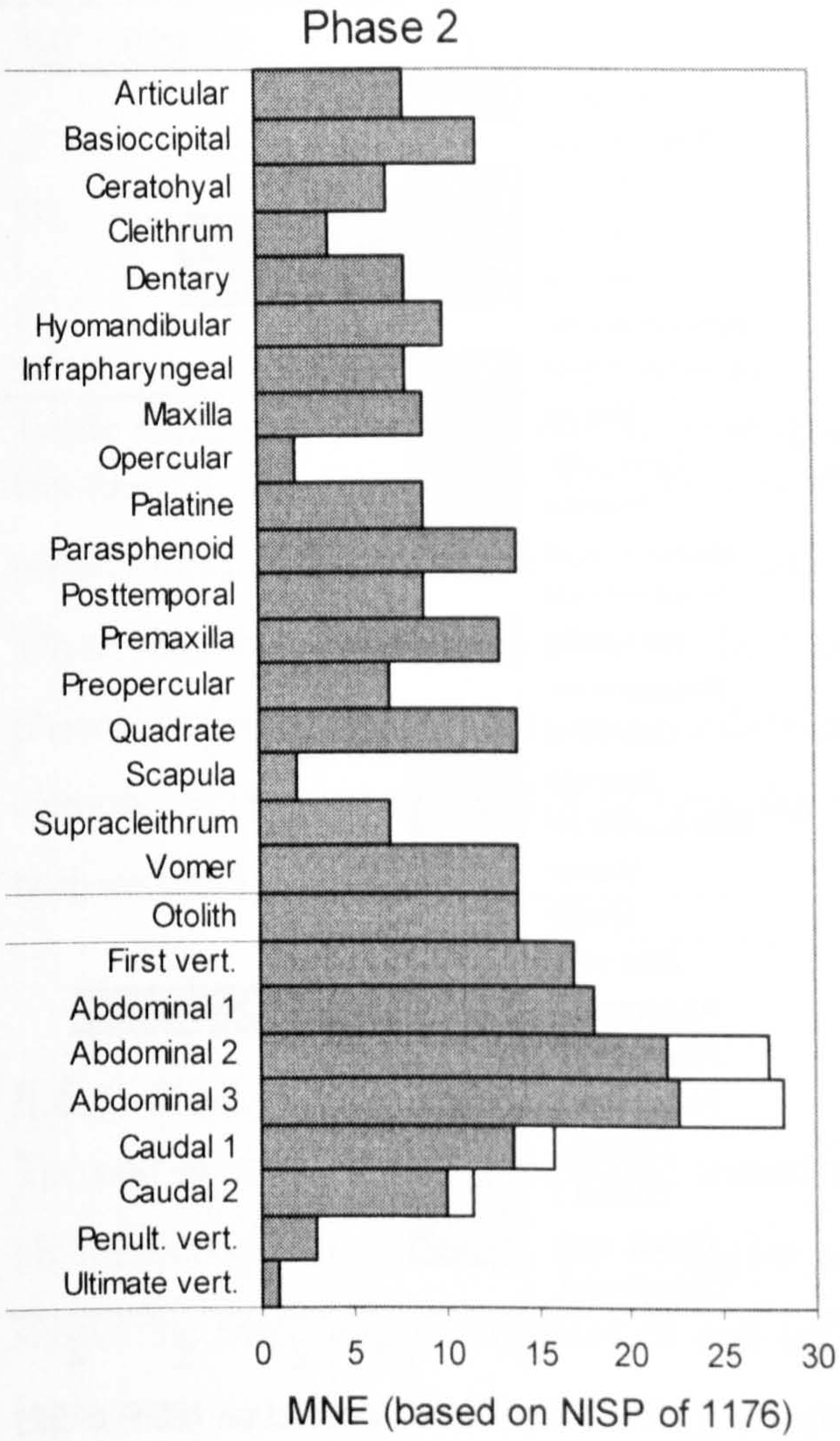


Figure 5.24: Saithe MNE

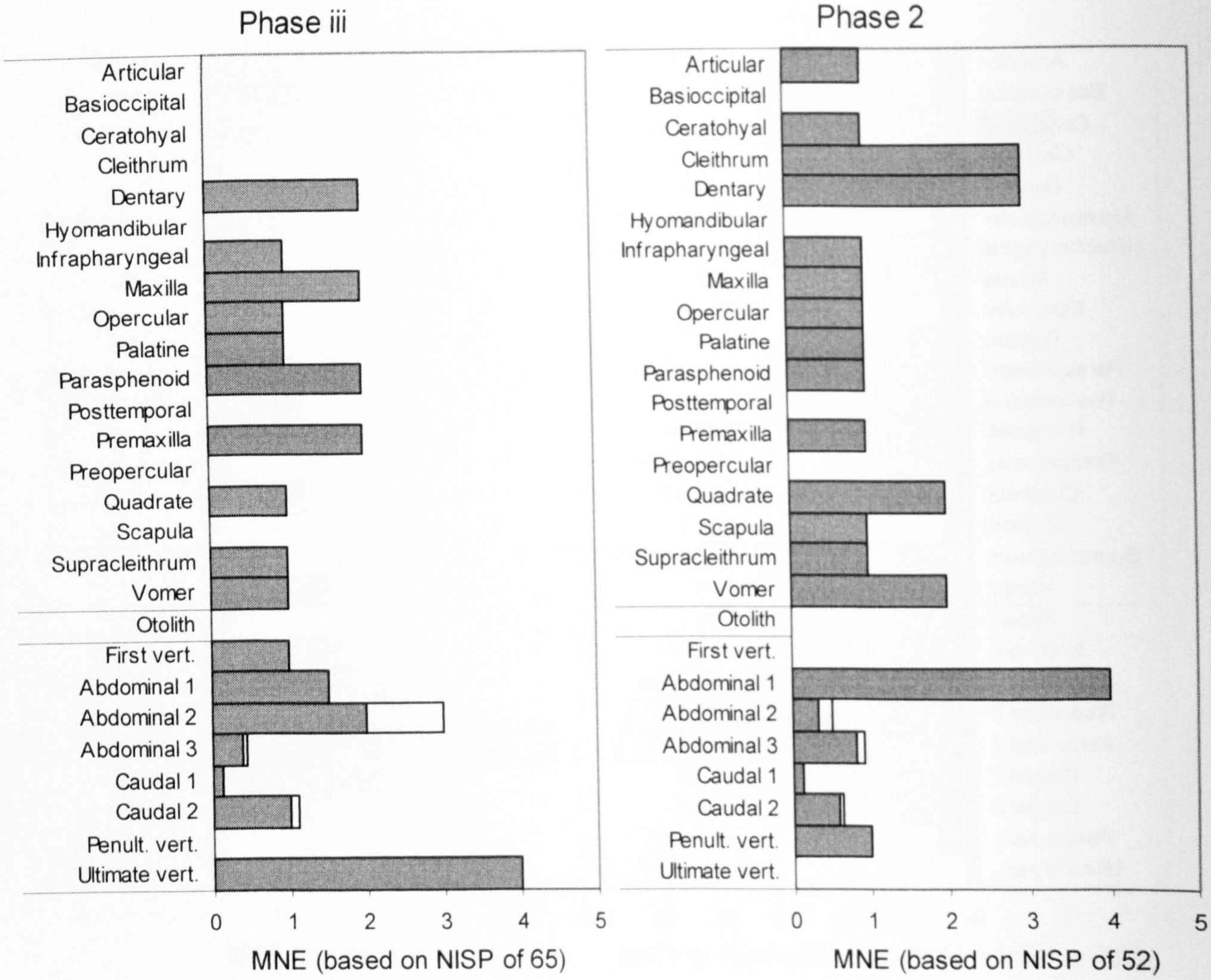


Figure 5.25: Ling MNE

5.5 Sizes and measurements

The importance of fish sizes to the interpretation of spatial and temporal patterning has been mentioned briefly above, when contrasting the element proportions of cod and saithe (see section 5.4). This section will present the full results of fish total length estimates from Quoygrew. Measurements were taken on a suite of elements, including the basioccipital, the quadrate, the dentary, the premaxilla and the otolith, all of which have regression equations to convert the measurements into a reasonably accurate total fish length (Jones 1991, Tab. 12; Watt *et al.* 1997). This is in addition to the ordinal size categories that were applied to all QC1 and QC4 elements during identification, which will also be investigated in detail.

The size categories used throughout this chapter, particularly as an abbreviation on tables and figures, were as follows:

Size category	Total lengths (mm)
t	<150
s	150-300
m	300-500
l	500-800
x	800-1000
xx	>1000

Table 5.22: Key to ordinal fish size categories used in tables and figures

Because of the excellent preservation in the later phases at Quoygrew, and the good preservation of the earlier phases, a considerable quantity of elements could be measured. There may be a slight decrease in the number of measurable elements in the earlier phases, because preservation was slightly poorer. The premaxilla was the most useful element, with large quantities of both the first and second measurements recorded for both cod and saithe.

5.5.1 Cod

The cod premaxilla first and second measurements were the most frequently occurring of all measurements, although the dentaries and otoliths also proved useful. Figure 5.26 shows the total length estimates of cod using the first premaxilla measurement and the regression equation of Jones (1991), combining all data from Quoygrew. These total lengths can be compared to Figure 5.27, which uses all ordinal size categories recorded for each QC1 and QC4 element. This combines the data from all phases without any separation by space or time. The ordinal size categories provide much coarser data than the total lengths determined by regression equations, but benefit from a much larger sample size. Over 1900 elements had sizes recorded, but only c. 80 premaxillae could be measured. The ordinal size category data indicate that most cod were in the region of 800-1000mm, with smaller quantities of both 500-800mm and >1000mm cod. Very few cod smaller than 500mm were recorded. The regression histogram indicates a primary mode around 1000mm, and a secondary one in the region of 600mm. Very few cod of <400mm or >1400mm were caught, with a sharp increase and decrease at either end of the size range. A paucity of cod around the 700-800mm total length was observed. Having ascertained the pattern for the site as a whole, spatial and temporal variation can now be examined.

Figure 5.28 illustrates the ordinal size patterns for each phase of the site, using data from all QC1 and QC4 elements. As usual, the matching >4mm and 2-4mm dataset is shown in light grey, and the unmatched >4mm in dark grey. Phases i and ii have more of an emphasis on 500-800mm fish, and lower proportions of larger fish. Phases iii and 1.2 include almost entirely 800-1000mm fish. Phase 2 also has many 800-1000mm fish, but smaller fish in the range of 300-800mm are also prevalent despite the fact that these phase groups are broadly contemporary. Phases i and 1.2 both have small sample sizes, and will thus not be considered further here.

Figure 5.29, Figure 5.30 and Figure 5.31 present the total length estimates based on the premaxilla, dentary and otolith regression formulae (Jones 1991). Phases i and 1.2 contained insufficient measurements to plot. Phase ii consistently indicated bimodality across all elements, with one large mode around 600-700mm and a smaller mode of 900-1000mm. Phase iii was again bimodal, with a smaller mode around 500-600mm (or 600-750mm based on the dentaries) and a larger one around 1000mm. Phase 2 was also bimodal. The first mode was between 500 and 600mm, and the second mode was between 900mm and 1000mm (although this was less pronounced using the dentary measurements).

A Kruskal-Wallis test on the ordinal size estimates for cod by phase indicated significant differences were present (for all data, Chi-Square value 23.852, four degrees of freedom, significance 0.000). These were further investigated by applying Kolmogorov-Smirnov tests to each pair of phases. Two significant differences were observed between pairs of phases: phase ii and phase iii (for matching 2-4mm and >4mm dataset, though significant for all data as well: greatest difference 0.155, Kolmogorov-Smirnov Z value 2.423, significance 0.000) and phase 2 and phase iii (0.137, 2.384, 0.000). Phase ii had significantly more 500-800mm length cod than phase iii. Phase iii in turn had significantly fewer 300-500mm length fish than phase 2.

In conclusion, bimodal distributions were observed throughout phases ii, iii and 2. Cod of 500-700mm total length estimates formed one mode, and cod of about 1000mm formed another mode. In phase ii the smaller, younger fish tended to be found in greater quantities than the larger mode. In contrast, in the later phases iii and 2 the two modes tend to be found in equal quantities, suggesting an increasing importance of the larger fish through time.

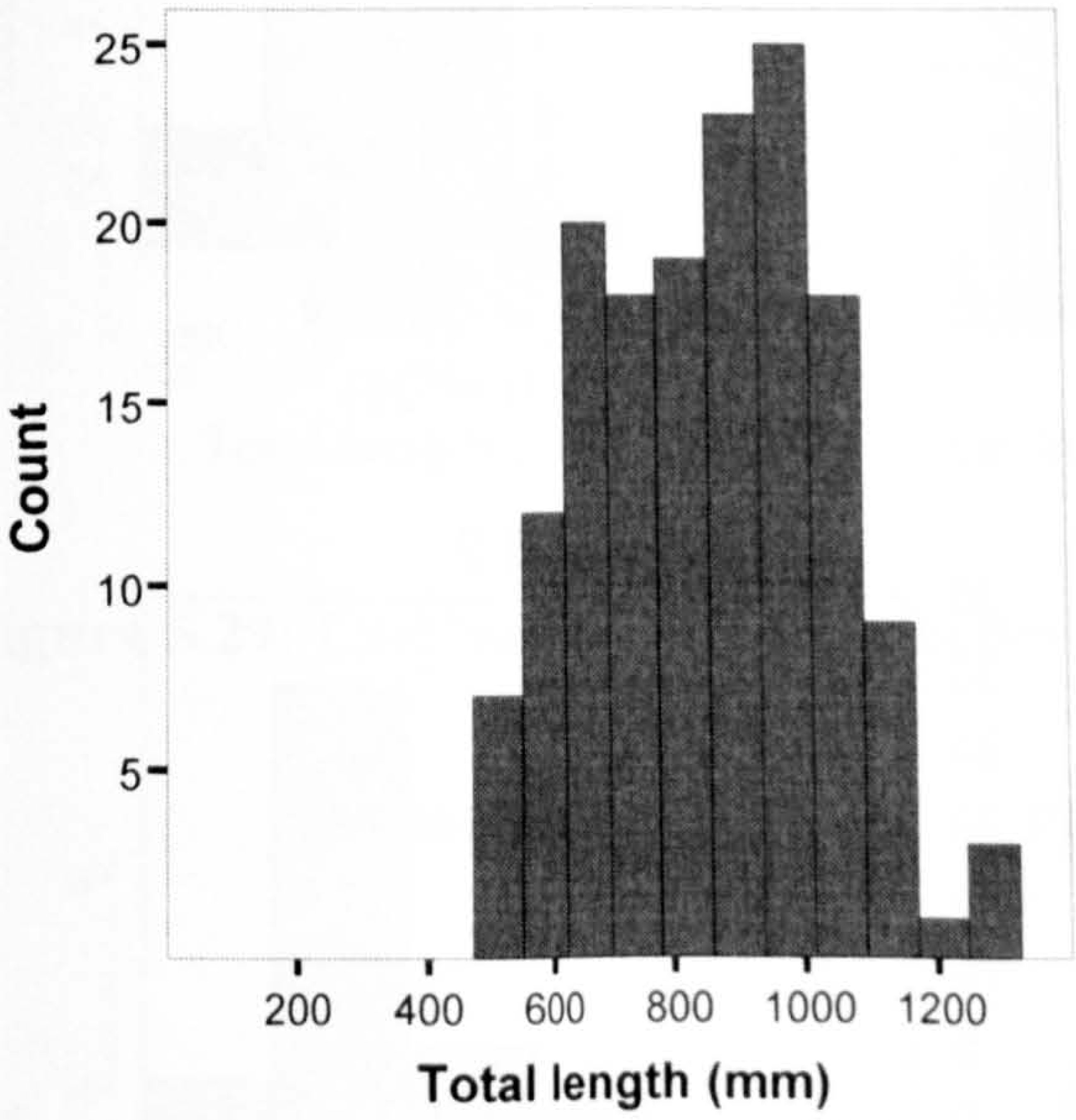


Figure 5.26: Cod total lengths determined by using the first premaxilla measurement, n=81, all data

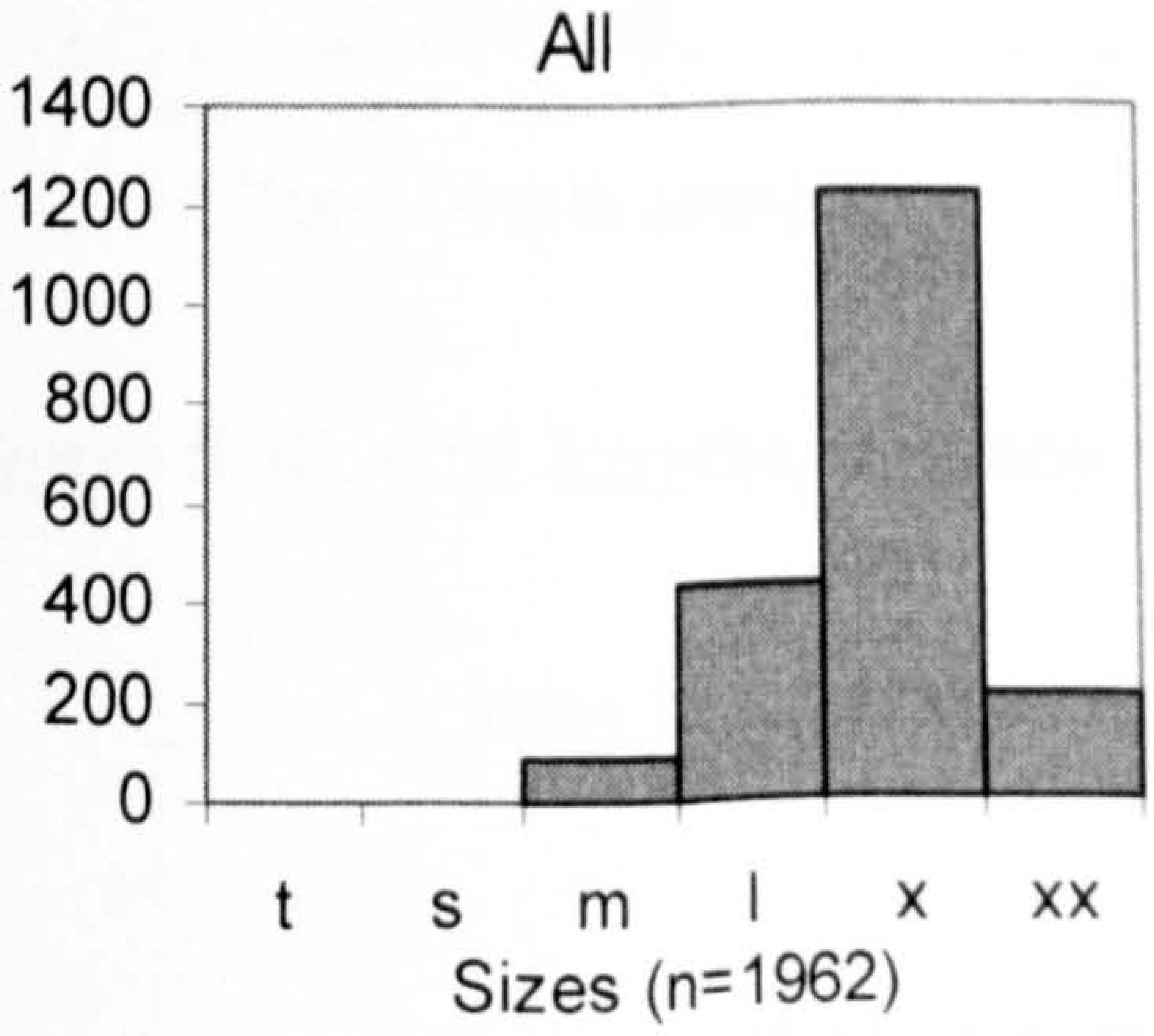


Figure 5.27: Cod sizes, all QC1 and QC4 elements, all data

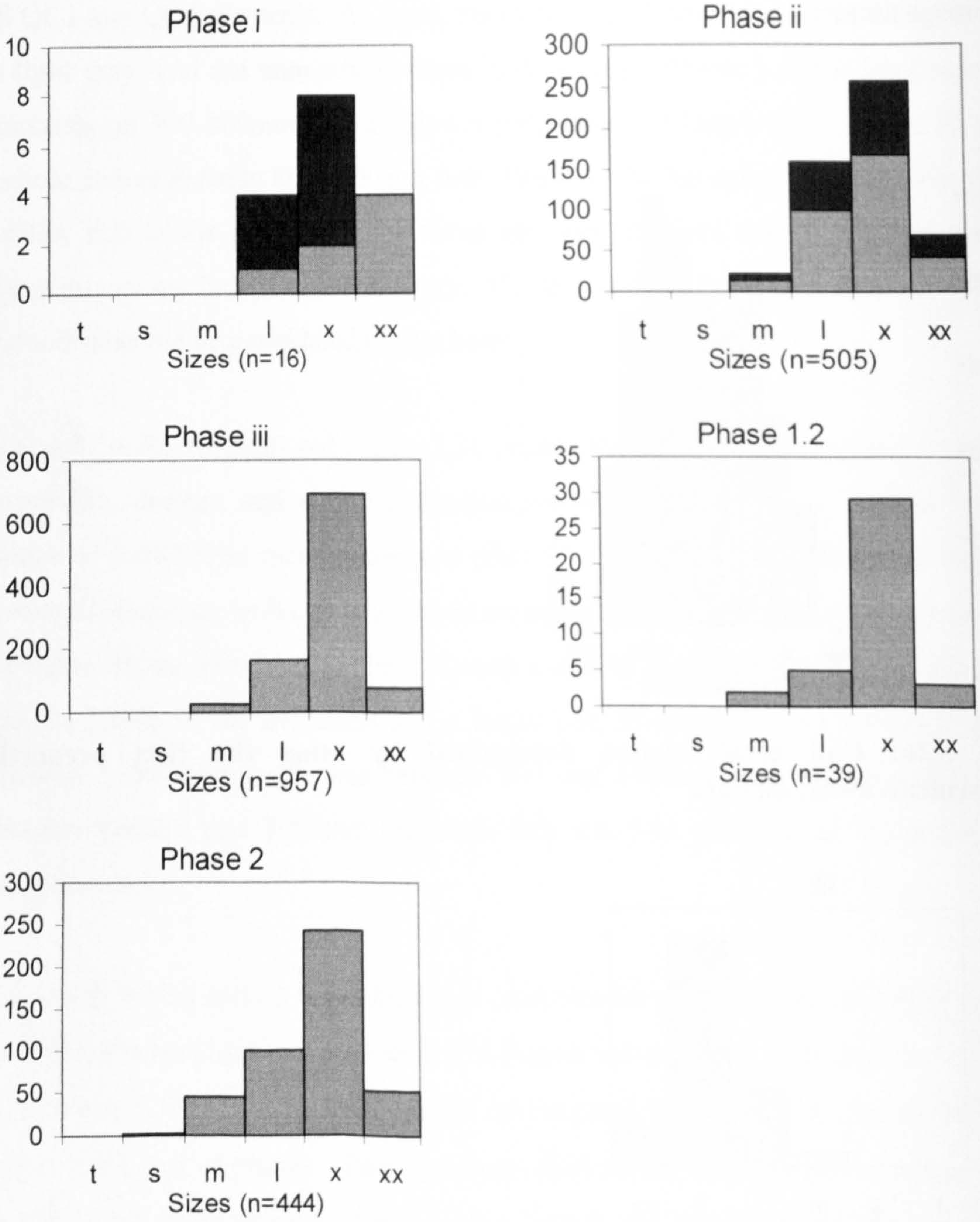


Figure 5.28: Cod QC1 and QC4 fish sizes (darker grey indicates results from coarse >4mm samples without matching 2-4mm fraction)

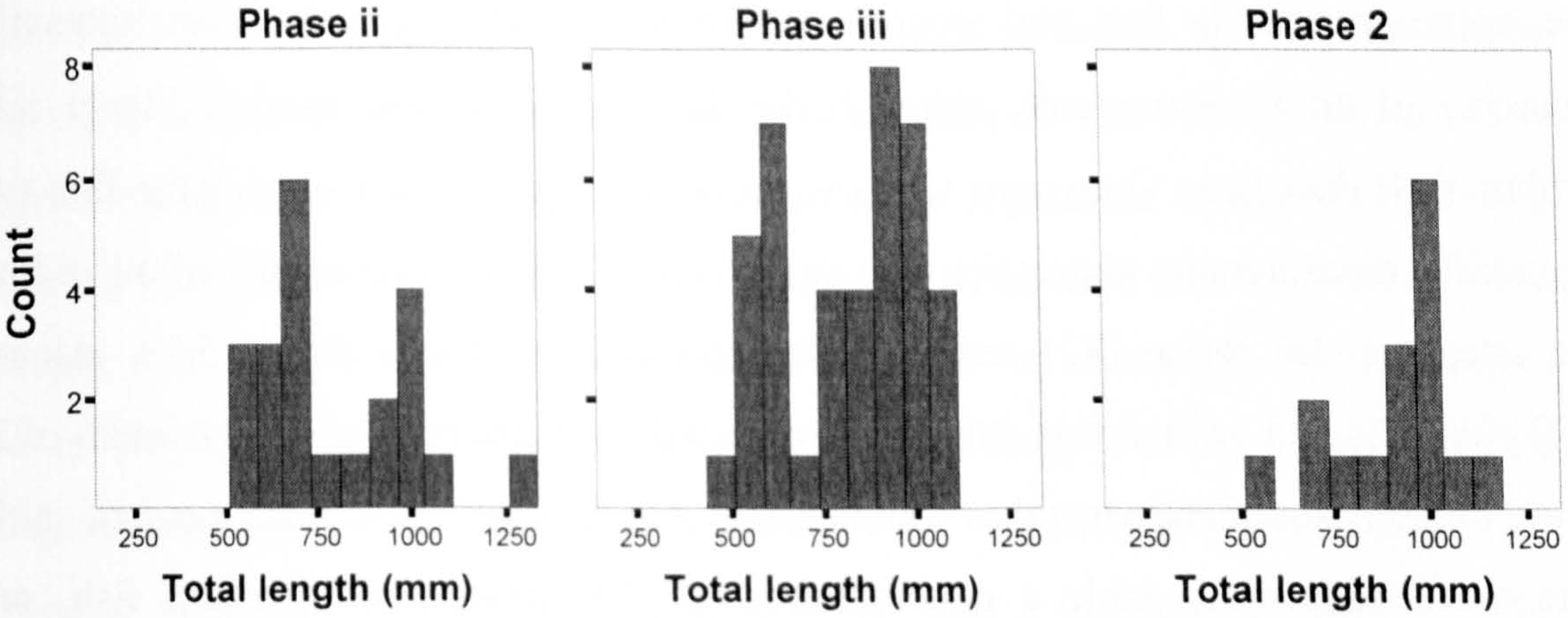


Figure 5.29: Cod lengths, premaxilla first measurement (all data)

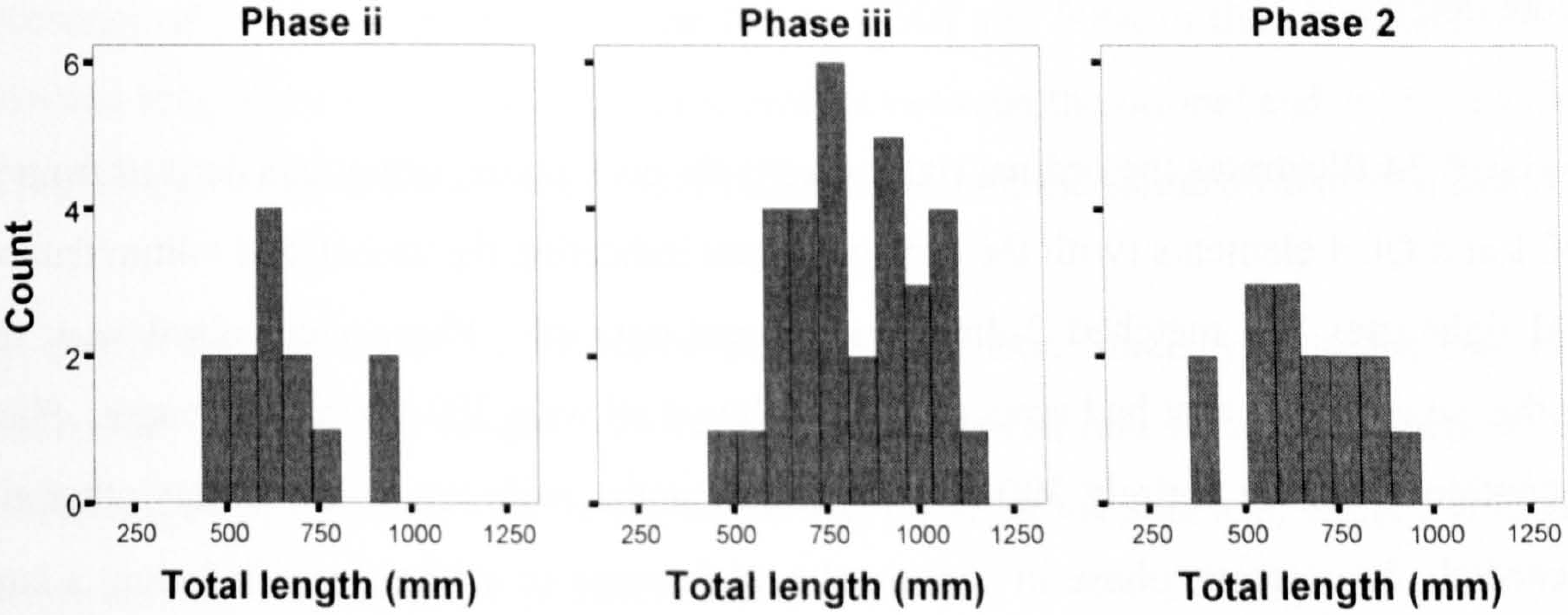


Figure 5.30: Cod lengths, dentary second measurements (all data)

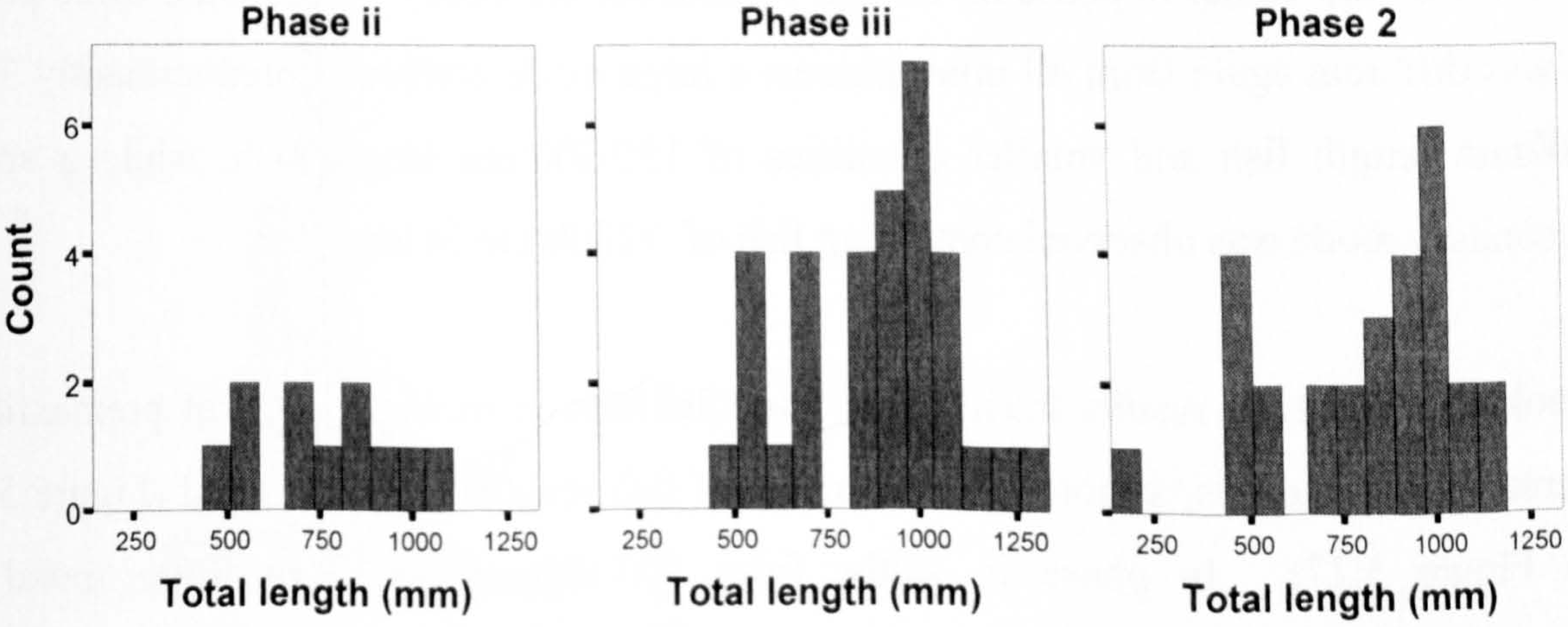


Figure 5.31: Cod lengths, otolith second measurements (all data)

5.5.2 Saithe

The saithe premaxilla first and second measurements were again the most frequently occurring of all measurements, although the dentaries were also useful. Figure 5.32 combines all data from Quoygrew to show the total lengths of saithe using the first two premaxilla measurement regression equations (Jones 1991). The results of all ordinal size categories for saithe QC1 and QC4 elements is contrasted in Figure 5.33. Almost 1000 elements had ordinal size categories recorded for them, but only a maximum of 74 of any one measurement was taken. The ordinal size data indicate a wide range of saithe sizes were recovered, with a concentration of 300-500mm total length fish, and moderate quantities of 150-300mm length fish. The results of the regression equations corroborate to this pattern. Variation between phases and areas can now be examined in more detail.

Figure 5.34 illustrates the ordinal size patterns for each phase, using data derived from all QC1 and QC4 elements (with the dark grey bars indicating the unmatched >4mm dataset, and light grey the matched 2-4mm and >4mm dataset). Phase i contained very few saithe, so of the 11 that had sizes recorded, almost all were 300-500mm in length. Phase ii contained almost entirely 300-500mm length saithe, with few saithe of any other size recorded. In contrast, phase iii contained a wide range of saithe sizes, including a large mode containing considerable quantities of 150-300mm and slightly smaller quantities of 300-500mm length, and a secondary small mode in the 800-1000mm size category. Phase 1.2 was similar to phase iii, though without the secondary small mode, while phase 2 was different again from all other phases: a large mode contained predominantly 300-500mm length fish and smaller quantities of 150-300mm length fish, while a small secondary mode was observed containing fish of >1000mm in length.

Looking now at the results from regression equations on measurements of premaxillae, dentaries and otoliths, a more detailed image of fish lengths can be formed (Figure 5.35 to Figure 5.37). In phase ii, saithe from 300-600mm in length were found in considerable quantities, with a mode between 300 and 450mm. Phase iii has a mode between 150 and 350mm in length, with one large outlier. Phase 2 contained greater quantities of measurable saithe, producing a mode at 250-350mm and a few larger outliers.

The regression results from phase iii differ slightly from the ordinal size pattern described above and illustrated in Figure 5.34: there, saithe of 300-500mm length were found in considerable quantities, second only to saithe of 150-300mm length. However, saithe of 300-500mm length do not appear in the regression histograms for phase iii. During the identification process, many saithe were recorded that were about 300mm in length, and could therefore be classed as either 'small' or 'medium'. Although the author made the best size estimates possible during recording, it is now clear that the vast majority of these saithe should have been in the 'small' category, between 150 and 300mm in length. To a lesser degree this was also a problem in phase 2, where the regression data indicate a primary mode between 250 and 350mm, thus straddling the 'small' and 'medium' ordinal size categories. Given that the regression data indicate the presence of greater quantities of saithe between 300 and 500mm than between 150 and 300mm long, there is not that much of a conflict between the ordinal and regression data. These biases make it unwise to conduct statistical test on the saithe ordinal size data.

In conclusion, almost all of the saithe at Quoygrew were small, young fish that rarely exceeded 450mm total length. There was some spatial and temporal variation, with phase ii tending to contain the larger saithe and phase iii the smallest, while a few much larger outliers were found in phases iii and 2.

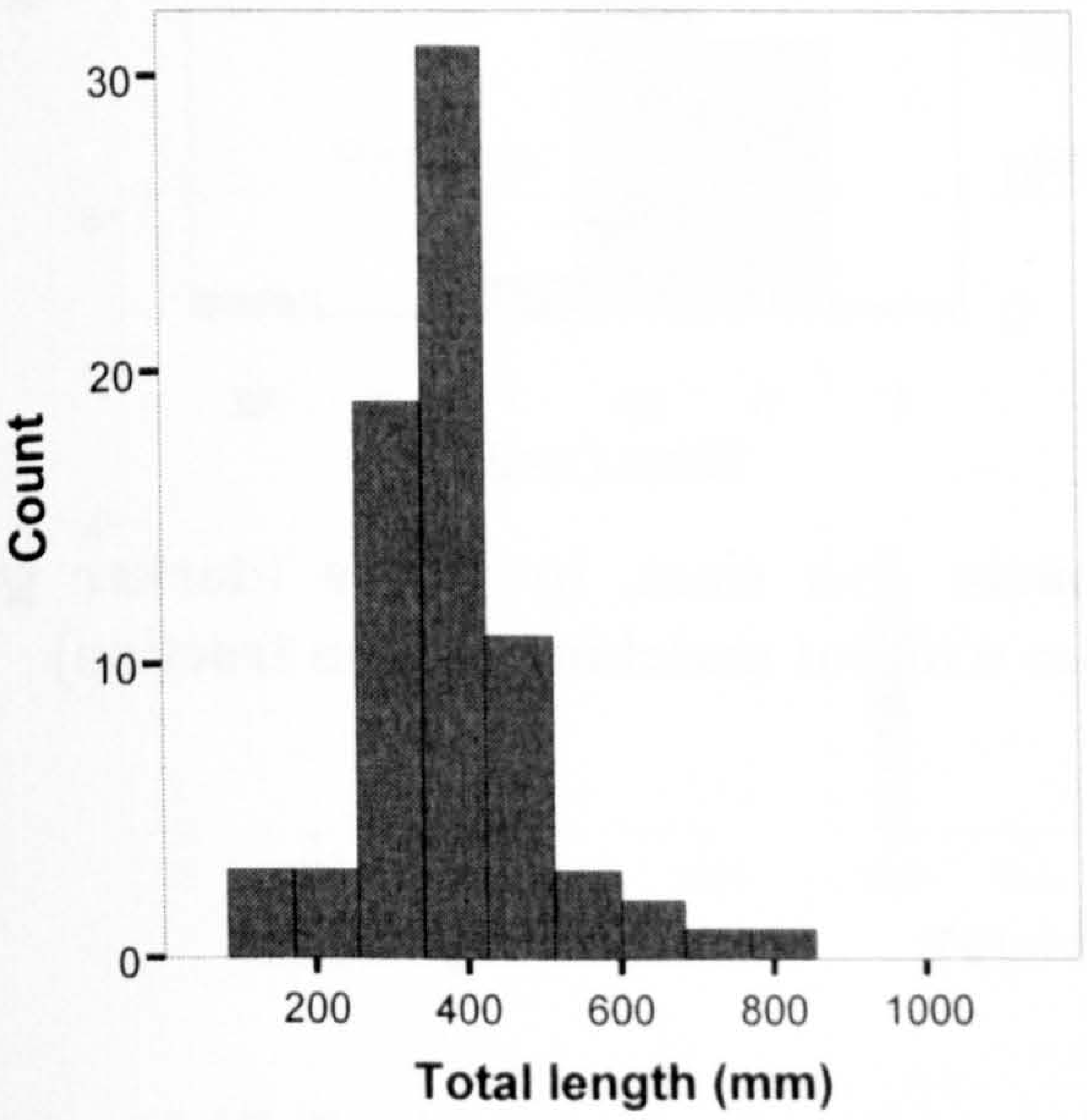


Figure 5.32: Saithe total lengths determined by using the second premaxilla measurement, n=74, all data

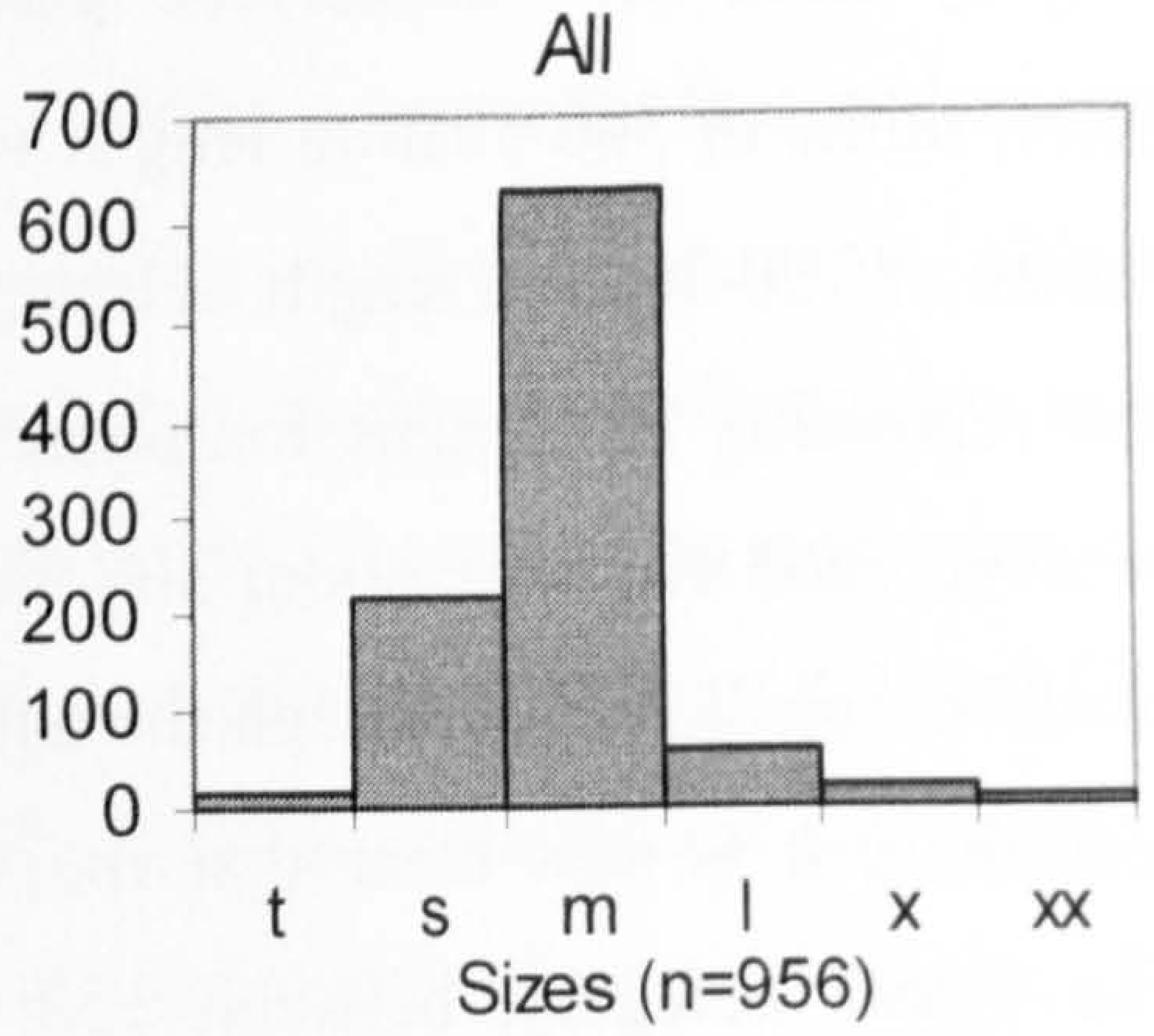


Figure 5.33: Saithe QC1 and QC4 element sizes, all data

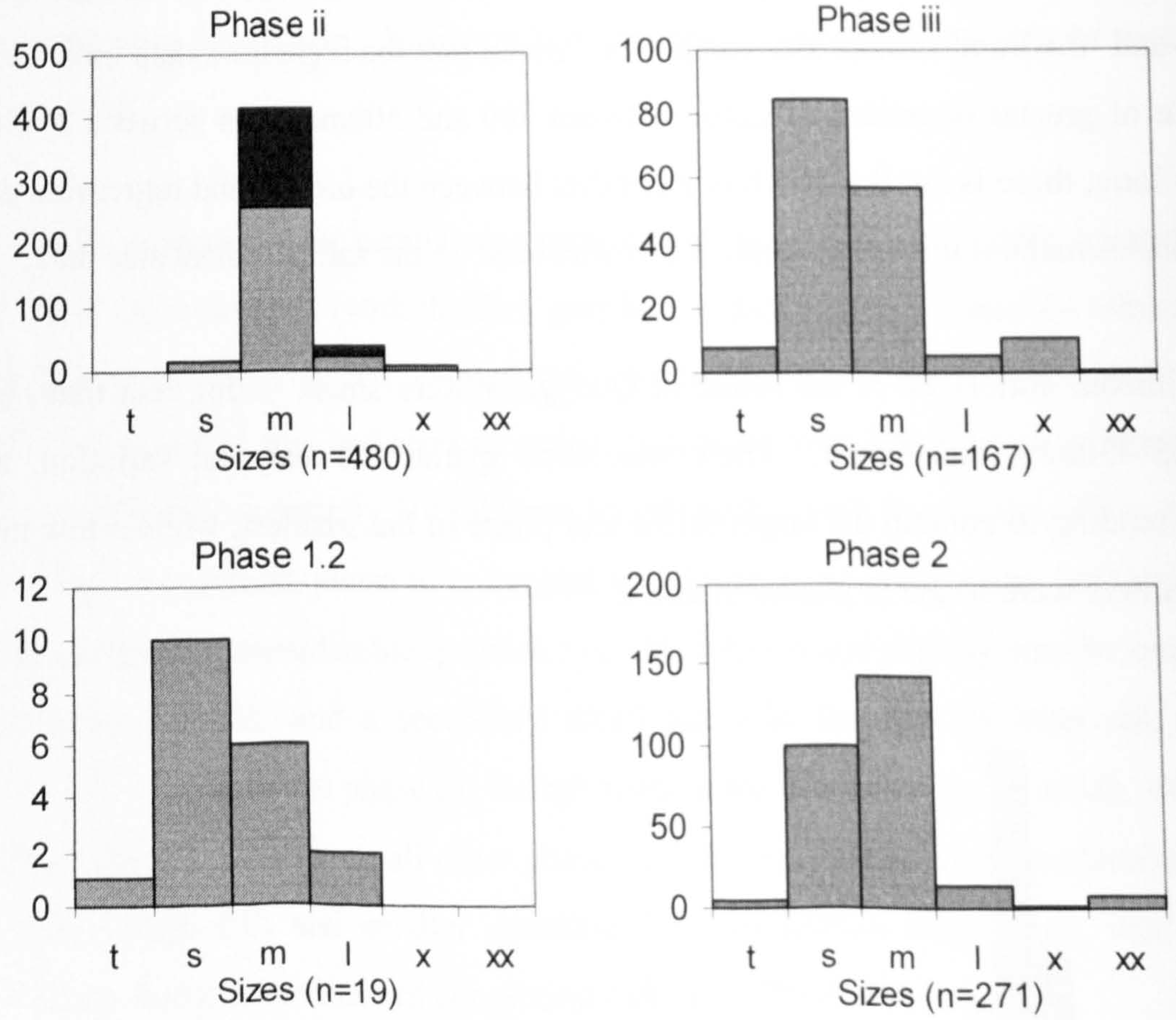


Figure 5.34: Saithe QC1 and QC4 element fish sizes, by phase (darker grey indicates results from coarse >4mm samples without matching 2-4mm fraction)

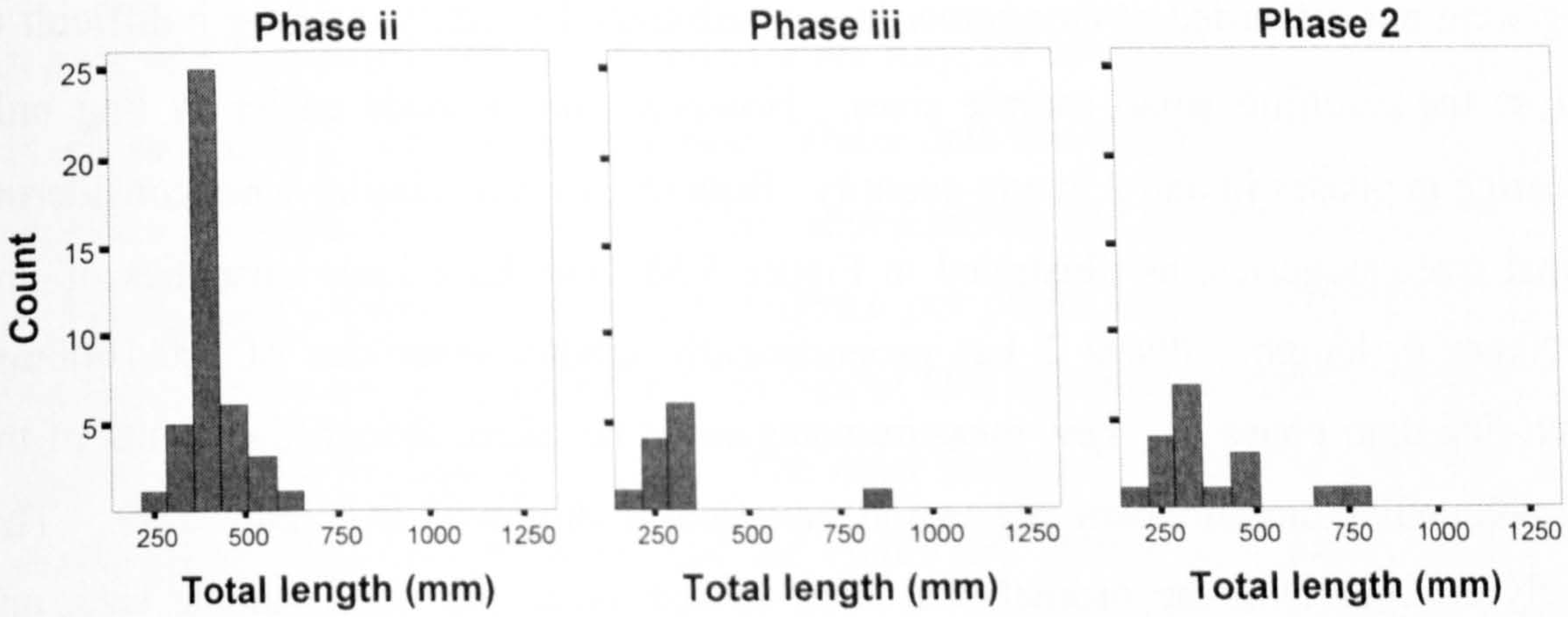


Figure 5.35: Saithe lengths, premaxilla second measurements (all data)

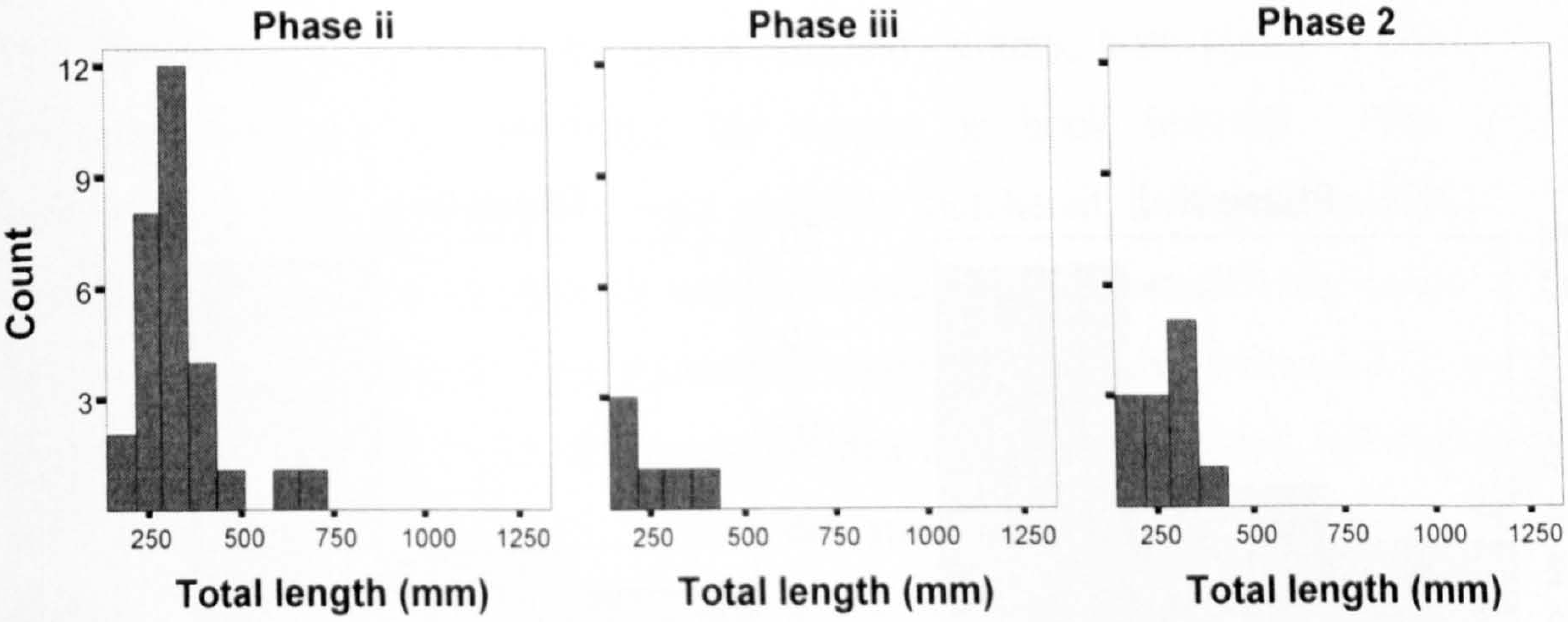


Figure 5.36: Saithe lengths, dentary second measurements (all data)

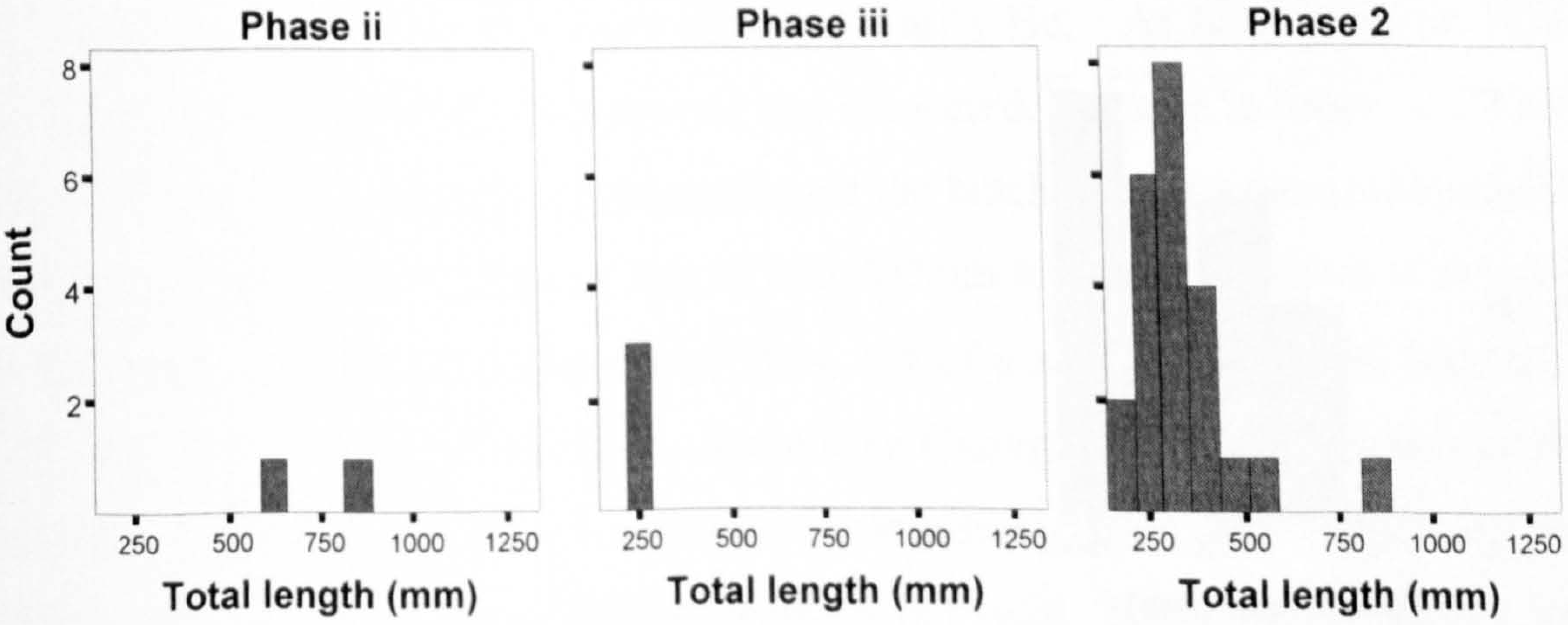


Figure 5.37: Saithe lengths, based on otolith second measurements

5.5.3 Ling

Ling were not discarded at Quoygrew in any substantial quantity, making it difficult to analyse the resulting small sample sizes. However, this is made easier by ling only appearing in phases iii and 2 in any quantity. Both phases were similar when considering ordinal size categories, as illustrated in Figure 5.38: both have large quantities of ling >1000mm in length. Phase 2 has proportionally smaller quantities of 500-1000mm length ling than phase iii. Few measurements could be taken, though the results of the first premaxilla measurement regression equation is displayed in Figure 5.39. This broadly concurs with the ordinal size data, though given the small sample size, any interpretation is difficult. No statistical differences were found between any of the ling ordinal size categories.

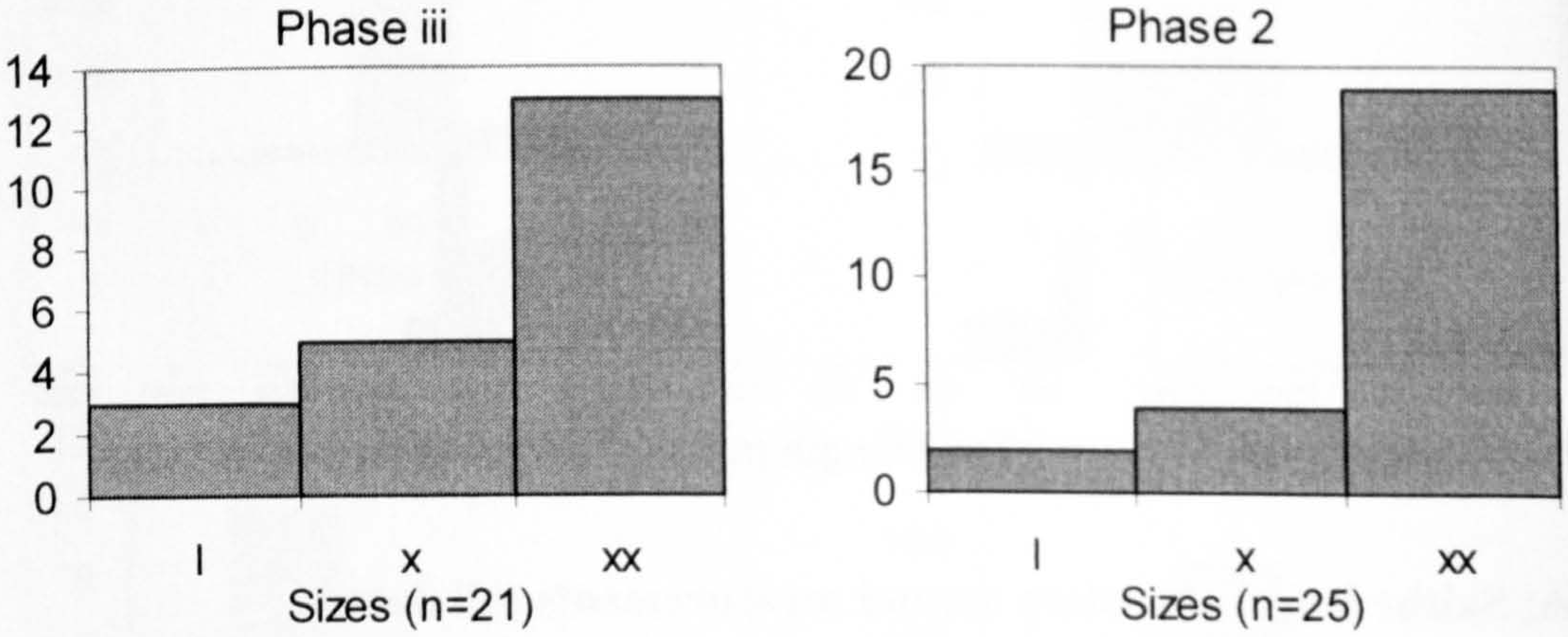


Figure 5.38: Ling QC1 and QC4 element fish sizes by phase

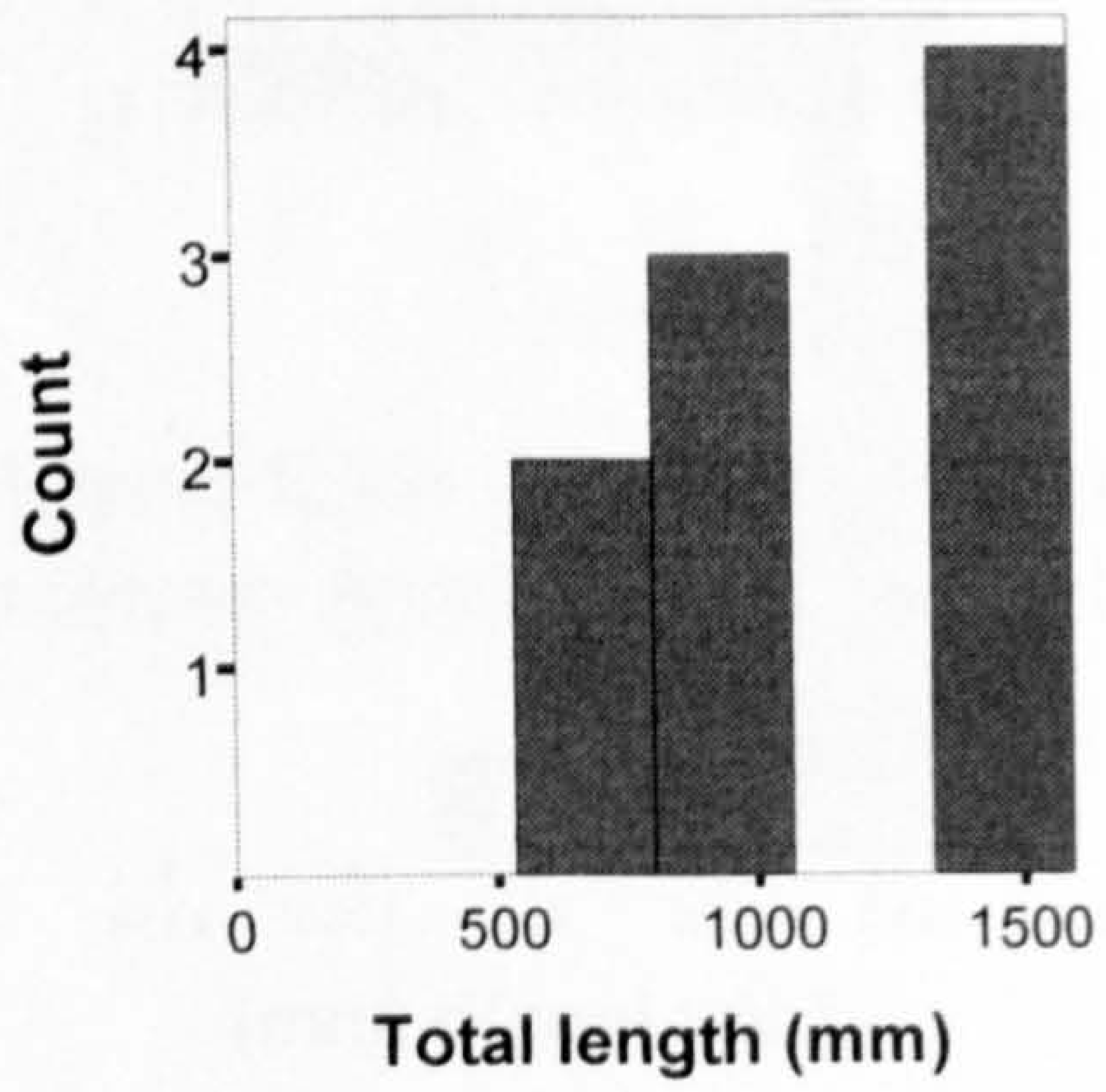


Figure 5.39: Ling lengths determined by using the first premaxilla measurement, n=9, all data

5.6 Butchery

A total of 32 elements were butchered in some way, 29 of which were cod, with one each of saithe and ling, and one unidentified. These data are summarised in Table 5.23, and all butchery marks for vertebrae, cleithra, supracleithra and posttemporals are illustrated in Figure 5.40, overlaid to show all evidence per phase on each element image. The butchered cod were predominantly from fish of 800-1000mm in length, with some from slightly larger or smaller individuals. The most frequently butchered elements were the posttemporal, the supracleithrum and the cleithrum. Phase ii contained slightly more butchery evidence than phase iii, and phase 2 contained less than either of the other major phases. No butchery evidence was found in the minor phases.

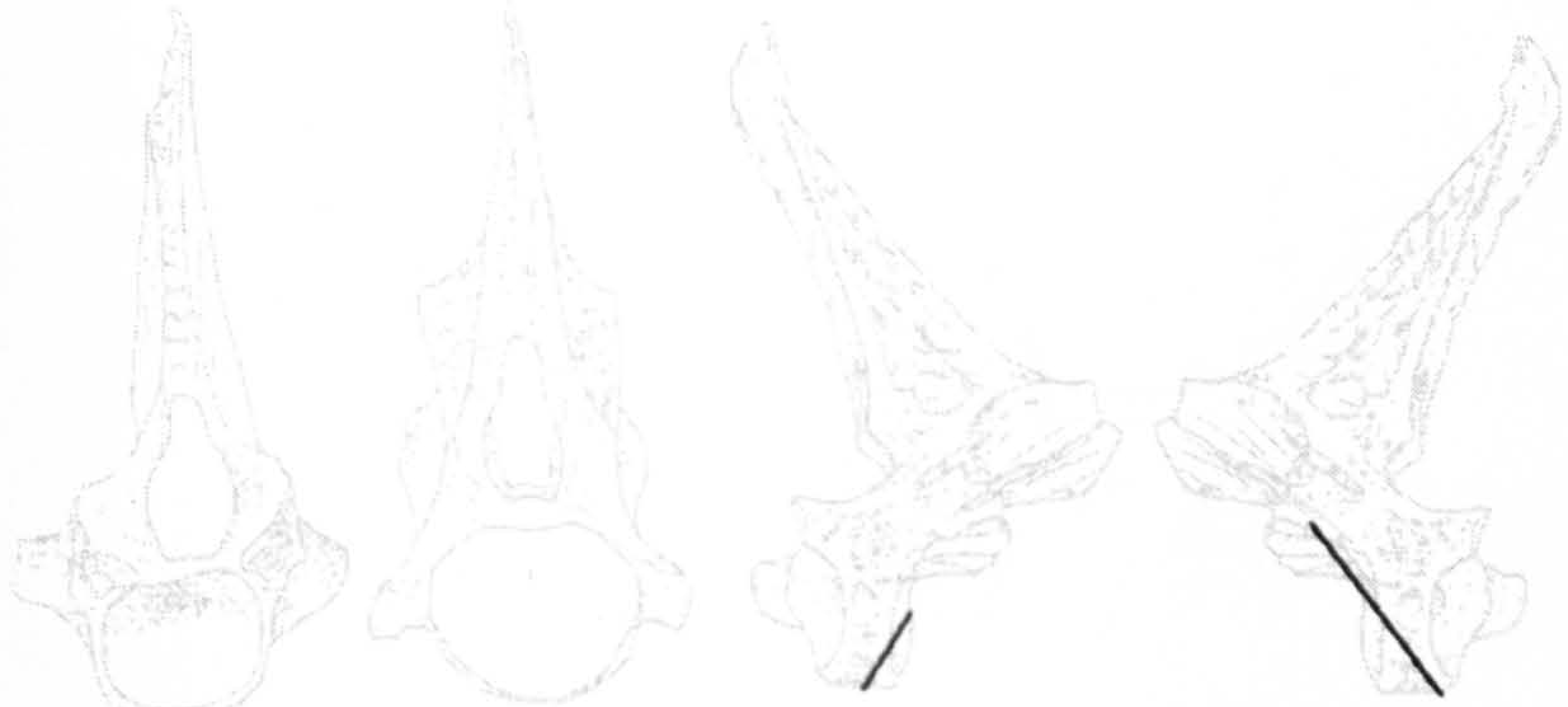
The cod butchery marks on the premaxilla and dentary, both found in phase ii, are probably indicative of processing for tongue or hook removal. The cleithra, posttemporals and supracleithra were probably butchered during decapitation. One unusual cod cleithra from phase iii was butchered both with small knife marks towards the dorsal anterior edge (as was commonly recorded), and also butchered by chopping towards the ventral tip. This effectively divided the cleithra into two, but both portions were found and are sketched in Figure 5.40 and illustrated in Figure 5.41. This was chopped and probably twisted to separate the parts of the bone when it was fresh, possibly as part of the decapitation process. Large quantities of butchered ventral cod cleithra tips were found at Knowe of Skea, on Westray, and a small number of butchered ventral haddock cleithra tips were found at Earl's Bu. At both of those sites, the matching butchered dorsal cleithra were not recovered, but here at Quoygrew, not only were both pieces recovered, but they indicated the butchering process occurred when the fish was freshly killed. This cod was of 500-800mm total length, which is substantially smaller than most found at Knowe of Skea, but of a similar size to the haddock from Earl's Bu. The absence of further evidence from Quoygrew suggests this was an isolated occurrence, possibly caused by a mistake during decapitation, and further comparisons with isolated ventral cleithra finds are probably not valid. However, any further work on this distinctive butchery pattern in the North Atlantic – outside of the scope of this thesis – should at least consider this one specimen from Quoygrew.

One cod caudal vertebra, group 1 from phase 2 was butchered in the transverse plane, and thus provides evidence of processing to sever the vertebral column, probably to remove and discard the anterior vertebrae from the fish during processing for drying (Barrett 1997, 628). This is consistent with proportions of cranial and vertebral elements found at Quoygrew, suggesting that fish processing for trade only occurred in phase 2 of the fish midden, and not in the farm mound. Other cod vertebrae show butchery evidence indicative of decapitation, found on the first vertebra and abdominal vertebrae group 1, and either decapitation or gutting, found on abdominal vertebrae group 2. These few butchery marks recorded were all from phases ii or iii.

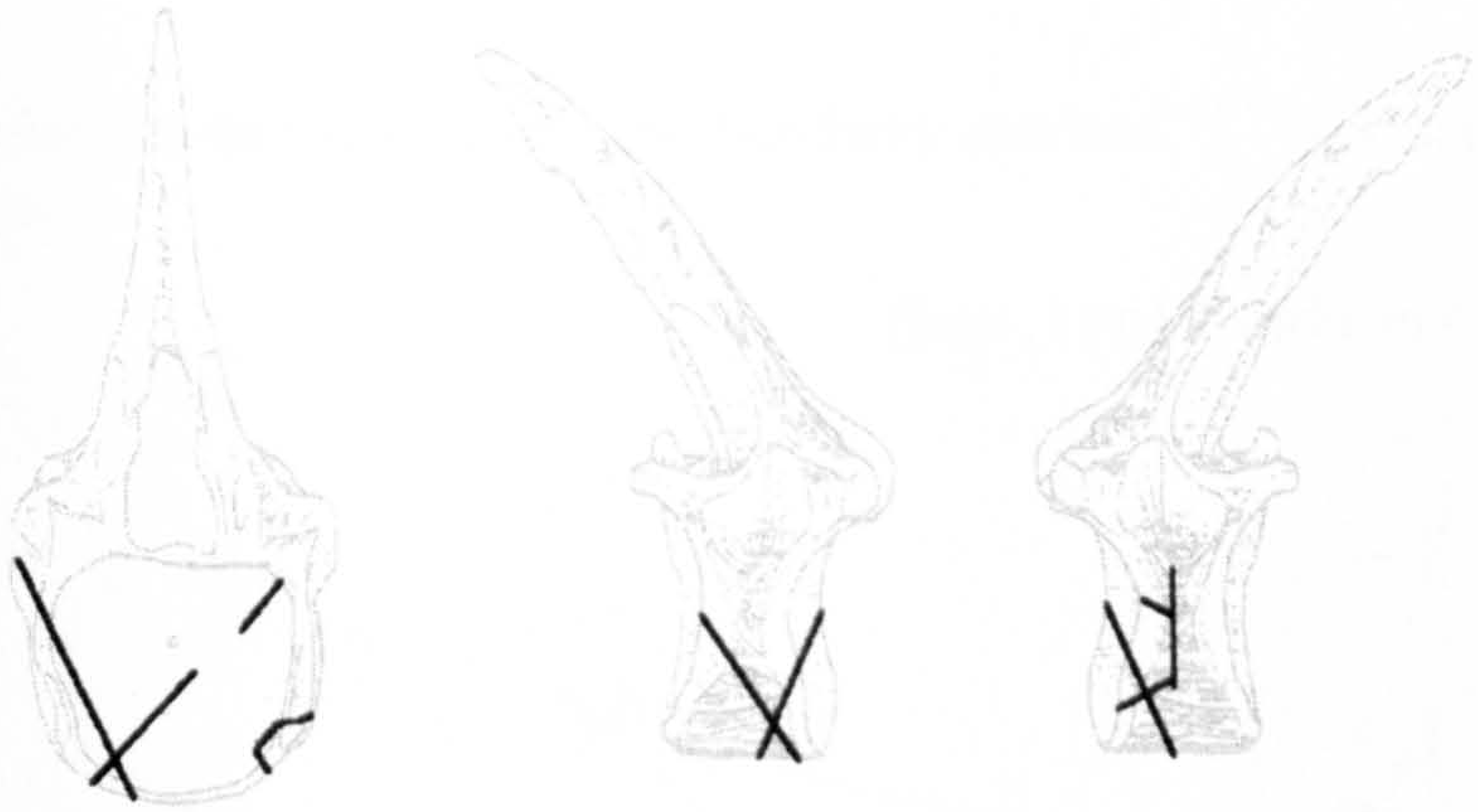
One saithe parasphenoid from phase ii was cut with a knife (from fish of size 150-300mm in length, not illustrated), possibly during decapitation or processing of the head, and one ling cleithrum from a fish of over 1000mm long, from phase ii, was cut with a knife. This is illustrated below in Figure 5.40 and is probably indicative of decapitation, as it follows a pattern observed in other species both at Quoygrew and at Earl's Bu (see, Chapter Four, section 4.7).

Species	Element	Phase ii	Phase iii	Phase 2
Cod	Abdominal Vertebra Group 1	3		
	Abdominal Vertebra Group 2	1		
	Basioccipital		1	
	Caudal Vertebra Group 1			1
	Cleithrum		4	
	Dentary	1		
	First Vertebra		1	
	Infrapharyngeal		1	
	Posttemporal	6	2	
	Premaxilla	1		
	Supracleithrum	1	1	5
Ling	Cleithrum	1		
Saithe	Parasphenoid	1		
Unidentified	Unidentified		1	
Grand Total		15	11	6

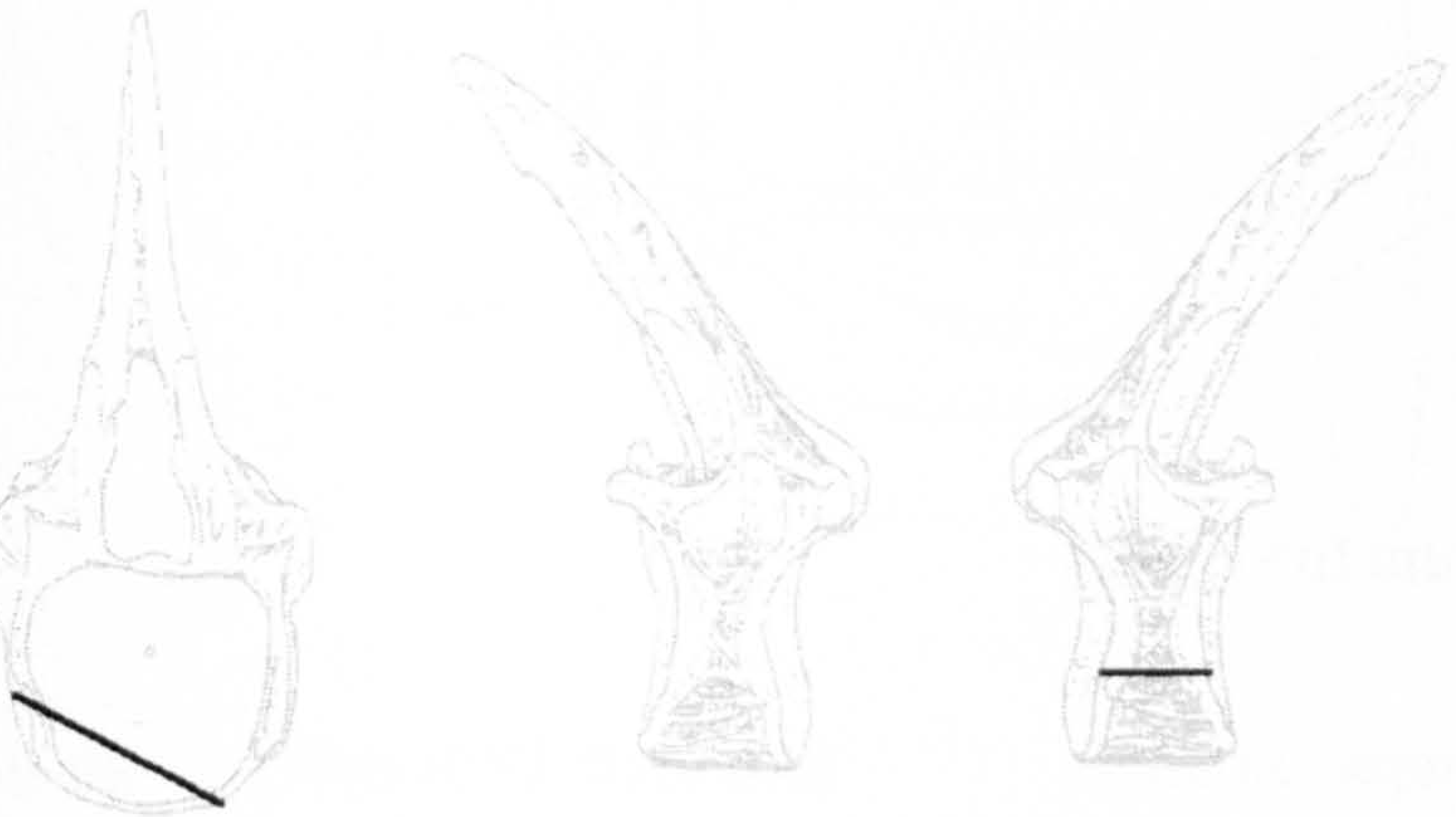
Table 5.23: Butchery summary



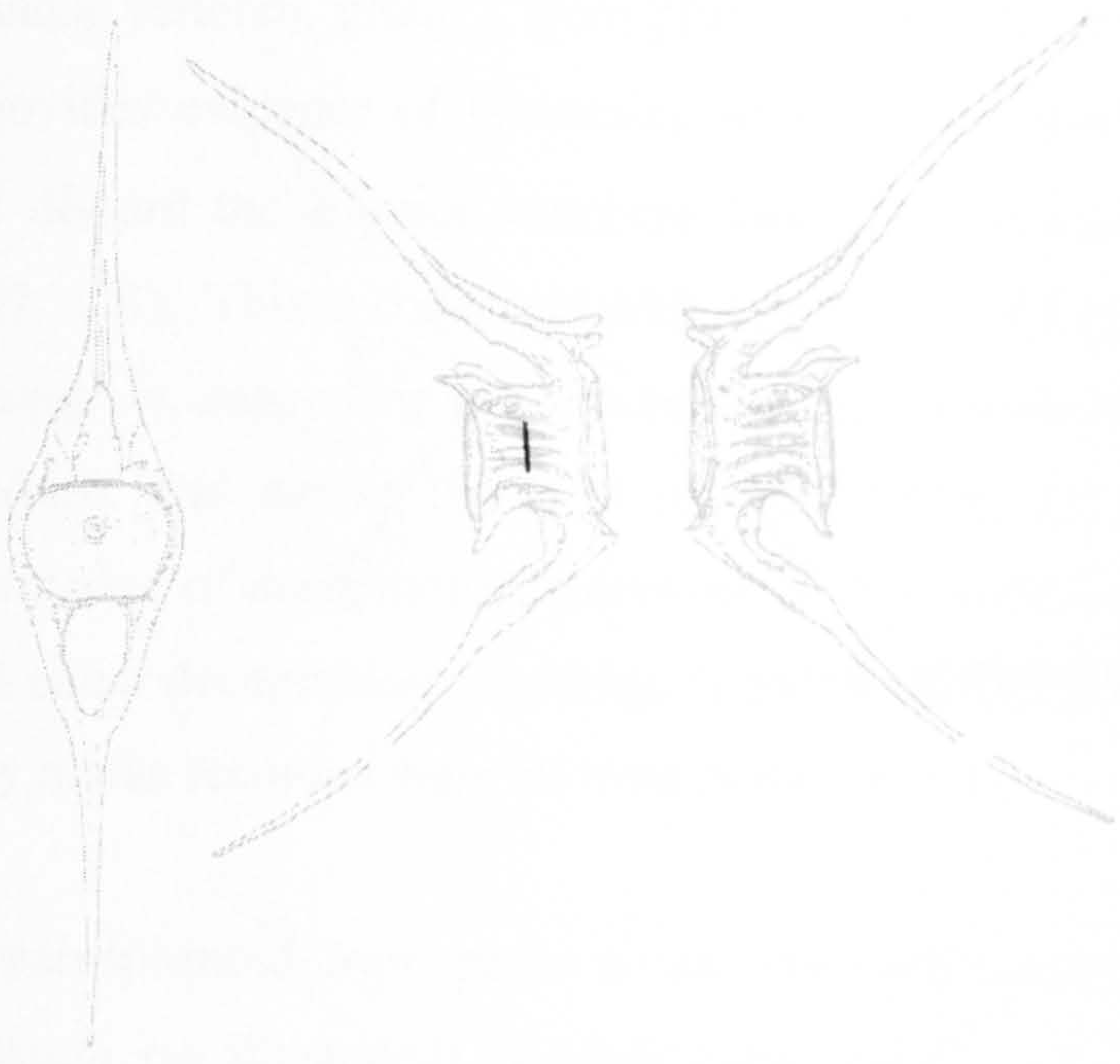
Phase iii, first vertebra (n=1, cod)



Phase ii, abdominal vertebrae 1 (n=2, both cod)

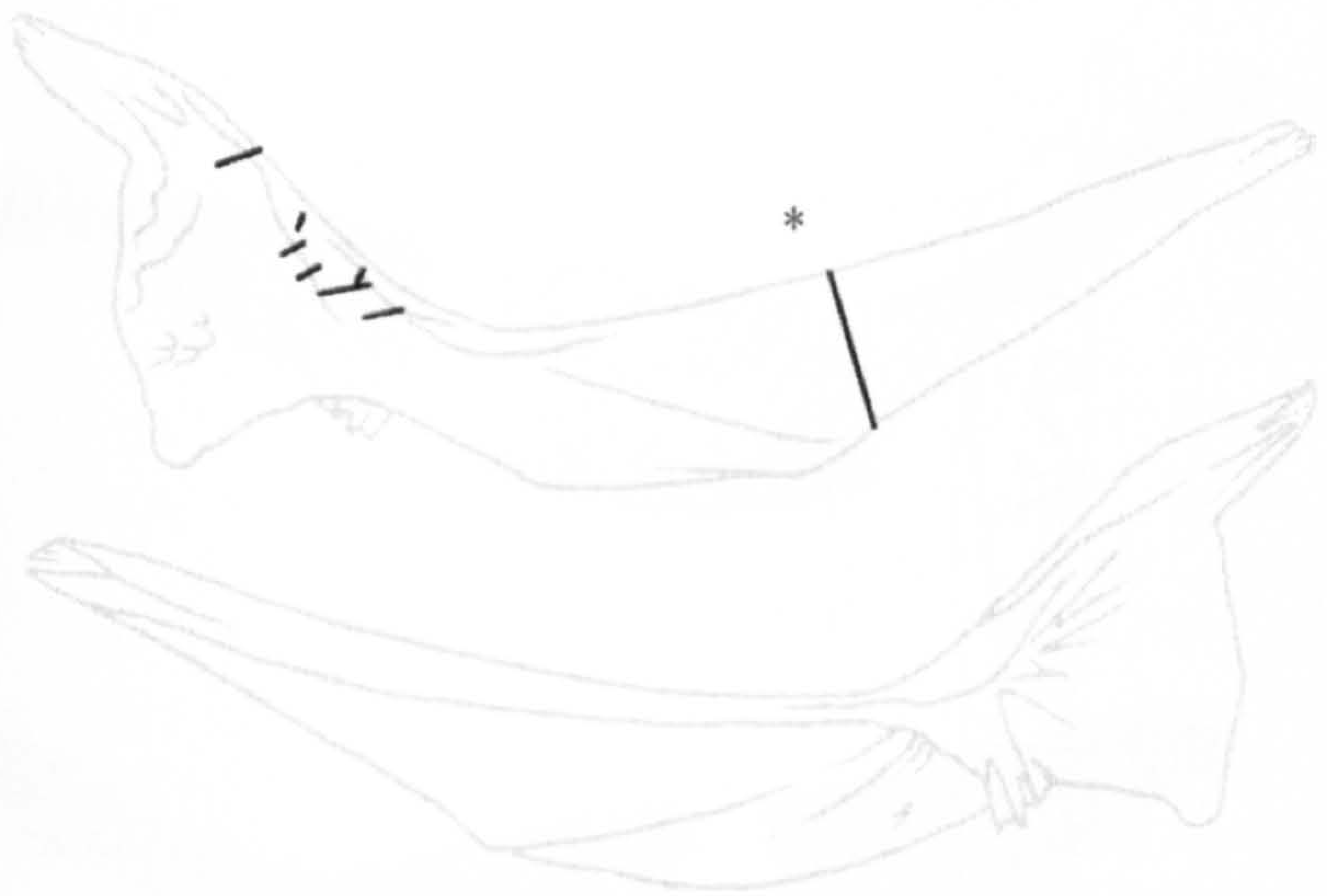


Phase ii, abdominal vertebra 2 (n=1, cod)



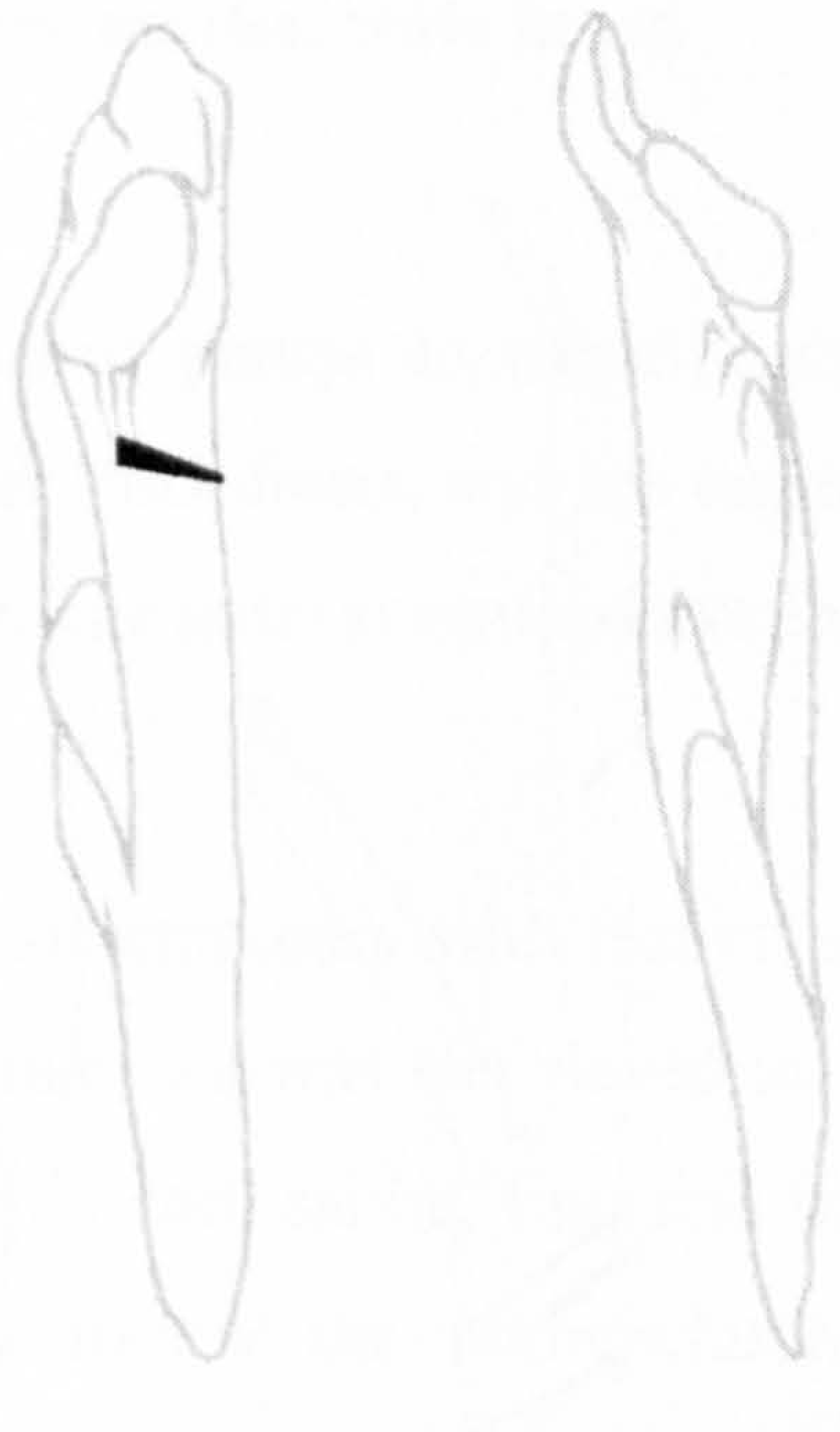
Phase 2, caudal vertebra 1 (n=1, cod)

Phase ii, cleithrum (n=1, ling)

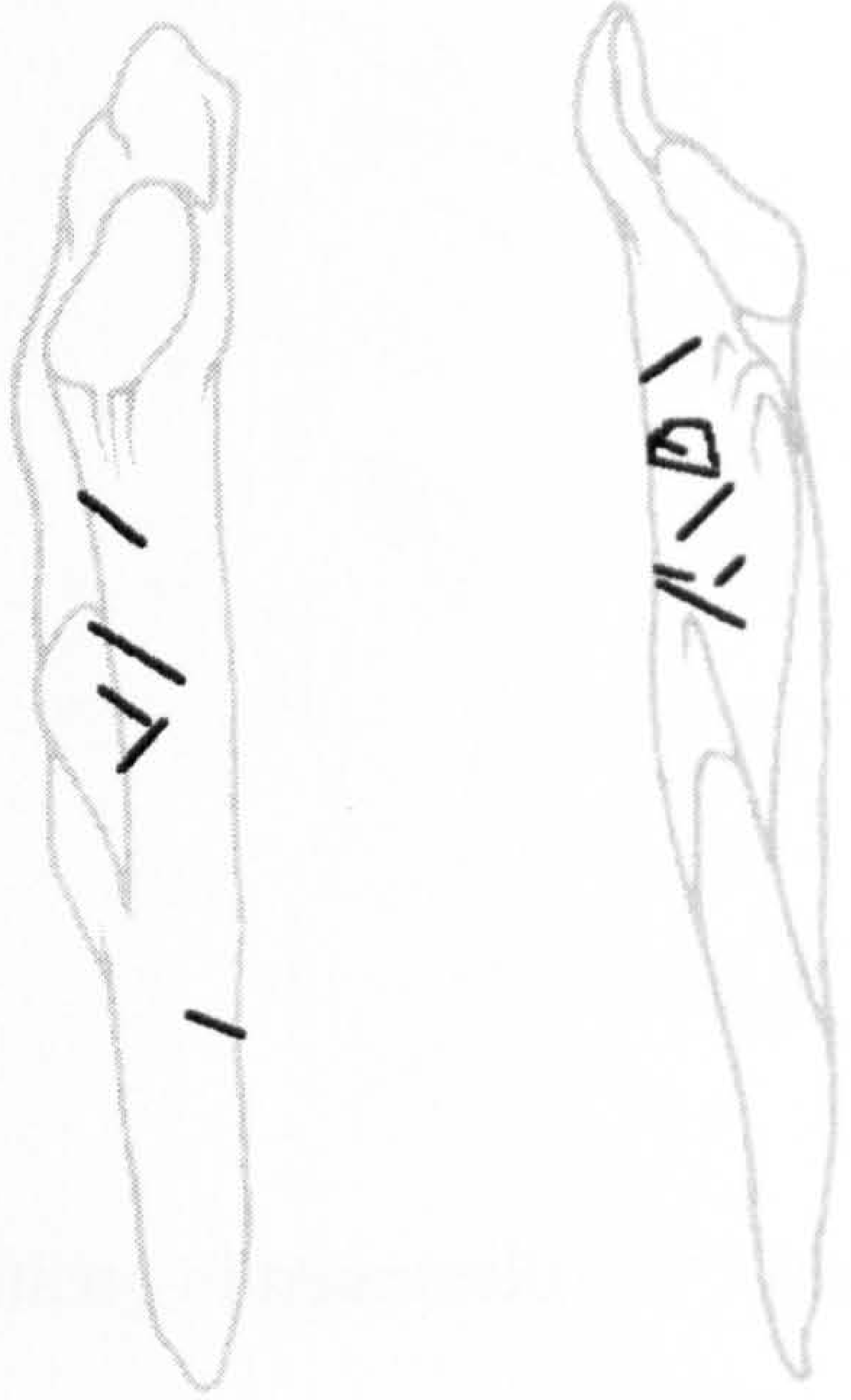


Phase iii, cleithra (n=3, all cod); the butchery marked '*' is illustrated in greater detail below

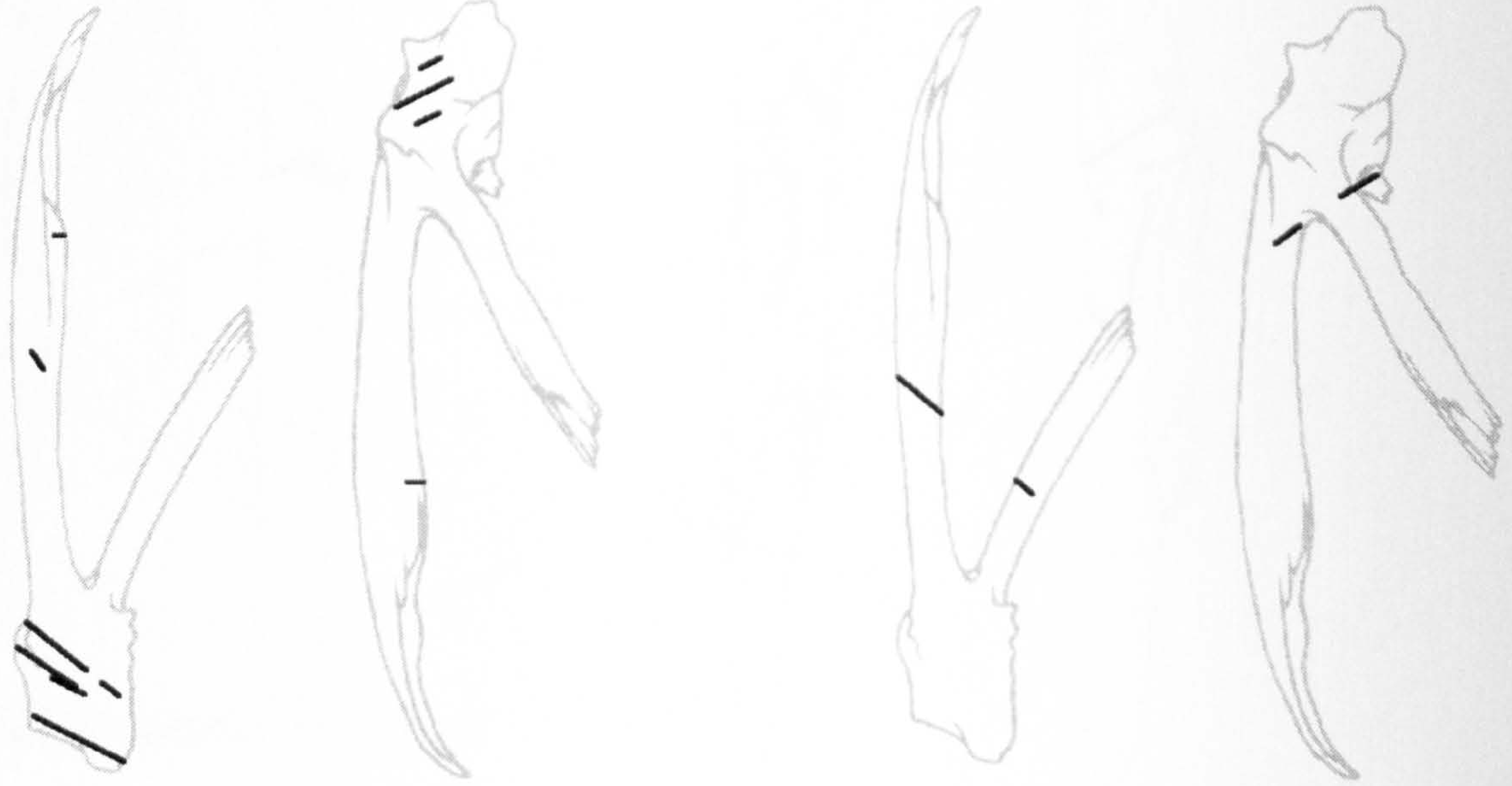
Phase ii, supracleithra (n=2, both cod)



Phase iii, supracleithrum (n=1, cod)



Phase 2, supracleithra (n=5, all cod)



Phase ii, posttemporals (n=5, all cod)

Phase iii, posttemporals (n=2, both cod)

Figure 5.40: Fish butchery diagrams

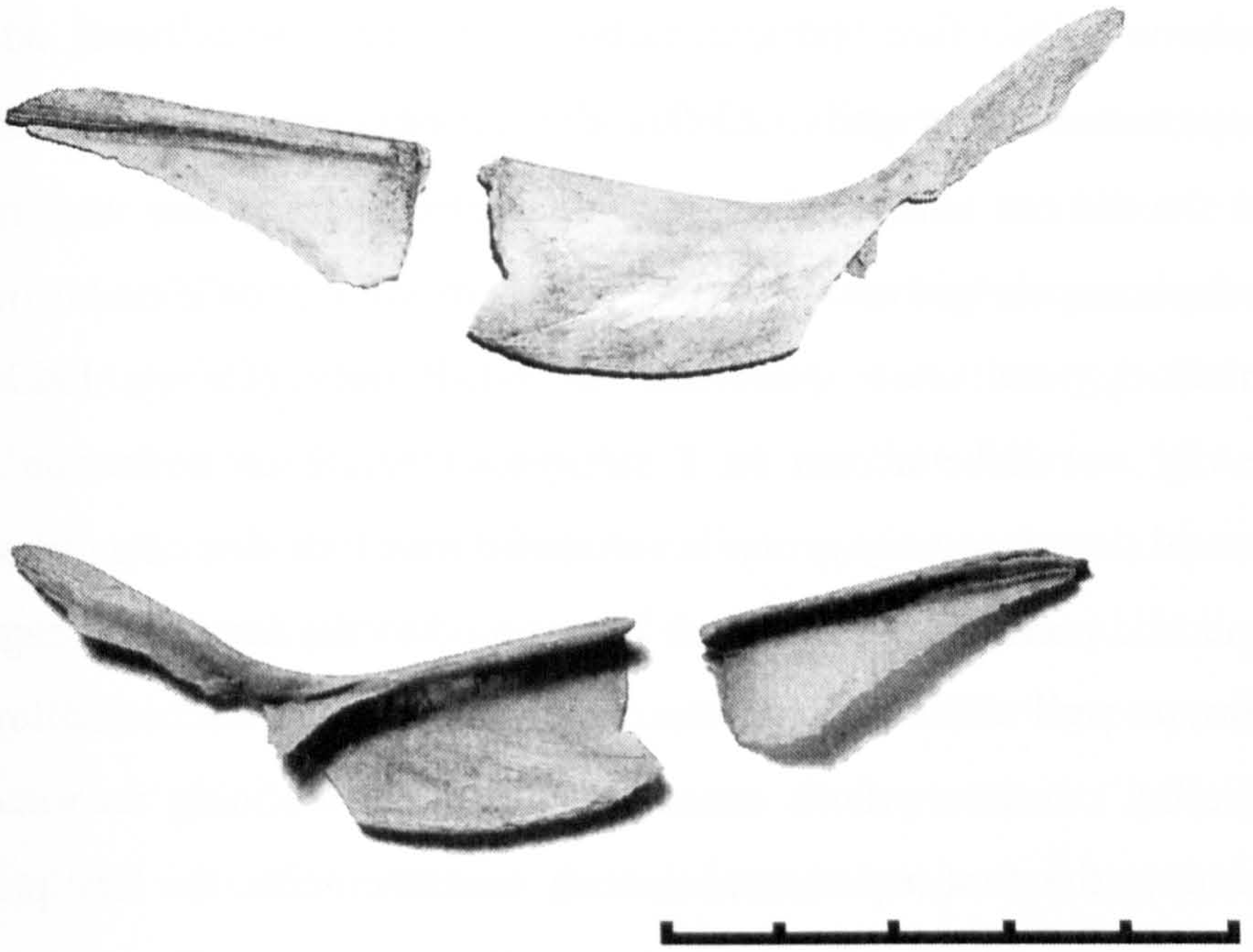


Figure 5.41: Cod cleithra from phase iii, with butchery marks, scale in cm

5.7 *Colley's results*

As outlined in Chapter Three, Sarah Colley was the first person to examine the fish midden at Quoygrew. Her results were presented in her PhD thesis, and are reproduced and reanalysed here for comparison with the results from the more recent excavations.

5.7.1 Methods and comparative potential

Colley's results from layers 3 to 16 are approximately contemporary with Barrett's phase 2, and layers 1 and 2 with Barrett's phase 7. Colley's material was wet sieved to 1.5mm in the sea (Colley 1983c, 209). A set of elements from cod, saithe, ling and haddock were regularly identified, comprising (converted to follow the nomenclature used throughout this study): articular, basioccipital, ceratohyal, cleithrum, dentary, hyomandibular, maxilla, palatine, parasphenoid, posttemporal, premaxilla, preopercular, quadrate, supracleithrum, vomer; otolith; abdominal vertebra and caudal vertebra (Colley 1983c, Fig. 6.3). Other elements from the four main gadid species were identified to a region in the body and recorded as 'gadoid', but were quantified with unidentified material in the NISP tables and are thus directly comparable to the method applied to the material from Barrett's excavation. All identifiable elements from other gadids and from non-gadids were fully identified (Colley 1983c, 189).

Colley's suite of elements was very similar to the York System, although we now divide the vertebral column into five groups rather than two and have added the infrapharyngeal, opercular and scapula. Colley did record levels of fragmentation and completeness, but she did not analyse these data or publish them in any way, making it difficult to assess taphonomic patterning or the minimum number of elements recorded; her results from Quoygrew were quantified as NISP only (Colley 1983c, 194). Furthermore, she did not have access to a substantial reference collection for size comparisons, so could therefore only group her material into four size categories. These included tiny, small and medium, all of which correspond to the same fish lengths used in the York System, as well as 'large', defined as any length over 50cm (Colley 1983c, 191). Some of Colley's measurements correspond to those routinely recorded in the York System, including the first and second dentary measurements, the first premaxilla measurement (equivalent to Colley's second premaxilla measurement), quadrate width and otolith length (Colley 1983c, Tab. 6.1, Fig. 6.4, measurements defined in the York System help files). However, she did not measure any material in the 'tiny' size category (Colley 1983c, 192). No routine presentation of taphonomic factors was attempted, but one note pertained to otolith survival: generally "poor" at all sites (Colley 1983c, 195), confirmed by the small proportion of any measurable otoliths (Fig. 7.3, 7.4 and 7.5).

5.7.2 Species

Colley identified 7369 elements from 25 fish species or species groups, out of over 29,000 fragments, of which 7066 elements and 24 species can be equated to phase 2 (Table 5.24). However, the total number of bones included all unidentified fragments from 1.5mm sieving, so is not directly comparable to later work from Quoygrew, where only >4mm unidentified fragments were counted. She had a smaller reference collection than the one available at York for later work on Quoygrew, which probably explains the smaller number of identified species. In contrast, the author identified 2517 elements from 29 species or species groupings from phase 2. Phase 7 contained 36 identified elements from 7 species or species groupings, while Colley's equivalent layers contained 303 identifications from 10 species or species groupings.

Colley identified all bones to family when possible, including elements from cod, saithe and ling that were not in her suite of 18 routinely identified elements. These were recorded as 'gadoid', but are distinct from Colley's 'cod family', which referred to elements from her suite of routinely identified cranial, appendicular and vertebral elements. It is therefore possible to accurately compare Colley's results with those from Barrett's excavation, because very similar recording methods were used in both species nomenclature and in the subset of routinely identified elements. Colley's results are summarised in Table 5.24, and indicate a much higher proportion of saithe and a correspondingly lower proportion of cod than was obtained during the analysis of Barrett's excavation. Results for phase 7 are not that different, given the small sample sizes involved, and the possibility for disturbance to these deposits (they represent bioturbated midden layers at the top of the midden sequence). The primary differences between the old and new results for phase 2 are the differing proportions of cod and the prevalence of 'gadid' in Colley's excavation. Colley's results indicate the proportion of identified cod was 17%, whereas the later results place cod at 42%. Saithe are 41% of Colley's phase 2, very similar to Barrett's phase 2, where saithe represented 37%. Use of the 'gadid' and *Gadus/pollachius* categories was only 6% in Barrett's phase 2, but Colley identified 42% of her assemblage as 'gadid'. Ling was 2.8% of Colley's phase 2, and therefore was again very similar to Barrett's phase 2, where ling represented 2.1%. It is possible that Colley's results underestimated the proportion of cod, and instead identified many cod as gadid. Colley admitted that her reference material was lacking, which may explain the differences in levels of identification. The alternative explanation is that many of Colley's elements were too fragmented or too poorly preserved to be identified to species, but the presence of large quantities of measurable material and very small but identifiable saithe negates this theory.

Similar quantities of Rajidae, eel, conger eel, clupeids, rocklings, haddock, wrasse, sea scorpions, butterfish, wolf-fish, sand eels and flatfish were found during both excavations, despite Colley's total numbers of bones being much higher. This may indicate poorer preservation, or could reflect Colley's smaller reference collection. The fact that certain of the rarer species (including the needlefishes or sauries and some rocklings) do not appear in Colley's summary suggest the latter, although the suggestion of poor preservation, as implied for otoliths (Colley 1983c, 195), may be indicative of differences between the preservation of Colley's material compared to that excavated in 1997. However, the high proportions of measurable material would suggest that preservation was very similar to that found during Barrett's excavation as noted above (Colley 1983c, Fig. 7.3).

Colley mentioned that quantities of articulated material were noticed during excavation, but with hindsight, she thought that "it seems likely that much more of the material was articulated or associated than was noticed during excavation" (Colley 1983c, 216). She did not fully quantify the articulations, but noted that many contained vertebrae, some were parts of the hyoid arch, and a few were cranial. The presence of these suggests quick deposition and low levels of disturbance.

It therefore appears that the only major difference between Colley's and Barrett's material is directly related to the availability of reference material and the differing degrees of identification to species, species grouping (e.g. *gadus/pollachius*) and family. Once these factors are considered, there are few differences in species composition between the two excavations.

Taxa	Layers 1 and 2 (equivalent to phase 7)		Layers 3 to 16 (equivalent to phase 2)		All	
	NISP	%	NISP	%	NISP	%
Rajidae			5	0.1	5	0.1
Clupeids	1	0.3	3	0.0	2	0.0
Eel			2	0.0	2	0.0
Conger eel			3	0.0	3	0.0
Pollack	6	2.0	23	0.2	17	0.3
Saithe	124	40.9	2731	36.9	2607	37.1
Cod	50	16.5	1256	17.1	1206	17.0
Haddock			3	0.0	3	0.0
Ling	18	5.9	216	2.8	198	2.9
Shore Rocking			4	0.1	4	0.1
Rockling	2	0.7	10	0.1	8	0.1
Gadid	98	32.3	3074	42.1	2976	41.7
Sea Bream			1	0.0	1	0.0
Ballan wrasse			3	0.0	3	0.0
Mackerel	1	0.3	1	0.0	0	0.0
Sand eel	2	0.7	3	0.0	1	0.0
Butterfish			9	0.1	9	0.1
Wolf fish?			1	0.0	1	0.0
Triglidae			1	0.0	1	0.0
Bull-rout			5	0.1	5	0.1
Sea scorpion			1	0.0	1	0.0
Cottids	1	0.3	3	0.0	2	0.0
Lumpsucker			4	0.1	4	0.1
Flounder			3	0.0	3	0.0
Flatfish families			4	0.1	4	0.1
Total ID	303	100	7369	100	7066	100
Unknown	1		40		39	
Unidentified	390		22030		21640	
TNB (sieved to >1.5mm)	694		29439		28745	

Source: Colley 1983, Tab. 7.1

Table 5.24: Colley's Quoygrew: NISP

5.7.3 Fish sizes

Using raw measurements on several elements, Colley produced histograms showing frequencies of fish sizes. She did not apply any regression formulae, but instead interpreted the resulting histograms using modern comparative data. Colley's raw data have been reconstructed using her histograms, and modern regression formulae have been applied to them by the author, as illustrated in Figure 5.42, Figure 5.43 and Figure 5.44.

In applying regression equations to Colley's cod measurements, a bimodal pattern can be observed. The larger mode is around 900-1000mm in length, with a smaller mode between 500 and 700mm in length; almost no fish were found between 700 and 800mm long. These results conform to the pattern observed during the recent excavations.

There are few differences between the saithe excavated by Colley and those excavated by Barrett, if one only compares regression equation results. Both have a primary mode around 300-400mm, with some outliers or even a secondary mode around 800-1000mm. This is very similar to Barrett's phase 2.

Colley recorded substantial amounts of 'tiny' saithe (i.e. <150mm) that were only partially quantified. They appeared on her size histograms, but were estimated and not actually measured; they were therefore not used when applying regression equations (Colley 1983, Fig. 7.3). Standard measurement values were approximately 1mm or less, making their total length estimates <70-90mm. It is difficult to interpret these 'tiny' saithe, because similarly sized saithe were not found during the more recent excavations. If they had been present, elements from 'tiny' sized fish should have been found in the 2-4mm fraction of Barrett's excavation, but clearly very few were recovered. Some of the recent Area A <2mm flotation residues were examined by James Andrews during the course of his MSc, but although he observed the odd single vertebra, he did not see *any* gadid QC1 elements (pers. comm. 2005). This leaves us with two alternative conclusions: either Colley did identify huge quantities of 'tiny' saithe, but these were not found during Barrett's excavations, or (probably more likely), the 'tiny' saithe were actually from a different species.

Colley's ling measurements indicated only fish of 900mm and larger were found. This is very similar to the results from the later excavation.

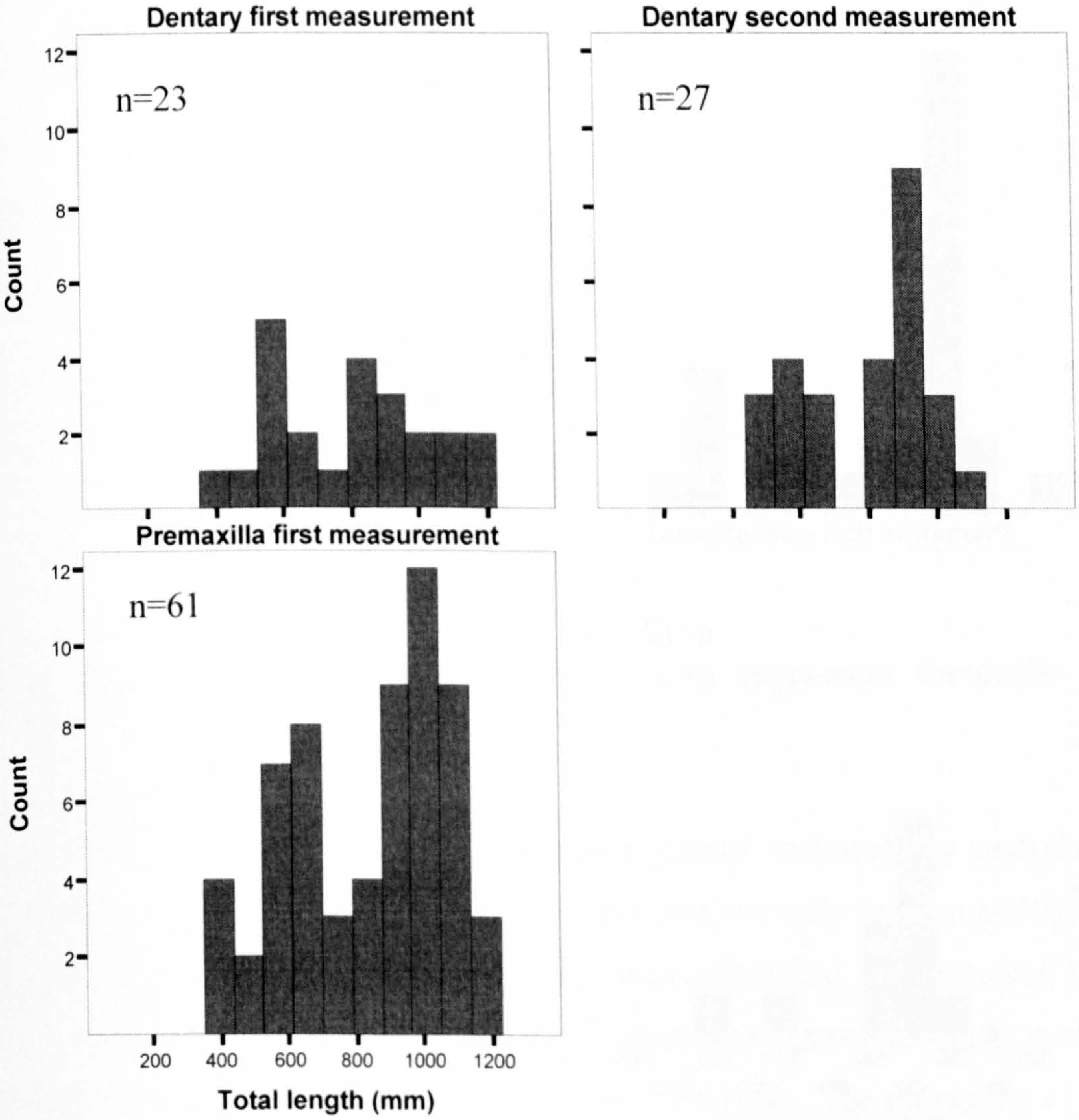


Figure 5.42: Colley's cod measurements, with regression formulae applied dentaries and premaxillae to illustrate fish lengths

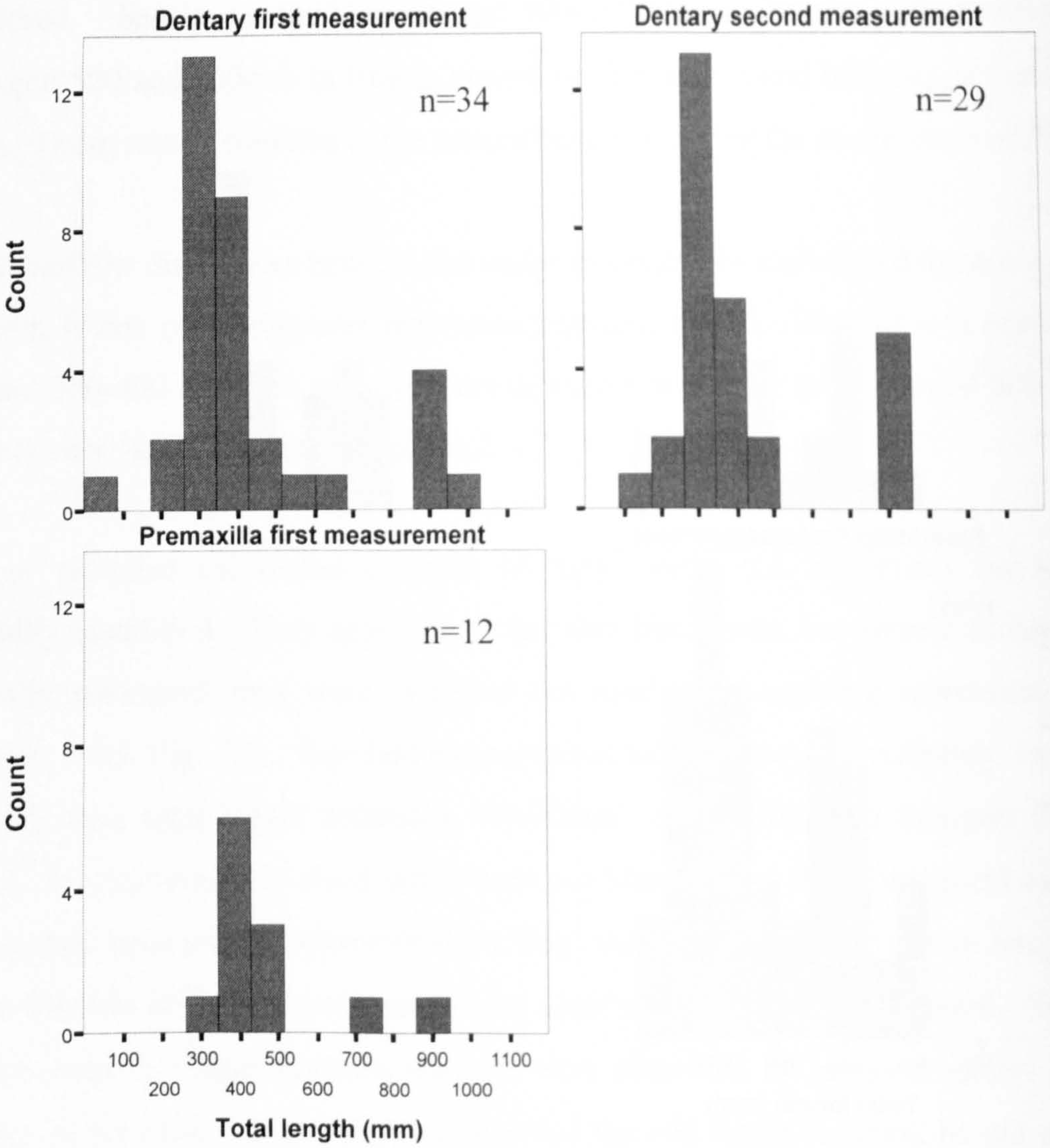


Figure 5.43: Colley's saithe measurements, with regression formulae applied to dentaries and premaxillae to illustrate fish lengths

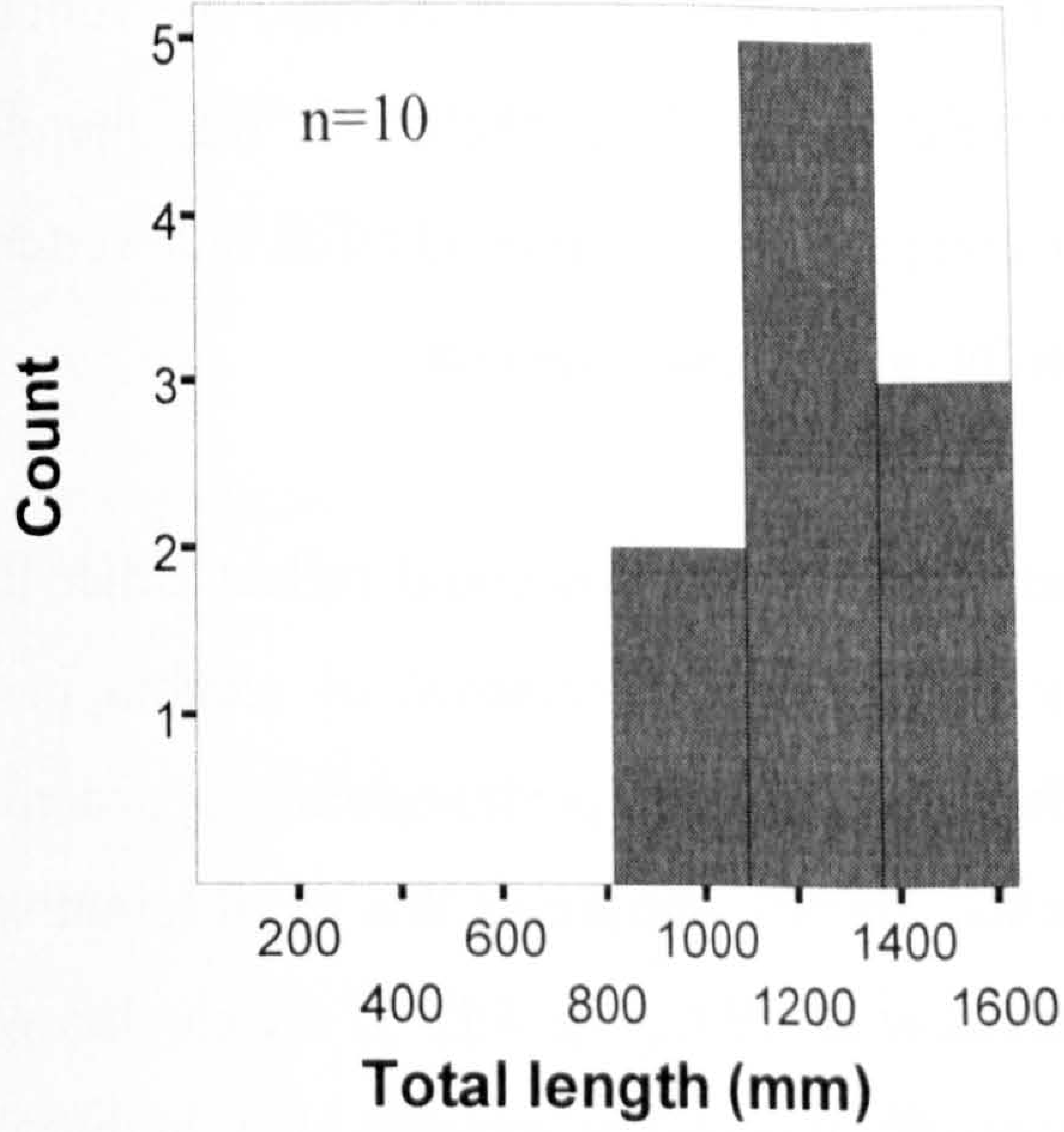


Figure 5.44: Colley's ling measurements, with regression formulae applied to illustrate fish lengths

5.7.4 Element distribution

Colley did not have access to a user-friendly computer, so found any analysis of element distributions and fragmentation extremely difficult; the only fully quantified results are those with useful measurements. These provide a quantified and measured subset of the more complete articulars, dentaries, palatines, parasphenoids, posttemporals, premaxillae, quadrates, vomers and abdominal vertebrae. The remaining elements were quantified for cod, saithe and ling, but without reference to size or fragmentation (Colley 1983c, Tab. 8.13). She stated, with respect to Quoygrew, Evertaft and Cleat, that "there were few gross differences, if any, in the parts of fish present… it was not possible to see all head bones in one place and all vertebrae in another" (Colley 1983c, 228). Colley's element data from Quoygrew has been interpreted by Barrett as possibly representing butchery waste from fish processing, but with ambiguous butchery data (Barrett *et al.* 1999, Fig. 8d).

The element results are summarised below, in Figure 5.45 and Figure 5.46 for cod, Figure 5.47 and Figure 5.48 for saithe and Figure 5.49 and Figure 5.50 for ling. These figures do not include a number of elements that Colley identified, because they were not routinely recorded using the author's methods (i.e. they equate to QC0 elements). There were only three elements that are now identified but that Colley did not include: the infrapharyngeal, opercular and the scapula. MNE was approximated from Colley's cod, saithe and ling data by halving the quantity of paired elements, and dividing the number of vertebrae by the quantity found in each fish skeleton. Colley divided the vertebral column into three categories, but these were not made explicit. It was therefore impossible to calculate MNE in order to compare cranial, appendicular and vertebral elements. Instead, the MNE was calculated for all vertebrae together.

The cleithra ranked low compared to other elements, but this could reflect either their fragility or a butchery pattern caused by processing and removal of cleithra in the processed fish (as discussed above). Supracleithra and posttemporals appeared at average quantities compared to other elements. Barrett interpreted this as an assemblage that "may also include butchery waste" (Barrett *et al.* 1999, Fig. 8d). If the cleithra were found in low proportions as a result of processing, it would be expected that higher than usual proportions of abdominal vertebrae would be found when compared to caudal vertebrae. Colley's vertebrae are displayed by NISP in Figure 5.45, and can be compared to vertebra NISP data from Barrett's excavation in Figure 5.19. However, each uses a different division of elements along the vertebral column. Without further information about Colley's methods, interpretation is difficult. However, using the MNE data, vertebrae appear slightly underrepresented compared to cranial elements, which may suggest some caudal vertebrae were being removed with prepared fish. Certainly the relative proportion of cod vertebrae is low when compared to saithe, which were probably deposited in their entirely (based on analogy with Barrett's excavation and the evidence of saithe sizes).

	Cod		Saithe		Ling	
Element	NISP	Ranking	NISP	Ranking	NISP	Ranking
Articular	47	*5*	32	*3*	4	*8*
Basioccipital (x2)	26	*11*	38	*2*	4	*8*
Ceratohyal	11	*16*	10	*13*	11	*1*
Cleithrum	18	*14*	3	*16*	1	*12*
Dentary	46	*6*	44	*1*	10	*3*
Hyomandibular	23	*12*	16	*9*	5	*6*
Maxilla	55	*4*	31	*4*	10	*3*
Opercular	18	*14*	2	*17*	1	*12*
Palatine	41	*8*	10	*13*	4	*8*
Parasphenoid (x2)	56	*3*	18	*6*	10	*3*
Posttemporal	41	*8*	17	*8*	2	*11*
Premaxilla	69	*2*	25	*5*	11	*1*
Preopercular	7	*17*	7	*15*		
Quadrate	43	*7*	18	*6*	1	*12*
Supracleithrum (x2)	35	*10*	14	*11*	5	*6*
Vomer	70	*1*	16	*9*		
Otolith	19	*13*	11	*12*		
First vert.	11		23		2	
Thoracic vert.	77		422		24	
Precaudal vert.	197		880		32	
Caudal vert.	360		1074		68	
Totals	1194		2675		198	

Table 5.25: Colley's NISP

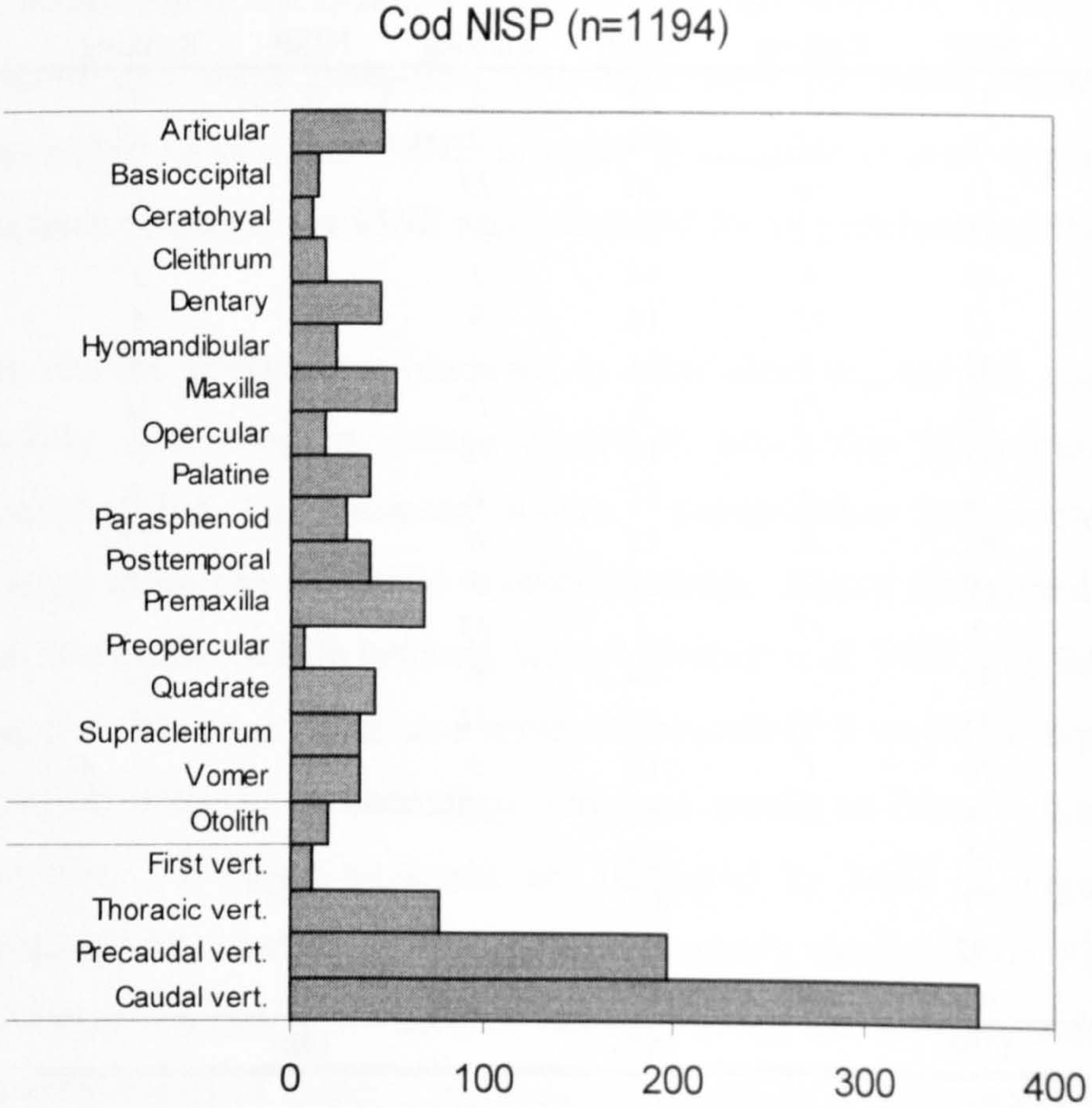


Figure 5.45: Colley's cod NISP

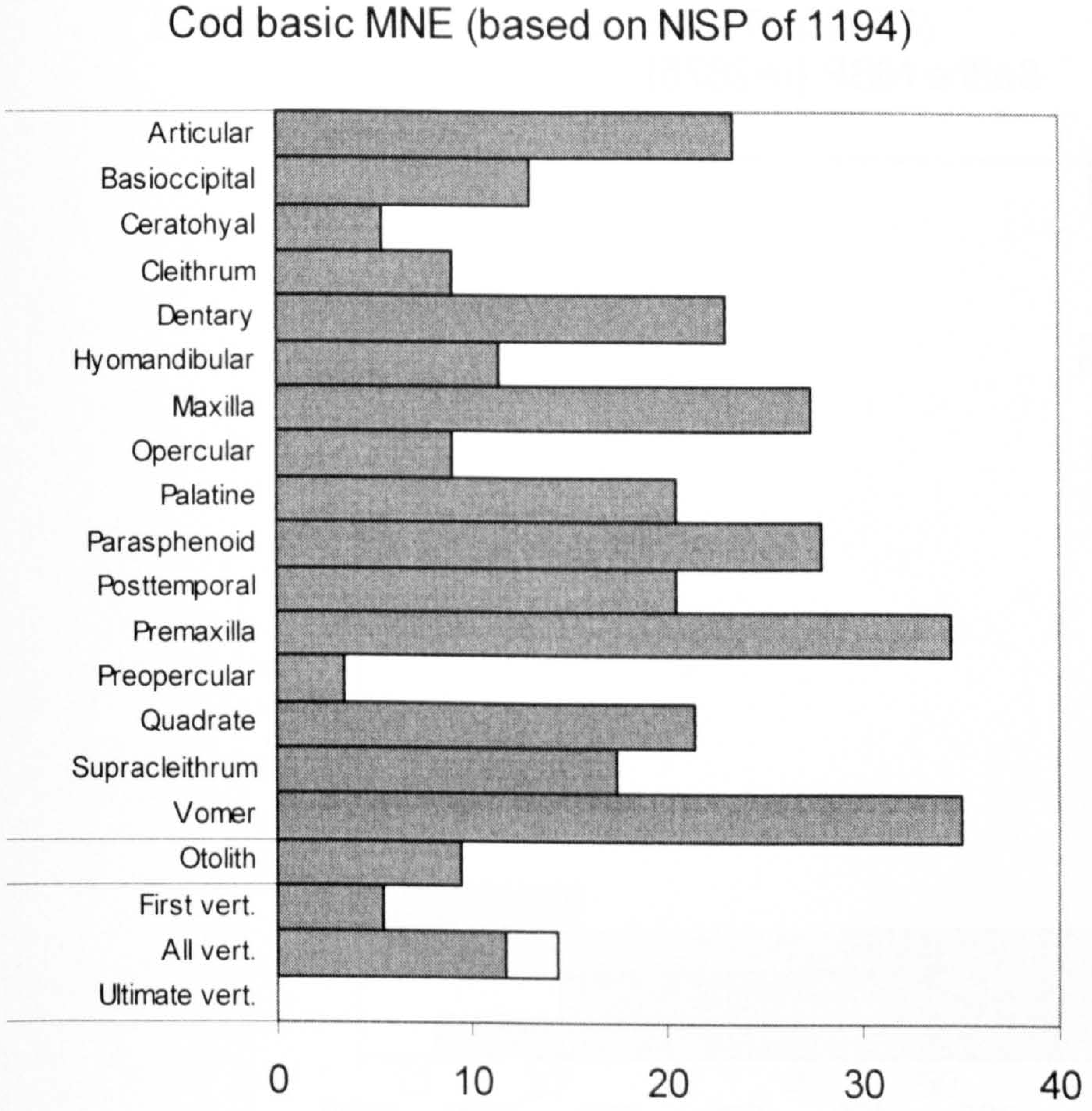


Figure 5.46: Colley's cod MNE

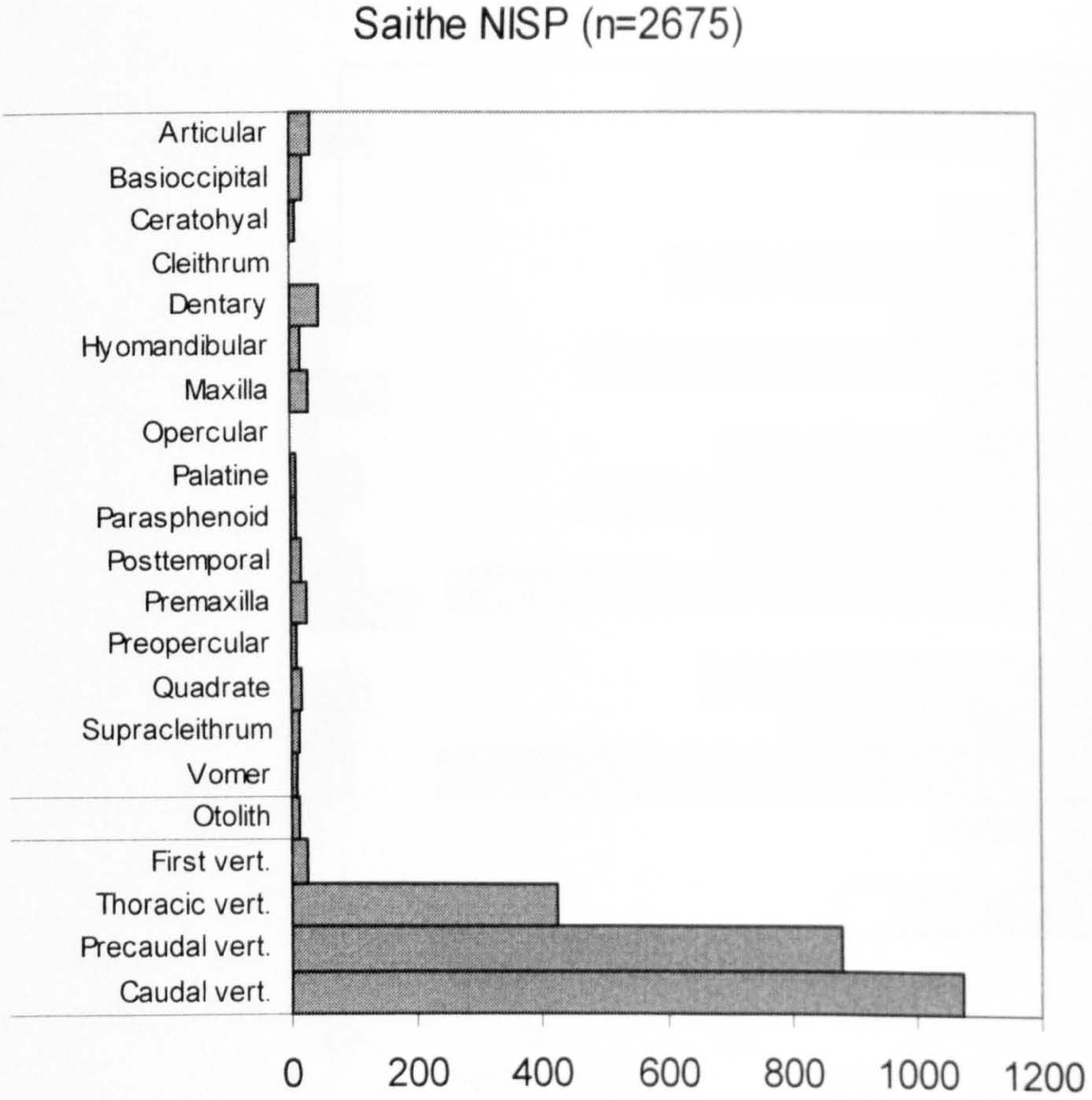


Figure 5.47: Colley's saithe NISP

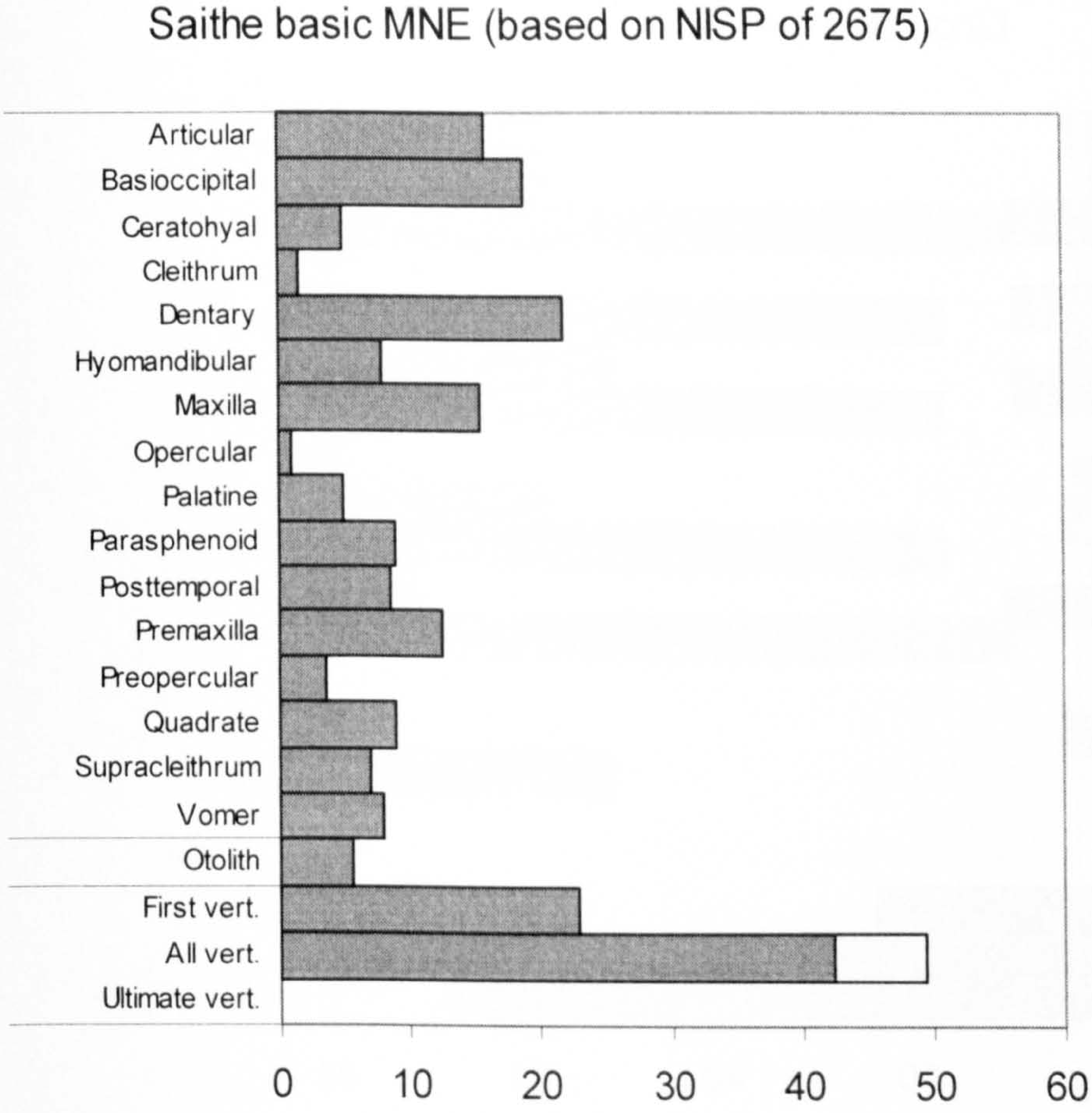


Figure 5.48: Colley's saithe MNE

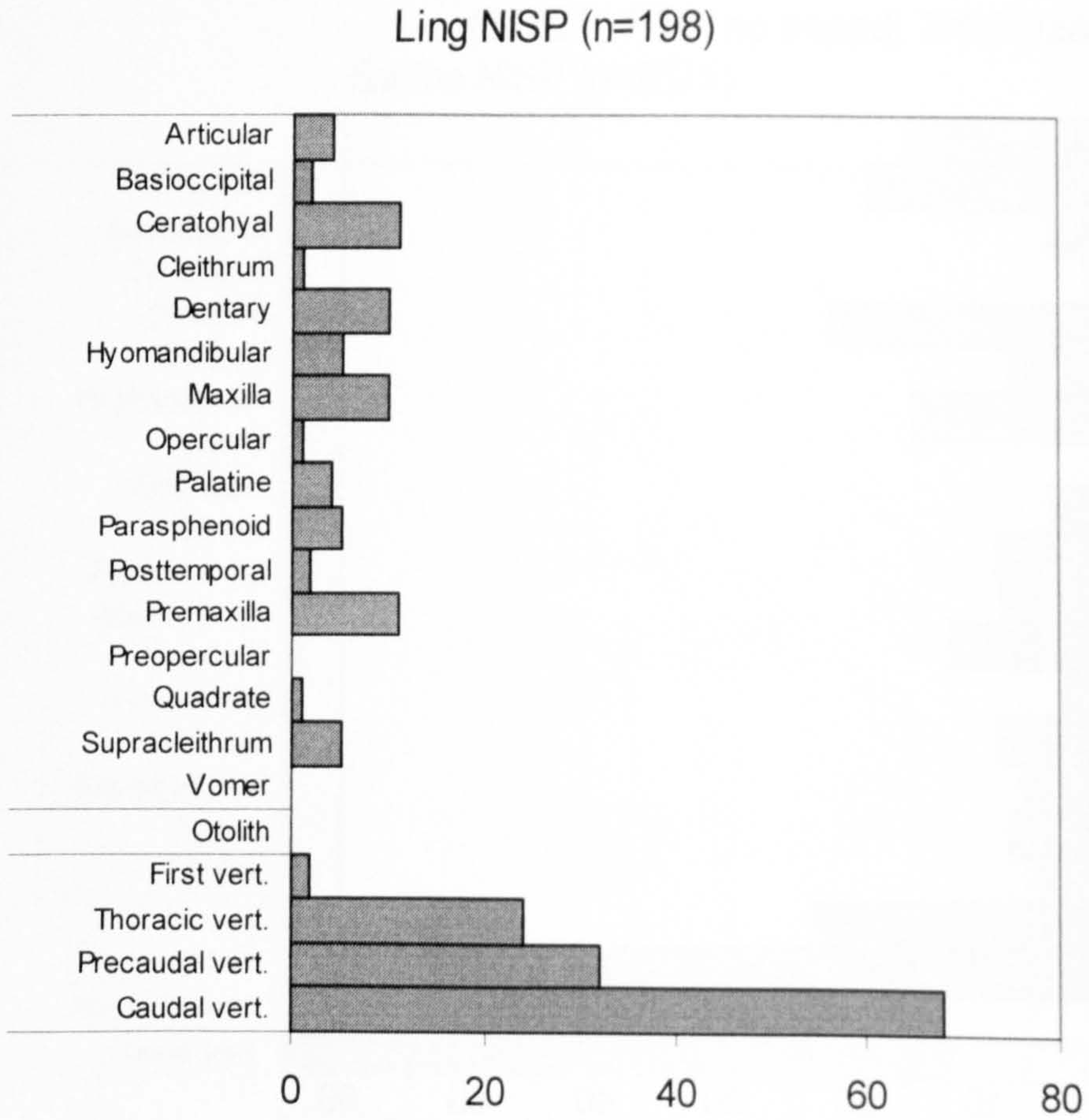


Figure 5.49: Colley's ling NISP

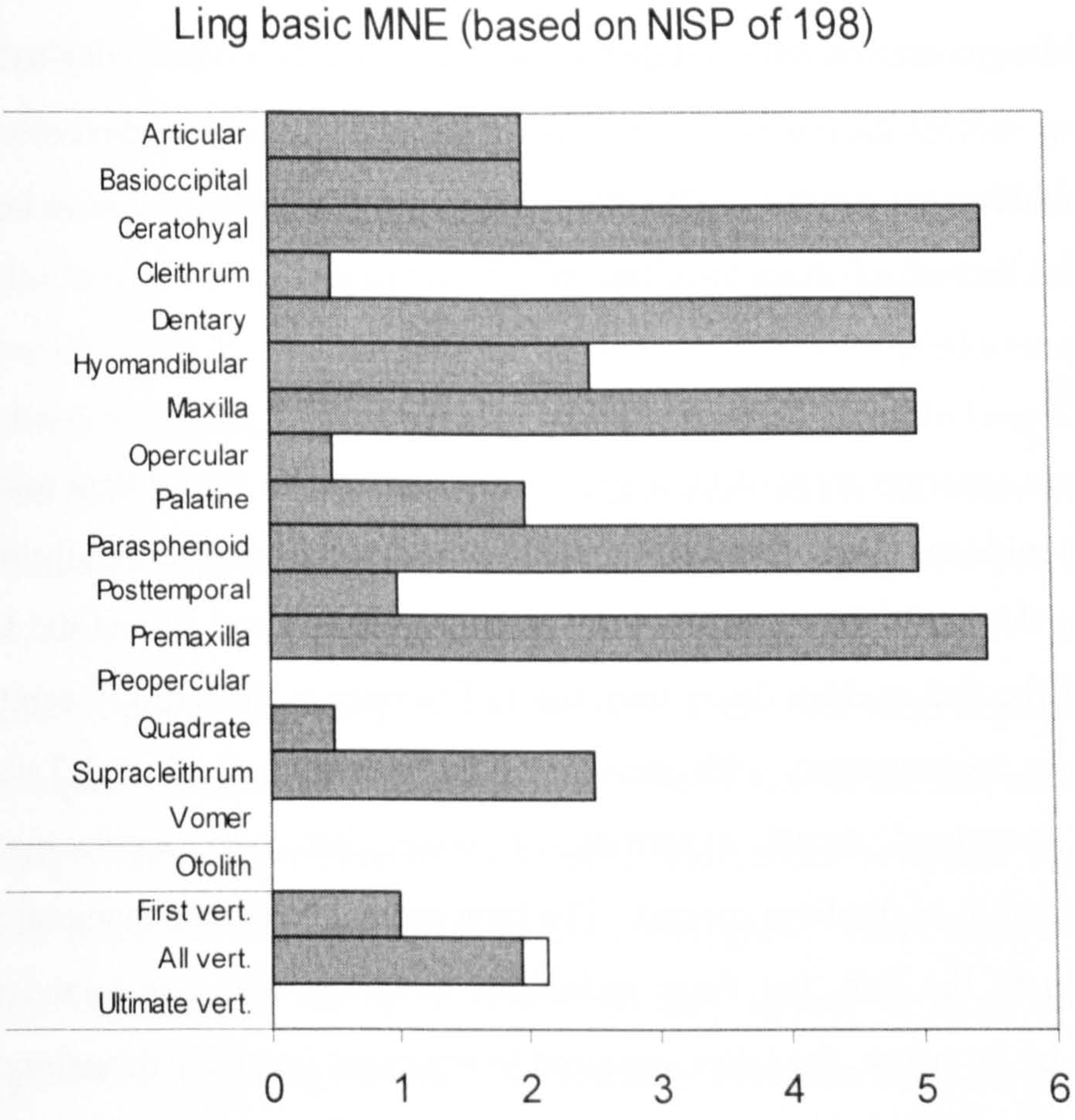


Figure 5.50: Colley's ling MNE

5.7.5 Butchery

Colley did not observe many butchery marks, though 7 were found on large gadid cleithra, posttemporals and supracleithra suggestive of head removal (Colley 1983c, 215-16, Fig. 7.6).

5.7.6 Summary of Colley's results

Despite difficulties in comparing Colley's work on the fish midden to the results obtained from Barrett's excavation, a few conclusions can be drawn. This has been helped by the similarity in recording methodology. Species proportions and size distributions for cod, saithe and ling are similar. The range of minor species was also similar, though restricted by Colley's smaller reference collection. A limited comparison of element proportions was possible, but there appeared to be a slight under representation of cod cleithra and vertebrae in Colley's excavation that would suggest some fish had been removed following processing. Although there was no direct butchery evidence for dried fish processing, cut marks did indicate decapitation. Saithe sizes and element proportions were indicative of entire fish being locally consumed and deposited. Ling quantities were too small to fully assess. The lack of taphonomic data on preservation and fragmentation have hampered the full interpretation of Colley's data, but the similarities in species proportions and sizes suggest that the preservation of each assemblage was probably also similar. Therefore, it appears likely that cod were being prepared and exported from the fish midden, but on a small scale.

5.8 Discussion

Fish remains from two separate areas of Quoygrew were studied: the inland farm mound and the coastal fish midden. Fish and marine shell deposition increased rapidly after about 1000, between the early phases of the farm mound (phases i and ii) and the later phase iii. Phase 2 of the fish midden dated from the 11th century to the late 13th century, and was approximately contemporary with phase iii of the farm mound. Phase 1.2 was a minor phase and contained small quantities of bone, but was approximately contemporary with phase ii of the farm mound. The farm mound contained mammal and bird bone in addition to the fish, but these inclusions were less common in the fish midden. As implied by its name, the latter appeared to represent intensive deposition of fish bone and shell with some bird (mostly marine species, see Chapter Seven), but with little mammal. The fish bone from Quoygrew therefore can illuminate chronological patterning between the earlier phases of the farm mound and the later phases of both the fish midden and the farm mound, and the contemporary but separated deposits from each area of midden can be examined for spatial patterning.

Cod and saithe dominated the assemblage in all phases, though small quantities of ling were also found along with many trace species. The earlier phases all contain relatively higher proportions of non-gadid family species, including phase 1.2 from the fish midden, while phases iii and 2, the later phases, indicate a much higher reliance on gadid family fish. Phase 2 has the highest proportion of these two later phases, indicating very few non-gadid fish were deposited in this area compared to the contemporary deposits in phase iii. Saithe were more common in the earlier phases i and ii that pre-dated the marine intensification, while cod was more common in phase iii. Saithe and cod were found at approximately similar quantities by NISP in phases 1.2 and 2 of the fish midden.

Fish sizes from Quoygrew were determined using both metrical data and using ordinal size categories taken during recording of all identified cranial and appendicular elements.

Cod size distributions were bimodal throughout all phases, with cod of 500-700mm total length forming one mode, and cod of about 1000mm forming another. In phase ii, the earliest phase with an adequate sample size, the smaller fish were found in greater quantities than the larger, while in the later phases iii and 2, approximately equal quantities of each mode were recovered. In contrast to the cod, saithe sizes were much smaller, rarely exceeding 450mm. Phase ii saithe were predominantly between 300 and 450mm in length, decreasing to between 150 and 250mm in length by phase iii. Phase 2 contained fewer of the very small saithe than phase iii, with most between 250 and 350mm. Phases 2 and iii contained a very small quantity of much larger outliers.

Element proportions suggest that all parts of the fish were deposited in the farm mound throughout its use, but a different pattern was found at the fish midden in phase 2. There, a slight under representation of cleithra and caudal vertebrae suggested some cod had been processed and were removed from Quoygrew. There is no evidence to indicate they were deposited in the farm mound, so they appear to have been exported, be it for regional or long-range trade. The butchery evidence from the fish midden corroborates this pattern, as does the size evidence. The saithe do not appear to have been exploited in this way, because all parts of the fish were present, and the sizes found were not within the range commonly used for drying for export. The results from Sarah Colley's excavation of the fish midden were difficult to interpret because of differences in the recording methodology and a lack of taphonomic data, but it appears that her cod element proportions and sizes also conform to these patterns. It appears likely that cod were being processed on a small scale at Quoygrew, and these cod were being exported from the site. However, the majority of cod caught were consumed locally, as were all saithe. It is interesting that despite the contemporary nature of phases iii and 2, and the fact that both contained cod of a size suitable for processing, it was only in phase 2 that processing and export of cod could be recognised. This suggest a deliberate spatial separation between domestic fish use and fish used for export as well as domestic use.

To summarise, the fish bone from Quoygrew has provided an interesting and important contribution to the spatial and chronological patterning of the Northern Isles. Within one site, a domestic farm mound contained fish for local, domestic use, while a fish midden contained similar species but provided evidence that some larger cod were being prepared and exported from the site. The intensification of fishing that occurred around

1000 influenced not only the rate of deposition of fish bone, but also the proportions of species used (and indirectly the sizes involved). Chapter Nine will compare the patterns from Quoygrew, which is likely to be a site of average status, to Earl's Bu, demonstrably a high status settlement, as well as other sites around the Northern Isles.

Chapter Six: Quoygrew Mammals

The aim of this chapter is to present the results of the mammal bone identified by the author. The emphasis is similar to the previous chapter which presented the results from the fish assemblage. Spatial comparisons between two main areas of the site – the shore-based fish midden and the inland farm mound (as introduced in Chapter Three) – and variation through time will be presented and discussed. The use of inter-site comparisons will be kept to a minimum in this chapter, but will be explored in more detail in Chapter Eight.

6.1 Recovery rates

Recovery for area G (i.e. phases i to viiii) included hand collection, >4mm and 2-4mm, while area A (i.e. phases 1.2, 2 and 7) was entirely sieved so had no hand collection. Consequently, when hand collection is discussed, it can only refer to area G mammal, and if area A is discussed, recovery can only be >4mm or 2-4mm.

Identification rates for mammals varied across the phases by recovery method and quantification code (Table 6.1; here and throughout, see methodology chapter for definitions), although the quantity of QC1 elements identified from the >4mm fraction was consistent at 2-3%. As expected, the hand collected fraction had higher rates of identification than the >4mm fraction. However, more variation was present in the hand collected assemblage than in the >4mm fraction, with similar identification rates from phases i and iii, but with phase ii showing about a 10% reduction in identification of QC1 and QC0 elements. This probably reflects a combination of economic and taphonomic factors that will be explored in more detail. Considering both hand collected and >4mm fractions together, the overall rate of identification was least in phase i and greatest in phase iii. Area A had no hand collected bone to compare with the phased data from area G, but overall rates of mammal identification were lower in area A than in any of the phases from area G. This probably relates to the tiny bone fragments recovered by sieving all sediment to >4mm.

Most of the elements from mammals of economic importance are captured by sieving to >4mm, or by hand collection. Some of the smaller and youngest cattle, caprine and pig bones will be underrepresented in hand collection because of their small size, as will be discussed below, but very few identifiable elements from large or medium mammals will ever be found in a 2-4mm sieve. Of the subset of 193 2-4mm samples analysed, only 12 recognisable large or medium mammal fragments were found, 11 of which were teeth (caprine, dog and larger cat). Rates of small mammal recovery by hand collection are varied and unreliable, and only the larger elements are likely to be found in a >4mm sieve (determined by use of the reference collection and personal experience). Consequently 193 2-4mm fractions from flotation samples were examined, corresponding for practical reasons to the subset of samples used for fish bone recovery. Few 2-4mm fractions contained any identifiable mammal bone, including 17% of flotation samples from area A, 14% from phase i, 55% from phase ii and 57% from phase iii. Almost all of these identifiable bones were from Orkney voles and mice (see section 6.8.9).

Phase	Recovery	QC4	QC1		QC0		Unidentified		TNB
Area A	2-4		4	33%	8	67%	0	0%	12
	4		32	2%	92	7%	1249	91%	1373
	Total		36	3%	100	7%	1249	90%	1385
Phase i	2-4		0	0%	3	100%	0	0%	3
	4		11	3%	49	12%	333	85%	393
	hc		8	23%	13	37%	14	40%	35
	Total		19	4%	65	15%	347	81%	431
Phase i/ii	hc		1	100%	0	0%	0	0%	1
	Total		1	100%	0	0%	0	0%	1
Phase ii	2-4		38	35%	71	65%	0	0%	109
	4		234	3%	575	7%	7402	90%	8211
	hc		506	13%	1155	29%	2293	58%	3954
	Total		778	6%	1801	15%	9695	79%	12274
Phase ii/iii	hc		6	29%	7	33%	8	38%	21
	Total		6	29%	7	33%	8	38%	21
Phase iii	2-4		17	43%	23	58%	0	0%	40
	4		225	3%	622	9%	5803	87%	6650
	hc	1	1391	21%	2531	39%	2596	40%	6519
	Total		1633	12%	3176	24%	8399	64%	13208
Phase iii/viii	hc		25	19%	31	24%	75	57%	131
	Total		25	19%	31	24%	75	57%	131
Phase viiii	hc		0	0%	0	0%	2	100%	2
	Total		0	0%	0	0%	2	100%	2
Grand Total		1	2498	9%	5180	19%	19775	72%	27454

Table 6.1: Identification by recovery method and quantification code (percentages show proportion of TNB for each recovery method)

6.2 Preservation

6.2.1 Texture

Bone texture was recorded for all QC1 elements on a scale of 1 (excellent) to 4 (poor). Over 80% of the mammal assemblage was divided equally between 2 (good) and 3 (fair), but neonatal and juvenile mammal bone (which make up much of the mammal assemblage, see section 6.5 for definitions and discussion), naturally tend towards a poorer texture than mature bone. Texture differences between phases or areas could therefore reflect differences in age distributions; likewise, differences between recovery methods could reflect real differences in textures, post-excavation biases, or differential recovery of neonatal and juvenile bone. Taking recovery methods first, post-excavation processing was basically similar for both fractions, although the sieved bones remained in storage for a period of time with other inclusions, including stone. Any post-excavation bias would therefore favour the texture of the hand collected assemblage. Neonates from both phases ii and iii have worse textures in the >4mm fraction than in the hand collected fraction, significantly so for phase iii (greatest difference 0.465, Kolmogorov-Smirnov Z value 3.192, significance 0.000), but no differences were observed for the other ages. This therefore indicates that overall, the neonatal bones probably suffered more from post excavation processing than did the more mature bone, although it is possible that hand collection favoured neonatal bones, or alternatively, bones with poor textures may have been more fragmented and thus better represented in the sieved material.

Looking then at differences in the mammal assemblage between phases, and maintaining the distinction between age groups, no differences were observed between the textures of phases ii and iii for the >4mm fraction, regardless of age group. Numbers were insufficient to compare phase i or area A at age group level. Significant differences were observed for the hand collected textures of juveniles (0.209, 2.039, 0.000) and neonates (0.311, 2.730, 0.000); for both age groups, phase iii had significantly better textures than phase ii (Table 6.2).

In conclusion, mammal texture differences were only important for juvenile and neonatal mammal bones, and for those age groups, phase iii had significantly better textures than phase ii (similar results were derived from the fish assemblage; see Chapter Five).

Recovery biases may have adversely influenced the textures of neonatal bones from sieved fractions, making them appear more poorly textured than neonatal bones from hand collection; or, bones with poor textures may have been more fragmented and therefore were better represented in the sieved material.

All mammal with texture recorded

Recovery	Texture	Area A		Phase i		Phase ii		Phase iii		Grand Total	
>4mm	1 (Excellent)	7	1%		0%	7	1%	26	2%	40	1%
	2	504	75%	5	16%	597	55%	851	69%	1957	64%
	3	149	22%	13	41%	419	38%	306	25%	887	29%
	4 (Poor)	13	2%	14	44%	71	6%	54	4%	152	5%
	Total	673	100%	32	100%	1094	100%	1237	100%	3036	100%
Hc	1				0%	42	8%	42	3%	84	4%
	2			5	63%	214	43%	517	38%	736	39%
	3			1	13%	154	31%	704	52%	859	46%
	4			2	25%	86	17%	101	7%	189	10%
	Total			8	100%	496	100%	1364	100%	1868	100%
Grand total		673		40		1590		2601		4904	

All juvenile mammal with texture recorded

Recovery	Texture	Area A		Phase i		Phase ii		Phase iii		Grand Total	
>4mm	1							2	3%	2	1%
	2	5				22	42%	13	17%	40	28%
	3	5		4		29	55%	51	67%	89	62%
	4					2	4%	10	13%	12	8%
	Total	10		4		53	100%	76	100%	143	100%
Hc	1					3	2%	1	0%	4	1%
	2					36	28%	124	33%	160	32%
	3					54	43%	225	61%	279	56%
	4			1		34	27%	21	6%	56	11%
	Total			1		127	100%	371	100%	499	100%

All neonatal mammal with texture recorded

Recovery	Texture	Area A		Phase i		Phase ii		Phase iii		Grand Total	
>4mm	1										
	2	1						1	2%	2	3%
	3	2				9	47%	19	37%	30	40%
	4			1		10	53%	32	62%	43	57%
	Total	3		1		19	100%	52	100%	75	100%
Hc	1										
	2			1		3	3%	12	2%	16	3%
	3					46	51%	412	83%	458	77%
	4			1		42	46%	75	15%	118	20%
	Total			2		91	100%	499	100%	592	100%

Table 6.2: Mammal texture by phase and recovery

6.2.2 Fragmentation

Fragmentation can be investigated using maximum linear dimension values or percent completeness scores recorded for all QC1 and QC4 specimens. Additionally, mammal fragmentation can be investigated using the overall size categories recorded at 2cm intervals for all fragments.

The histograms shown in Figure 6.1 are based upon the maximum linear dimensions recorded for all mammal QC1 and QC4 elements, and limited to values of 200mm and below (sizes for mammals ranged up to 350mm, although very few elements were longer than 200mm). Quantities for phase i and area A mammal were limited so will not be discussed further. Size differences between phases ii and iii were negligible for both recovery methods. These histograms show evidence of a slight bimodality, particularly apparent in the hand collected material because of its larger quantities. A secondary peak in sizes of around the 100mm size category is apparent, in addition to the primary peaks in the 25-35mm categories for the hand collected material and 15-25mm for the sieved material. This was also observed for mammal percent completeness scores (see below), and could represent different species and age combinations, two differing economic uses or various taphonomic phenomena. The results from cod dentaries of a fixed size, as presented in Chapter Five, indicated that the mean fragment size increased from phase ii to phases iii and 2. Fish bones are more highly fragmented in the older deposits, but there was little difference in mammal bone fragmentation. This suggests that mammal fragmentation remained consistent throughout, but some factors influenced the fish fragmentation patterning.

Percent completeness values, which are not directly influenced by age and species, can provide an indication of the rates of element breakage or usage. Percent completeness was recorded for all QC1 elements. Figure 6.5 illustrates the completeness rates by recovery and phase for all QC1 elements. Although mammal hand collection was thorough, it is immediately apparent that the 1-20% category is much higher for the >4mm fraction; this correlates with the maximum linear dimension evidence discussed above, providing further evidence that smaller sized fragments were not being recovered by hand. The 40-61% category is consistently lower than all others, regardless of phase or recovery: this may be a continuation of the bimodality observed above in fragment sizes, and possibly represents a combination of two or more economic, cultural or taphonomic pathways. The fish percent completeness scores do not display any unusual decrease in the 40-61% category (see Chapter Five), suggesting that the pattern observed for mammal is real, and not unconscious avoidance of the category by the author.

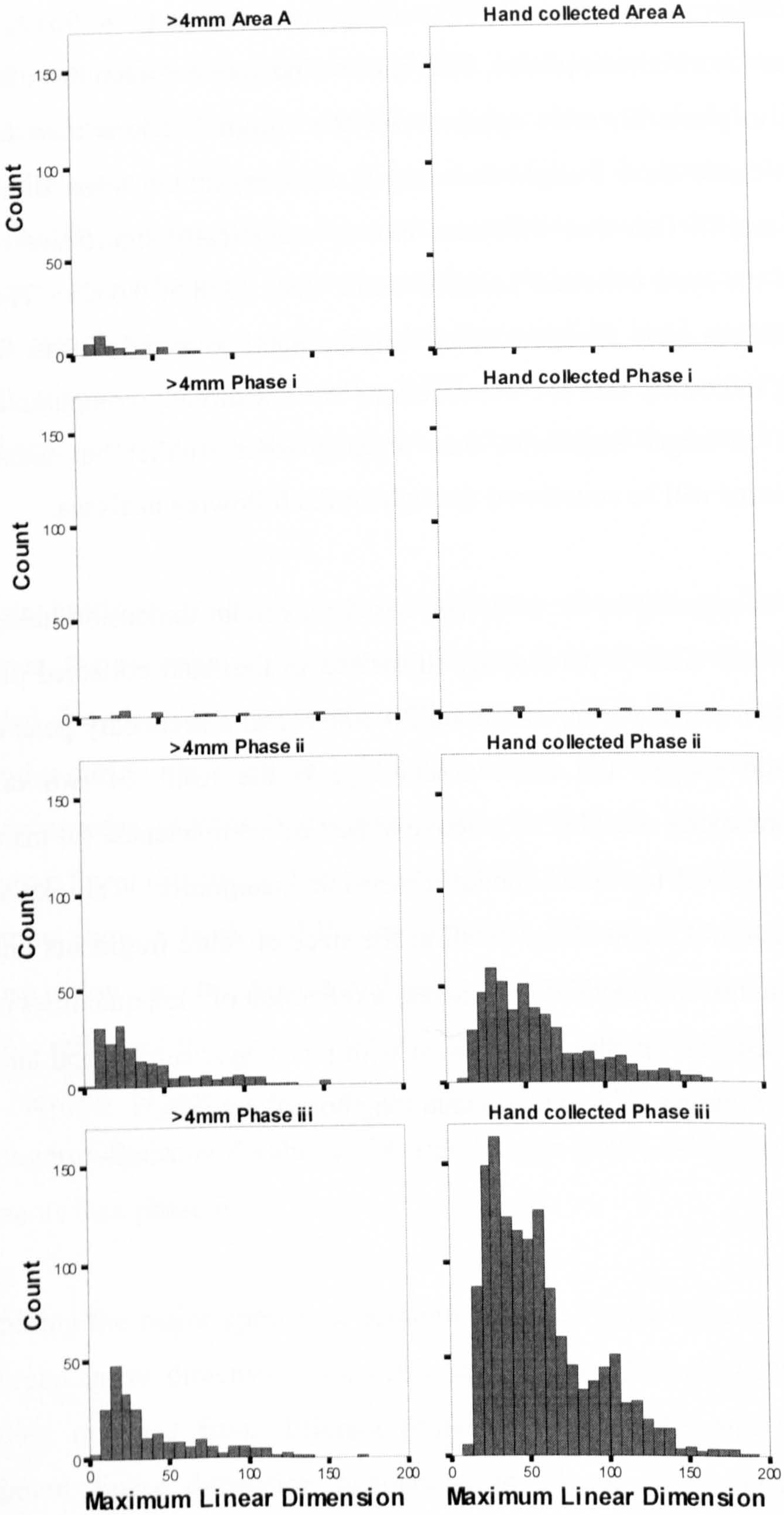
Statistical differences were observed between phases ii and iii of the mammal hand collected fraction (phase iii was more complete than phase ii: greatest difference 0.130, Kolmogorov-Smirnov Z value 2.474, significance 0.000). This difference continued to be significant within the cattle subset (0.202, 2.596, 0.000), but when adults and neonates were tested independently, no significant differences were found. Likewise, significant differences were found between phases ii and iii of the cattle >4mm fraction (0.313, 1.665, 0.008), but not within the adult or neonate subdivisions. The only significant differences found between recovery methods, phases and ages for caprines was between percent completeness scores for neonates recovered by hand, compared to those sieved, for all phases combined (0.346, 1.707, 0.006). In summary, mammal percent completeness scores indicate that phase ii was significantly more fragmented than phase iii.

Because levels of fragmentation can influence the rates of identification, and thus influence the recording of maximum linear dimension measures (which were only recorded for identified specimens), all mammal QC0 bones were grouped into size categories during identification. Although coarse, at 2cm intervals, these categories can provide an idea of overall fragment sizes, particularly when grouped with the QC1 maximum linear dimension data as shown in Figure 6.4. The hand collected assemblages appear to show a marked difference between phases, even when phase i is ignored because of low counts. Area A and phase iii mammal have very similar fragment sizes, possibly reflecting their similar chronologies. The only statistically significant difference was between phases ii and iii of the >4mm fraction (greatest difference 0.065, Kolmogorov-Smirnov Z value 2.074, significance 0.000), with phase iii containing larger fragments than phase ii.

Examining the major species of economic value, Figure 6.2 and Figure 6.3 present the maximum linear dimensions for cattle and caprine QC1 elements, thus separating the variation resulting from different proportions of smaller and larger animals in the maximum linear dimension histograms in Figure 6.1. (Quantities of pig were insufficient.) Recovery biases were a possible source of variation, so therefore each age group was analysed separately by comparing the maximum linear dimension scores from hand collection with those from >4mm sieving. The following were significantly smaller in the sieved portion and thus were likely to be under-represented by hand collection:

cattle juveniles (n 251, Mann-Whitney U 3039.5, significance 0.001); cattle neonates (504, 5917.0, 0.000); caprine adults (360, 5183.5.0, 0.000); caprine sub-adults (92, 241.0, 0.006); caprine juveniles (318, 5850.5, 0.000) and caprine neonates (144, 961.5, 0.000). Looking then at variation between phases, both species indicate a reduction in fragment size from phase ii to phase iii, more apparent for the >4mm fractions than for hand collected material. Cattle show a slight decrease in mean maximum linear dimensions between phases ii and iii (but this difference is only statistically significant between phases ii and iii of the hand collected juvenile cattle: 204, 3338.5, 0.032). The mean sizes for >4mm fractions were always smaller than the hand collected means, for both species and phases, indicating that the two fractions are not directly comparable: hand collection focussed on larger fragments, thus missing some smaller but identifiable fragments. These biases will be considered throughout the following analyses.

A slight bimodality is apparent in the cattle age-based maximum dimension histograms, as shown in Figure 6.2. This is particularly illustrated in the hand collected phase iii histogram, which has a primary peak of around 20-30mm and a secondary peak around 100mm. This would suggest the cattle assemblage is the result of two or more populations. This bimodality was also seen above in percent completeness for mammals, and in the overall mammal maximum linear dimension histograms. The explanation became apparent when looking in closer detail at the sizes of cattle fragments linked to various ages and elements: the bimodality is merely a reflection of high quantities of very small but unbroken neonatal epiphyses combined with phalanges, carpals and tarsals of all ages, and a cluster of larger unbroken neonatal long bone diaphyses.



Area A
>4mm
Count: 32
Mean: 27.4

Phase i
>4mm
Count: 11
Mean: 58.1

Hc
Count: 8
Mean: 108.1

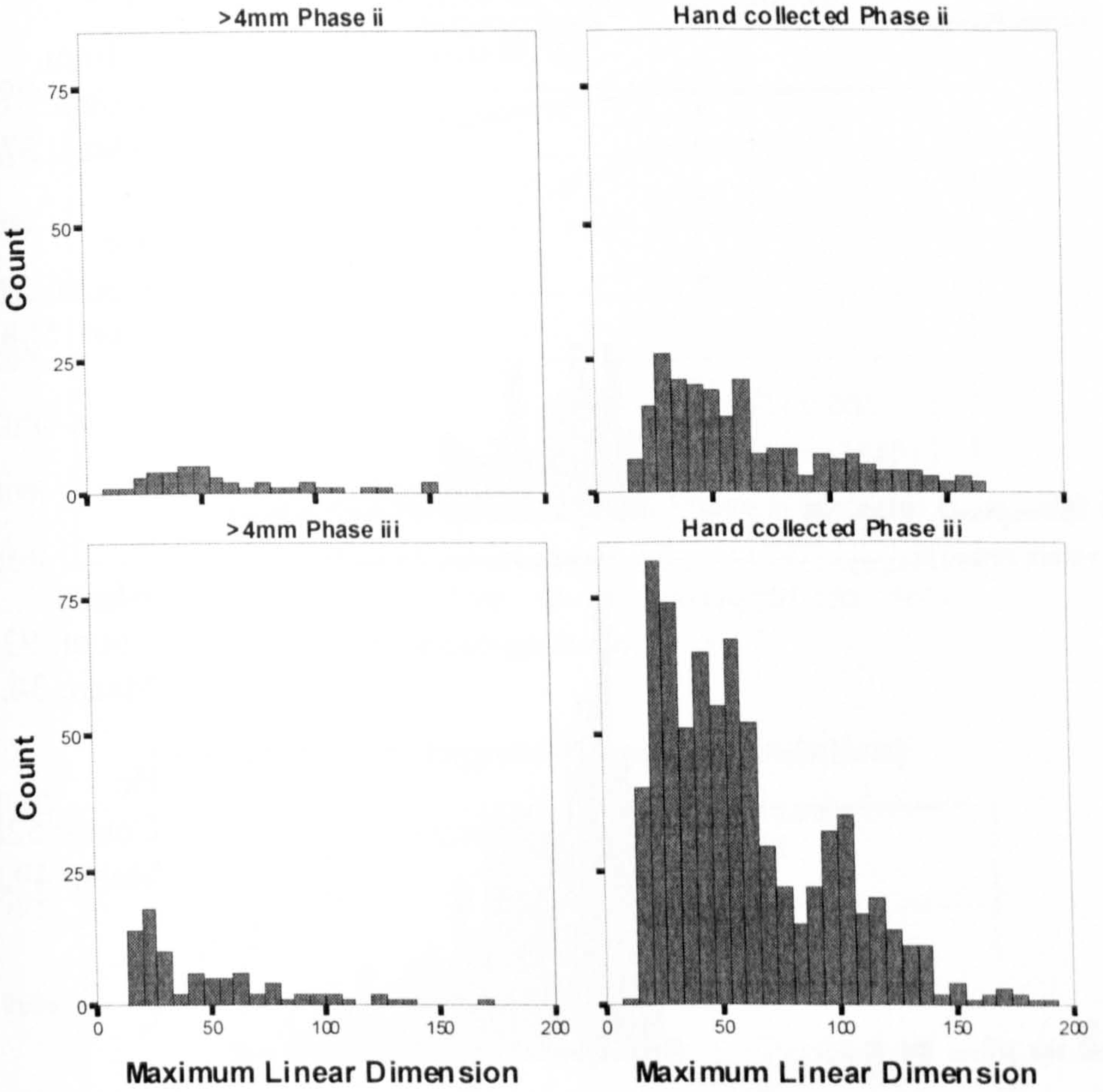
Phase ii
>4mm
Count: 234
Mean: 39.9

Hc
Count: 506
Mean: 58.0

Phase iii
>4mm
Count: 225
Mean: 39.8

Hc
Count: 1392
Mean: 57.1

Figure 6.1: Maximum linear dimension histograms for QC1 and QC4 mammals (in mm, cut off at 200mm)



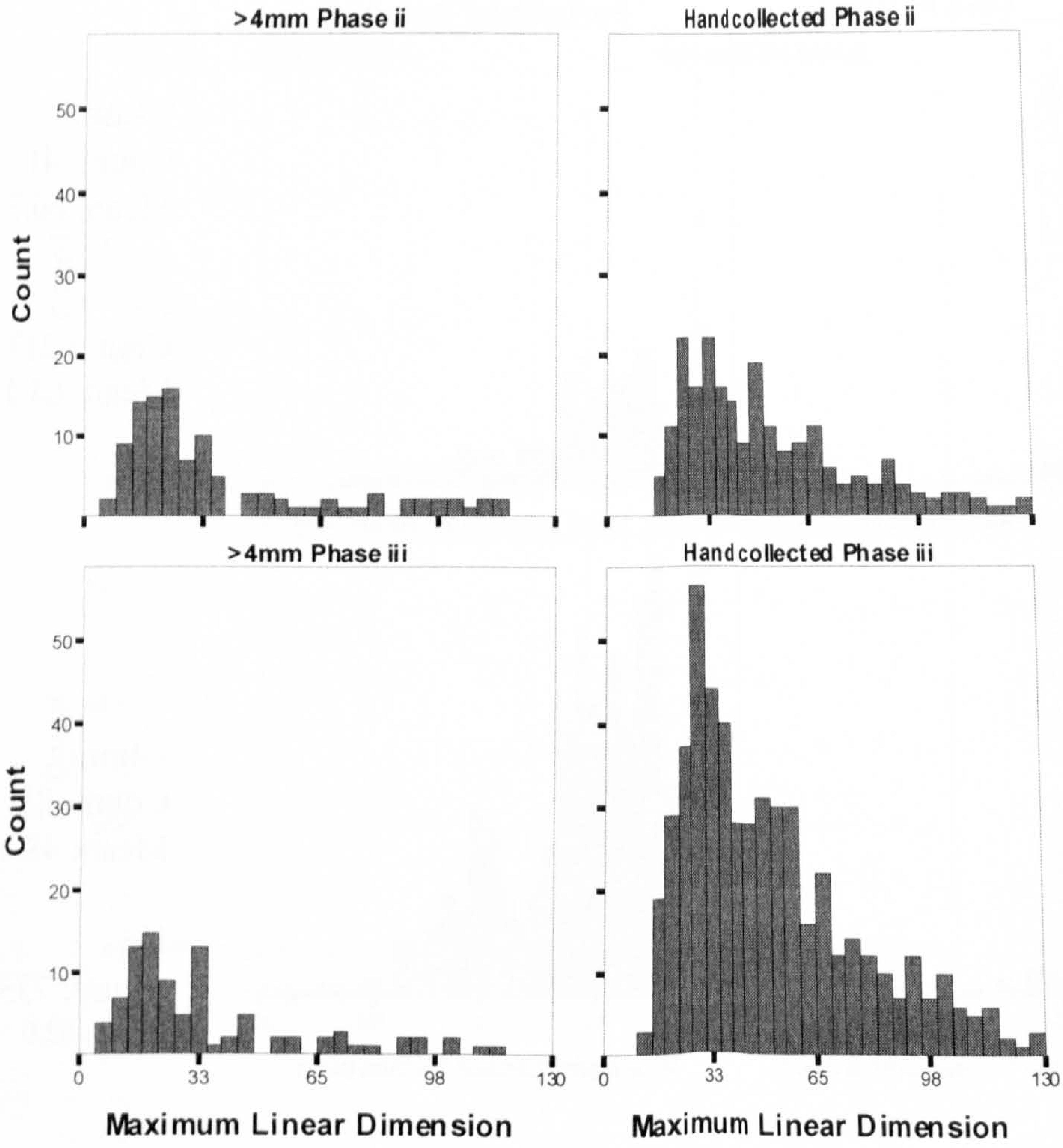
>4mm
Count: 41
Mean: 60.7

Hc
Count: 217
Mean: 64.4

>4mm
Count: 85
Mean: 48.4

Hc
Count: 735
Mean: 62.0

Figure 6.2: Cattle QC1 maximum linear dimensions (in mm, cut off at 200mm)



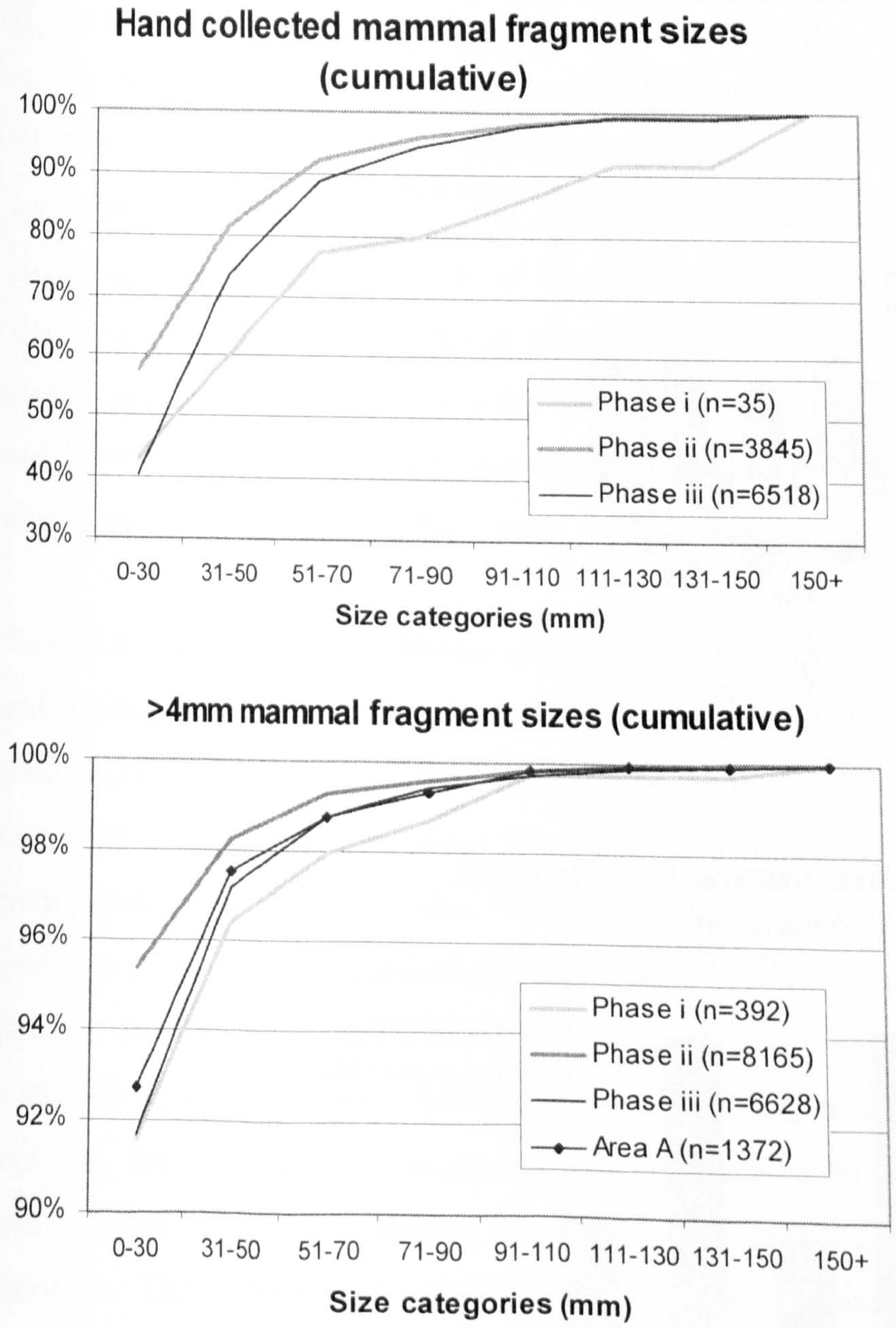
>4mm
Count: 108
Mean: 37.6

Hc
Count: 222
Mean: 51.8

>4mm
Count: 93
Mean: 34.7

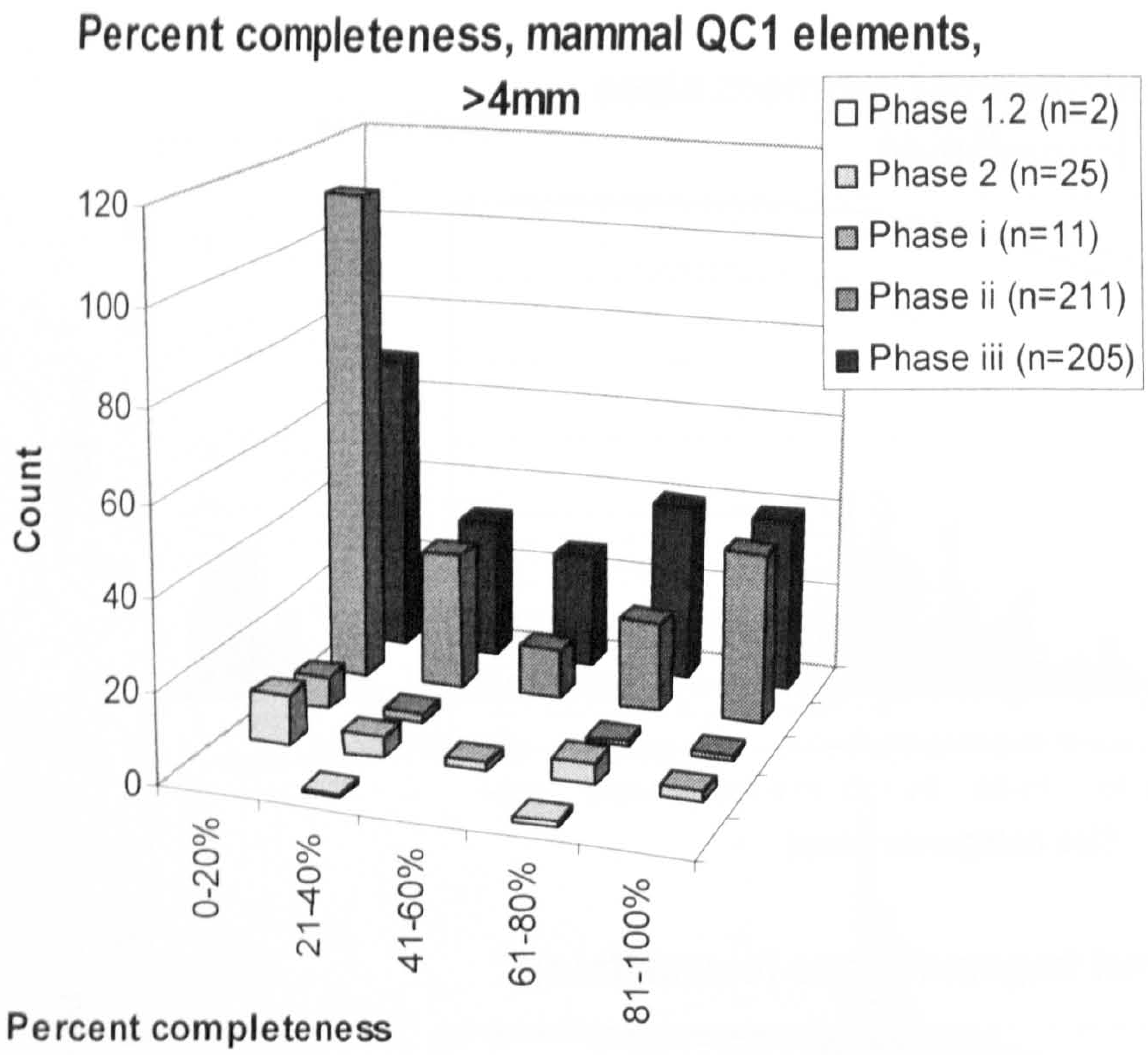
Hc
Count: 528
Mean: 49.8

Figure 6.3: Caprine QC1 maximum linear dimensions (in mm, cut off at 130mm)


Hand collected mammal fragment sizes (cumulative)

>4mm mammal fragment sizes (cumulative)

Figure 6.4: Fragment sizes for all data, by recovery method



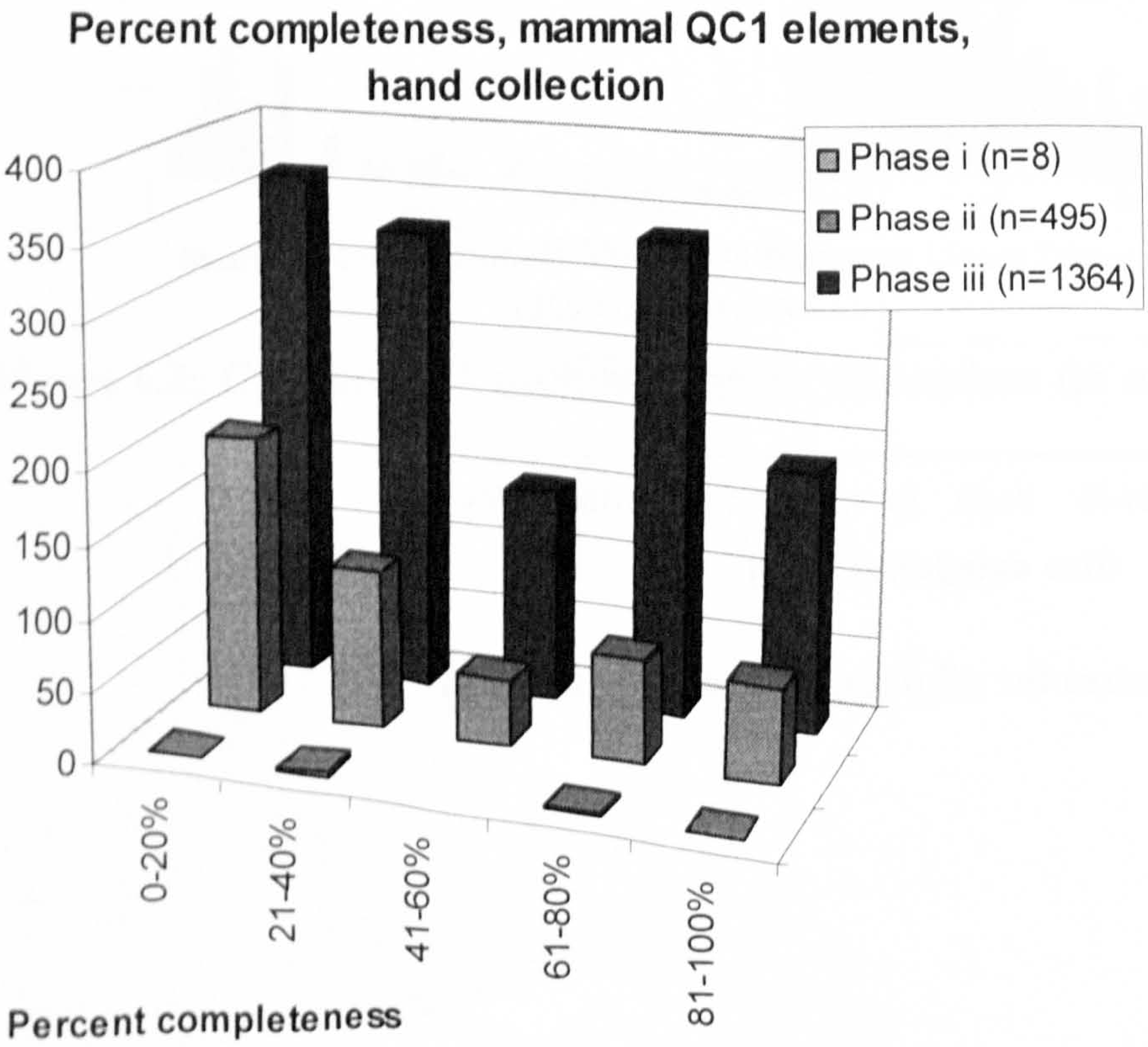


Figure 6.5: Mammal QC1 percent completeness

6.2.3 Other taphonomic alterations

A few fragments showed evidence of taphonomic alterations, including burning, butchery (summarised below), digestion, tooth marks, etc. Excluding burnt specimens, only nine fragments were noticeably different in colour from the rest of the mammal assemblage, indicating low levels of disturbance or intrusive activity. One possible rabbit vertebra from G052 differed in colour and was probably intrusive (historical sources suggest a 17th century date for their arrival in Orkney (Berry 1985, 139; Booth and Booth 1994, 8) but this was not considered a problem because it was found soon after re-opening the midden at the start of an excavation season.

Table 6.3 summarises the evidence using counts for burning within the mammal bone, and is complemented by Table 6.4, which displays the same data using weights rather than counts. These indicate that burning was by far the most common alteration, with up to half of all fragments from phase 2 burnt (equivalent to 30% by weight). The results from phases ii and iii were similar, with about 40% by count or 20% by weight showing evidence of burning; phase i had slightly less at 35% by count, under 10% by weight. Because burning has a detrimental effect on identification, far lower percentages of identified bones were burnt. Using the >4mm dataset, burning decreased for caprines and pigs, from 30% and 15% in phase i respectively, to 15% and 7% by phase iii. There was no burnt cattle bone in phase i, but quantities decreased from 6% in phase ii to 3% in phase iii. This pattern may relate to the differences in preservation noted above, or to changing refuse disposal strategies.

Mammal fresh breakage was present throughout most contexts at a low level (136 fragments). These tended to be larger elements, including ribs, scapulae and crania, and most tended to be over 5cm long even when broken. Larger cetacean elements were very susceptible to fresh breakage, but most were easily reassembled. Processing and transportation were the likely cause, and affect on the assemblage was minimal.

Summaries of carnivore activity (gnawing and acid etching), rodent gnawing, and root etching were provided in Chapter Five. Carnivore gnawing was the most common alteration, being found throughout the assemblage at a consistently low frequency, averaging less than 0.3%. It was unlikely to have had a detrimental affect on the assemblage, given that all mammal elements were present (see section 6.4), even those easily destroyed by carnivore attrition (Lyman 1994, 249). None of these various modifications would have provided anything but a minimal influence on the assemblage (see section 6.8.3 for more on carnivore gnawing).

Phases	>4mm		Hand collected	
1.2	45	34.9%		
2	594	50.4%		
7	4	6.1%		
i	139	35.4%	1	2.9%
ii	3342	40.7%	183	4.6%
iii	2605	39.2%	244	3.7%

Table 6.3: Mammal burning by count (percentages of TNB)

Phase	>4mm		Hand collected	
1.2	8.1	25.2%		
2	150.8	30.1%		
7	0.9	7.8%		
i	26.82	7.5%	26.82	0.2%
ii	744.89	19.9%	744.89	3.6%
iii	637.48	17.4%	637.48	2.6%

Table 6.4: Mammal burning by weight in grams (percentages of total weights)

6.2.4 Taphonomic summary

The taphonomic analyses discussed above can be summarised as follows:

Post-excavation processing variation

- hand collected neonatal mammal bones have a significantly better texture than sieved, possibly caused by difference in post-excavation processing, or by the under-representation of poorly textured neonates by hand collection

Recovery variation

- smaller sized fragments of caprines of all ages are under-represented by hand collection
- smaller sized juvenile and neonatal cattle are under-represented by hand collection

Phase and area variation

- phase iii hand collected juvenile and neonatal mammal bones have better textures than phase ii
- mammal fragmentation and completeness scores indicate fragments from phases 2 and iii were larger and more complete than phase ii

Other observations

- bimodal distributions were noted in phase ii and iii maximum linear dimension histograms, and in percent completeness scores, but simply reflected two separate clusters of epiphyses and diaphyses

6.3 Summary of species

A total of 6597 mammal elements were identified to 22 different species or species groupings from an assemblage consisting of over 27,000 mammal fragments. One amphibian element from phase 2 was identified as a frog or toad and will not be further discussed. Table 6.5 provides a summary of the mammals identified by phase, quantified by basic NISP data. The minor transitional phases of i/ii and ii/iii and the small phases that post date iii are summarised in Table 6.7 and will not be discussed further. Percentages indicate the proportion of the identified subset represented by each species. The range of species represented is to be expected for an Orcadian site of this period, given the size of the assemblage and the sampling strategy applied. The assemblage is dominated by the main domestic species: cattle, caprines, pigs, large mammal sized fragments (likely to be cattle) and "medium mammal 1" sized fragments (likely to be caprine or pig) make up 97% of the identified subset. Each of the main domestic species is discussed below (see section 6.4 for element distributions, 6.5 for ageing, and 6.7 for pathologies). The other mammal species are discussed separately in section 6.8.

	Area A			Area G					
	1.2	2	7	i		ii		iii	
Common name	>2mm	>2mm	>2mm	>2mm	hc	>2mm	hc	>2mm	hc
Seal				3		1	3	6	20
Whale sp.						2	2	2	9
Dog							2	2	3
Cat		1					9	6	16
Horse							4	1	7
Pig	1	6	1	2	1	19	124	57	74
Red deer							2		
Cattle		4		10	5	68	301	126	1048
Caprine	1	33		6	2	193	292	167	800
(of which sheep)								6	25
(of which goat)									1
Vole or mouse		4		2		6		10	
Vole species						8	1	8	1
Orkney vole				1		87		20	
Mouse sp.								2	
Wood Mouse		1				4		5	
House Mouse								1	
Rabbit		1	2					2	2
Small mammal		7	1			26		2	
Medium mammal 2				2		8	4	3	2
Medium mammal 1	6	29	3	13	12	172	494	234	1057
Large mammal		5		5	1	45	260	100	327
Sea mammal							5		1
Other								2	
Total identified	8	91	7	44	21	639	1503	756	3367
Unidentified	121	1099	59	352	14	7681	2451	5934	3152
Total	129	1190	66	396	35	8320	3954	6690	6519

Table 6.5: NISP by count and recovery method (QC 0, 1, 4; sieved fractions include subset of 2-4mm identified species, but unidentified bone only counted for >4mm)

	Area A			Area G					
	1.2	2	7	i		ii		iii	
Common name	>2mm	>2mm	>2mm	>2mm	hc	>2mm	hc	>2mm	hc
Seal				6.8%		0.2%	0.2%	0.8%	0.6%
Whale sp.						0.3%	0.1%	0.3%	0.3%
Dog							0.1%	0.3%	0.1%
Cat		1.1%					0.6%	0.8%	0.5%
Horse							0.3%	0.1%	0.2%
Pig	12.5%	6.6%	14.3%	4.5%	4.8%	3%	8.3%	7.5%	2.2%
Red deer							0.1%		
Cattle		4.4%		22.7%	23.8%	10.6%	20%	16.7%	31.1%
Caprine	12.5%	36.3%		13.6%	9.5%	30.2%	19.4%	22.1%	23.8%
(of which sheep)								0.8%	0.7%
(of which goat)									0%
Vole or mouse		4.4%		4.5%		0.9%		1.3%	
Vole species						1.3%	0.1%	1.1%	0%
Orkney vole				2.3%		13.6%		2.6%	
Mouse sp.								0.3%	
Wood Mouse		1.1%				0.6%		0.7%	
House Mouse								0.1%	
Rabbit		1.1%	28.6%					0.3%	0.1%
Small mammal		7.7%	14.3%			4.1%		0.3%	
Medium mammal 2				4.5%		1.3%	0.3%	0.4%	0.1%
Medium mammal 1	75%	31.9%	42.9%	29.5%	57.1%	26.9%	32.9%	31%	31.4%
Large mammal		5.5%		11.4%	4.8%	7%	17.3%	13.2%	9.7%
Sea mammal							0.3%		0%
Other								0.3%	
Total identified	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 6.6: NISP by percent and recovery method (QC 0, 1, 4; sieved fractions include subset of 2-4mm identified species, but unidentified bone only counted for >4mm)

Common name	i/ii	ii/iii	iii/viii	viiii	Unphased
Sea mammal				1	
Dog			2		
Cat			1		
Horse			1		
Pig	1	2	3		
Pig?			1		
Cattle		1	9		4
Sheep/ Goat		4	20		2
Sheep		1			
Medium Mammal 1		4	7		
Large Mammal			4		
Unidentifiable Mammal		9	83	1	
Grand Total	1	21	131	2	6

Table 6.7: NISP for minor phases

6.3.1 Cattle, caprines and pigs

Table 6.8 indicates the raw counts and percent proportions for the main domestic species, by recovery method and phase. The few probable identifications have been grouped with definite for clarity, and definite sheep or goat identifications have been grouped into the caprine category (used here and throughout). Cattle and caprines dominate in varying proportions, while pigs remain constant at less than 10% of the domestic species, decreasing slightly from phase ii to phase iii when using overall percentages, but increasing slightly in the sieved subset. Cattle represent from 24 to 32% of the hand collected domestic species in area G, but 14 to 28% of the sieved material in that area. Cattle represent only 5% of the sieved material in phase 2. In contrast, caprines represent 42% of the sieved material in phase 2, and 17 to 38% in area G. The hand collected caprine bone varies from 10 to 24% in area G. The hand collection bias caused by under-representation of all small caprine fragments, compared to the under-representation of only juvenile and neonatal cattle (see section 5.2.4), could explain the difference between recovery methods. Considering only the >4mm fraction, caprines constantly outnumber cattle in all phases except phase i (where sample sizes are low). A real difference can be observed between the largest two phases: phase ii has considerably more caprines by sieving and equal quantities by hand collection, whereas phase iii has only slightly more caprines by sieving but considerably more cattle by hand collection. Allowing for the bias in hand collection, caprines outnumber cattle only in phase ii. This is consistent with overall proportions of large to medium mammal: only >4mm phase ii medium mammals are present in higher quantities than large mammals.

The ratio of cattle to caprines using NISP data was used to compare the relative proportions of species from the hand collected subset of the two largest phases (QC1 elements only, illustrated in Figure 6.6). Despite the bias towards over-representation of older cattle in the hand collected subset, considerably higher quantities were recovered by hand collection than by sieving; hand collection is therefore less susceptible to random variation because of its much larger sample size. The ratio was relatively constant at around one caprine fragment to one cattle fragment, although phase iii had a higher ratio (i.e. slightly more cattle) than phase ii – consistent with basic NISP data. Each element is approximately a similar proportion to every other element, suggesting caprines and cattle elements were of similar economic value, or were processed in a broadly similar way. Smaller caprine elements are known to be under-represented in the hand collected assemblage (see section 6.2); thus the ratios for second and third caprine phalanges compared to cattle are artificially low.

			Large mammal	Cattle	Medium mammal 1	Caprine	Pig	Total
Phase 2	>4mm	NISP	5	4	29	32	6	76
		%	6.6%	5.3%	**38.2%**	**42.1%**	7.9%	100%
Phase i	>4mm	NISP	5	10	13	6	2	36
		%	13.9%	27.8%	36.1%	16.7%	5.6%	100%
	Hc	NISP	1	5	12	2	1	21
		%	4.8%	23.8%	**57.1%**	9.5%	4.8%	100%
	Total	NISP	6	15	25	8	3	57
		%	10.5%	26.3%	**43.9%**	14%	5.3%	100%
Phase ii	>4mm	NISP	45	68	171	188	19	491
		%	9.2%	13.8%	34.8%	**38.3%**	3.9%	100%
	Hc	NISP	260	301	494	292	124	1471
		%	**17.7%**	20.5%	33.6%	19.9%	8.4%	100%
	Total	NISP	305	369	665	480	143	1962
		%	15.5%	18.8%	33.9%	24.5%	7.3%	100%
Phase iii	>4mm	NISP	100	126	234	165	57	682
		%	14.7%	18.5%	34.3%	24.2%	8.4%	100%
	Hc	NISP	327	1048	1057	800	74	3306
		%	9.9%	**31.7%**	32%	24.2%	2.2%	100%
	Total	NISP	427	1174	1291	965	131	3988
		%	10.7%	29.4%	32.4%	24.2%	3.3%	100%
Grand total		NISP	743	743	1562	2010	1485	283
		%	12.2%	25.7%	33%	24.4%	4.7%	100%

Values in bold indicates values 5% greater than the total; underlined values are 5% less than the total

Table 6.8: NISP by recovery for main domestics, QC0, 1, 4

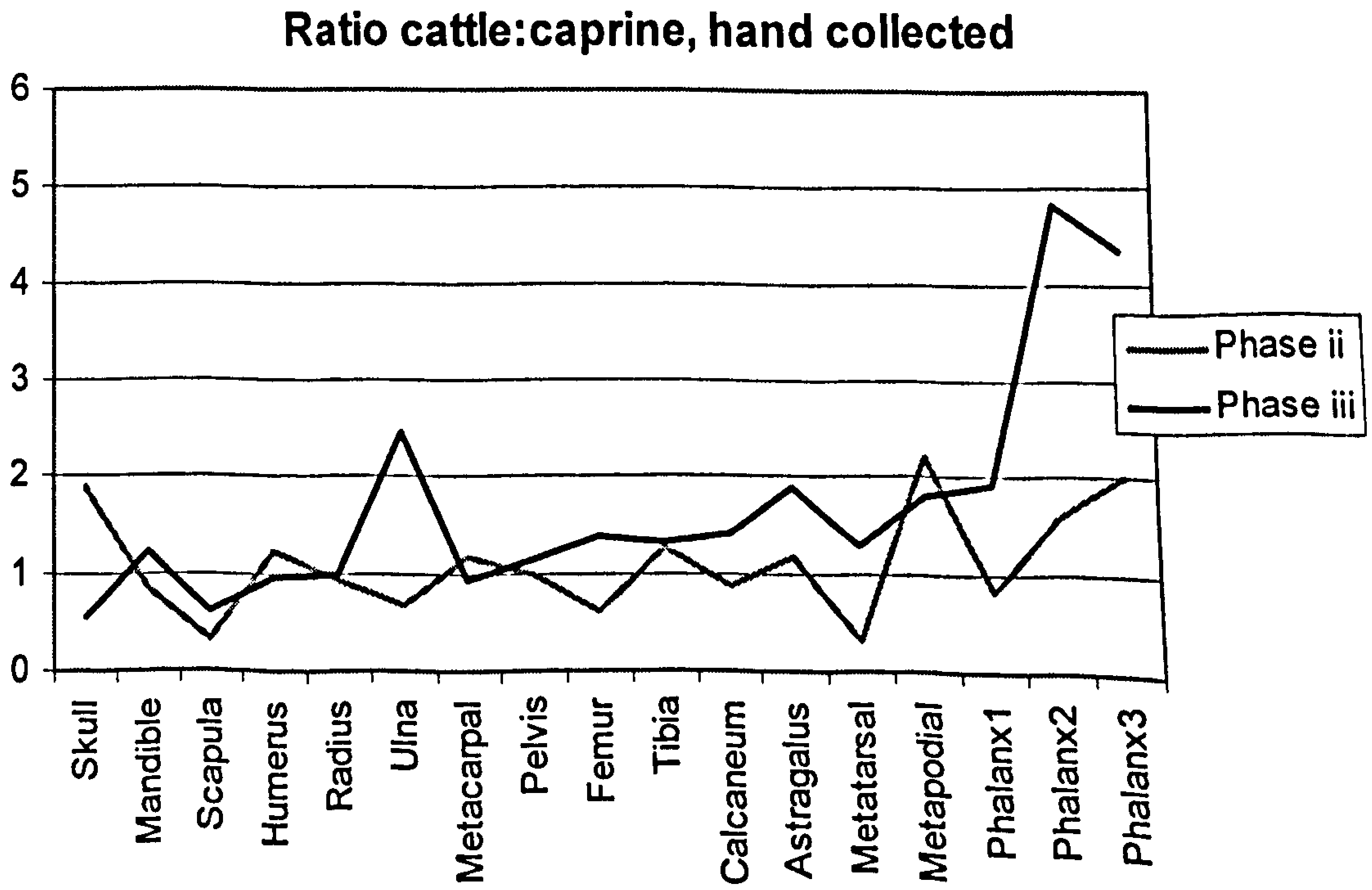


Figure 6.6: Ratio cattle to caprine, hand collected

6.4 Elements

QC1 element representations are presented by NISP in Table 6.9, Table 6.10 and Table 6.11, separated by recovery method for cattle and caprines, but not for pigs because of their low quantities. Cattle mandibles show the most variation of any QC1 element between phases, probably because phase ii is more fragmented than phase iii and thus has more loose teeth. Although metapodials appear to be higher in phase ii, when quantified with metacarpals and metatarsals, the difference lessens. Cattle second and third phalanges occur in considerably higher proportions in phase iii. Because these variations appear in the both the sieved and hand collected portions, they are not the result of recovery biases, but they may reflect the increased fragmentation in phase ii, which made these elements more difficult to identify. A Chi-Square test on element counts revealed significant differences between phases ii and iii (hand collected: Chi-Square value 43.988, 16 degrees of freedom, significance 0.000; total dataset: 57.247, 16, 0.000); this likely reflected the difference in preservation and fragmentation between phases rather than economic patterning.

The most considerable variation in caprine QC1 elements is again differing mandible proportions: phase ii has a much greater proportion than phase iii. Metapodials are also variable: when combined with the metacarpals and metatarsals, they are over-represented in phase ii >4mm compared to phase iii. In contrast, the pelvis is under-represented in phase ii >4mm compared to phase iii >4mm. Significant differences were identified between phases ii and iii when the >4mm and hand collected data are combined (29.318, 16, 0.022, one cell with expected count <5.0), but not within the hand collected subset alone (0.940, 16, 0.813, two cells with expected counts <5.0). Thus these results most likely reflect interrelated fragmentation and recovery differences.

Pig specimens were low in quantity, so hand collected and sieved material were combined; any younger individuals will therefore be under-represented. The largest difference in element proportions was the over-representation of phase ii metapodials, compared to phase iii. When summed with metacarpals and metatarsals, this difference continued; they were over-represented in phase ii. However, the quantities were insufficient for statistical testing.

In summary, the NISP data show the following differences between phases ii and iii: cattle mandibles decrease, radii decrease, and second and third phalanges increase; caprine mandibles decrease, metapodials decrease, and pelves increase; and pig metapodials decrease.

Rather than indicating butchering and disposal patterns, these observed differences probably relate to a combination of the relative occurrence of each element within the body, the number of identifiable zones within each element, the level of fragmentation, and differing mortality profiles (which influence rates of identification and fragmentation). For example, the high incidences of mandibles may be the result of the excellent preservation of teeth (because the 'mandible' category includes all loose fourth premolars and molars), and differences in mandible quantities for cattle and caprines may reflect differing levels of fragmentation. Phase ii has lower percent completeness scores than phase iii, so the higher mandible counts in phase ii are to be expected. Similarly high counts of mandibles have been noted at other sites in the Northern Isles (e.g. Sandwick North, Barrett and Oltmann 2000, 16).

In order to control for these issues, MNE (minimum number of elements) was calculated for each element using the maximum recorded value for any one diagnostic zone, taking into account each age group (see section 6.5) and side (the greatest of left or right was used for non-midline elements), and frequency of occurrence in each species (e.g. the greatest of the left or right value for cattle phalanges was then divided by four to equally compare to other paired limb bones). These used the combined >4mm and sieved dataset. The results are displayed as Figure 6.7 to Figure 6.9; basic NISP data is also shown, separated by age groupings.

Based on cattle MNE (Table 6.12, Figure 6.7), phase iii shows a more constant level across all large elements compared to phase ii. This is to be expected, given its larger sample size. In phase ii, the phalanges are constantly lower than other elements, while the metapodials, radii, mandibles and skulls are higher than the norm. In phase iii, the phalanges are again lower compared to all other elements, which is a predictable recovery bias. The skull appears to be under-represented, but this must represent random variation because the mandible is again more abundant than other elements. A difference in age distributions can also be seen between phase ii and iii: phase iii has a much higher frequency of neonatal elements than phase ii. This is discussed further in section 6.5.

Caprine MNE (Table 6.13, Figure 6.8) also show minor differences between phases ii and iii. In phase ii, the mandible is over-represented while the ulna and the final two phalanges are under-represented. In phase iii, the ulna and final two phalanges are again under-represented, while no one element is over-represented. Because MNE was calculated on combined sieved and hand collected material, the under-representation of smaller elements is to be expected (see section 6.2); the pattern displayed by the ulna and phalanges is therefore a recovery bias.

MNE and NISP values for pig (Table 6.14, Figure 6.9) were small, making identification of element patterning difficult. No considerable over- or under-representations were observed.

In summary, the element pattern is consistent with all parts of the skeleton being used at Quoygrew, with no elements removed or added. Some significant differences were observed for the cattle hand collected subset when quantified by NISP, probably resulting from differences in fragmentation levels. These are unlikely to represent economic patterning.

Element	Phase 2	Phase i		Phase ii						Phase iii					
	>4mm	>4mm	hc	>4mm		Hc		total		>4mm		hc		Total	
	NISP	NISP	NISP	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
Skull				2	4	15	**7**	17	**7**			10	**1**	10	**1**
Mandible			1	13	**29**	33	15	46	**18**	5	6	84	11	89	**11**
Scapula			1			5	2	5	2			25	3	25	3
Humerus	1	1	1	1	2	16	7	17	7	5	6	45	6	50	6
Radius	1			4	9	15	7	19	7	3	**3**	47	6	50	6
Ulna				1	2	2	1	3	1	2	2	22	3	24	3
Metacarpal		1		2	4	13	6	15	6	4	5	43	6	47	6
Pelvis		1		1	2	17	8	18	7	4	5	41	6	45	5
Femur		2		1	2	8	4	9	3	5	6	48	7	53	6
Tibia				2	4	14	7	16	6	3	3	45	6	48	6
Astragalus				1	2	7	3	8	3	2	2	32	4	34	4
Calcaneum				2	4	7	3	9	3	3	3	27	4	30	4
Metatarsal			2	1	2	5	2	6	2	3	3	35	5	38	5
Metapodial				7	**16**	22	10	29	**11**	10	**11**	41	6	51	6
Phalanx1				4	9	14	7	18	7	11	13	80	11	91	11
Phalanx2				2	4	11	5	13	5	15	**17**	58	8	73	9
Phalanx3	1			1	**2**	10	5	11	4	12	**14**	48	7	60	7
Totals	3	5	5	45	100	215	100	260	100	88	100	732	100	820	100

Differences of 5% or greater are in bold

Table 6.9: QC1 cattle NISP by element

Element	Phase 2	Phase i		Phase ii						Phase iii					
	>4mm	>4mm	hc	>4mm		hc		total		>4mm		hc		total	
	NISP	NISP	NISP	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
Skull		1		3	3	8	4	11	3	5	5	17	3	22	4
Mandible	1	1		24	**20**	39	**18**	63	**19**	7	**7**	68	**13**	75	**12**
Scapula				2	2	19	9	21	6	4	4	41	8	45	7
Humerus	1		1	2	2	13	6	15	4	7	7	47	9	54	9
Radius	1	1		5	4	16	7	21	6	4	4	47	9	51	8
Ulna					0	3	1	3	1	1	1	9	2	10	2
Metacarpal	1		1	4	3	11	5	15	4	6	6	46	9	52	8
Pelvis				5	4	18	8	23	7	9	**10**	36	7	45	7
Femur	4			6	5	13	6	19	6	2	2	35	7	37	6
Tibia	1			6	5	11	5	17	5	4	4	34	6	38	6
Calcaneum	2			5	4	8	4	13	4		0	19	4	19	3
Astragalus				4	3	6	3	10	3	6	6	17	3	23	4
Metatarsal	1			4	3	16	7	20	6	4	4	27	5	31	5
Metapodial	2	1		16	**14**	10	5	26	8	5	**5**	23	4	28	4
Phalanx1	1			10	8	17	8	27	8	11	12	42	8	53	8
Phalanx2	1	1		15	13	7	3	22	7	10	11	12	2	22	4
Phalanx3				7	6	5	2	12	4	9	10	11	2	20	3
Totals	16	5	2	118	100	220	100	338	100	94	100	531	100	625	100

Differences of 5% or greater are in bold

Table 6.10: QC1 caprine NISP by element

Element	Phase ii		Phase iii	
	NISP	%	NISP	%
Skull	1	3%	3	5%
Mandible	7	20%	12	18%
Scapula			1	2%
Humerus	2	6%	6	9%
Radius	1	3%	1	2%
Ulna			5	8%
Metacarpal			1	2%
Metacarpal3	1	3%	2	3%
Metacarpal4			2	3%
Pelvis	3	9%	7	11%
Femur			1	2%
Tibia	2	6%		
Calcaneum			3	5%
Astragalus			1	2%
Metatarsal	1	3%		
Metatarsal3	1	3%		
Metatarsal5			1	2%
Metapodial	8	23%	2	3%
Phalanx1	1	3%	3	5%
Phalanx2	5	14%	5	8%
Phalanx3			5	8%
Lateral phalanx	2	6%	5	8%
Totals	35	100%	66	100%

Table 6.11: QC1 pig NISP by element, combined hand collected and sieved

	Phase ii						Phase iii					
	None	Adult	Sub-adult	Juvenile	Neonate	Total	None	Adult	Sub-adult	Juvenile	Neonate	Total
Skull	5.5	1	0	1	1	8.5	2.5	1	0	2	0	5.5
Mandible	6	4	1	1	1	13	4	8	0	13	4	29
Scapula	1	1	0	2	0	4	1	4	0	2	6	13
Humerus	0	1	1	2	4	8	0	2	0	2	11	15
Radius	0	2	1	4	5	12	0	5	1	2	11	19
Ulna	0	1	0	2	0	3	0	3	1	3	6	13
Metacarpal	0	4	1	1	2	8	0	6	0	4	9	19
Pelvis	0	2	1	1	3	7	0	2	0	3	14	19
Femur	0	1	1	1	3	6	0	2	2	3	14	21
Tibia	1	2	1	2	2	8	0	2	1	5	8	16
Calcaneum	0	1	1	2	2	6	0	1	4	6	8	19
Astragalus	0	3	0	3	0	6	0	2	1	6	12	21
Metatarsal	0	2	0.5	2	0	4.5	0	5	0	4	10	19
Metapodial	1	2.5	2	3.5	4	13	0	3.5	0.5	1.5	15.5	21
¼Phalanx1	0	1	0	0.75	0.25	2	0	3.25	0.25	1.75	4.25	9.5
¼Phalanx2	0	0.75	0	0.75	0.5	2	0	2.75	0.25	1.25	4.75	9
¼Phalanx3	0	1.25	0	0.25	0.25	1.75	0	3.25	0	1.75	3	8

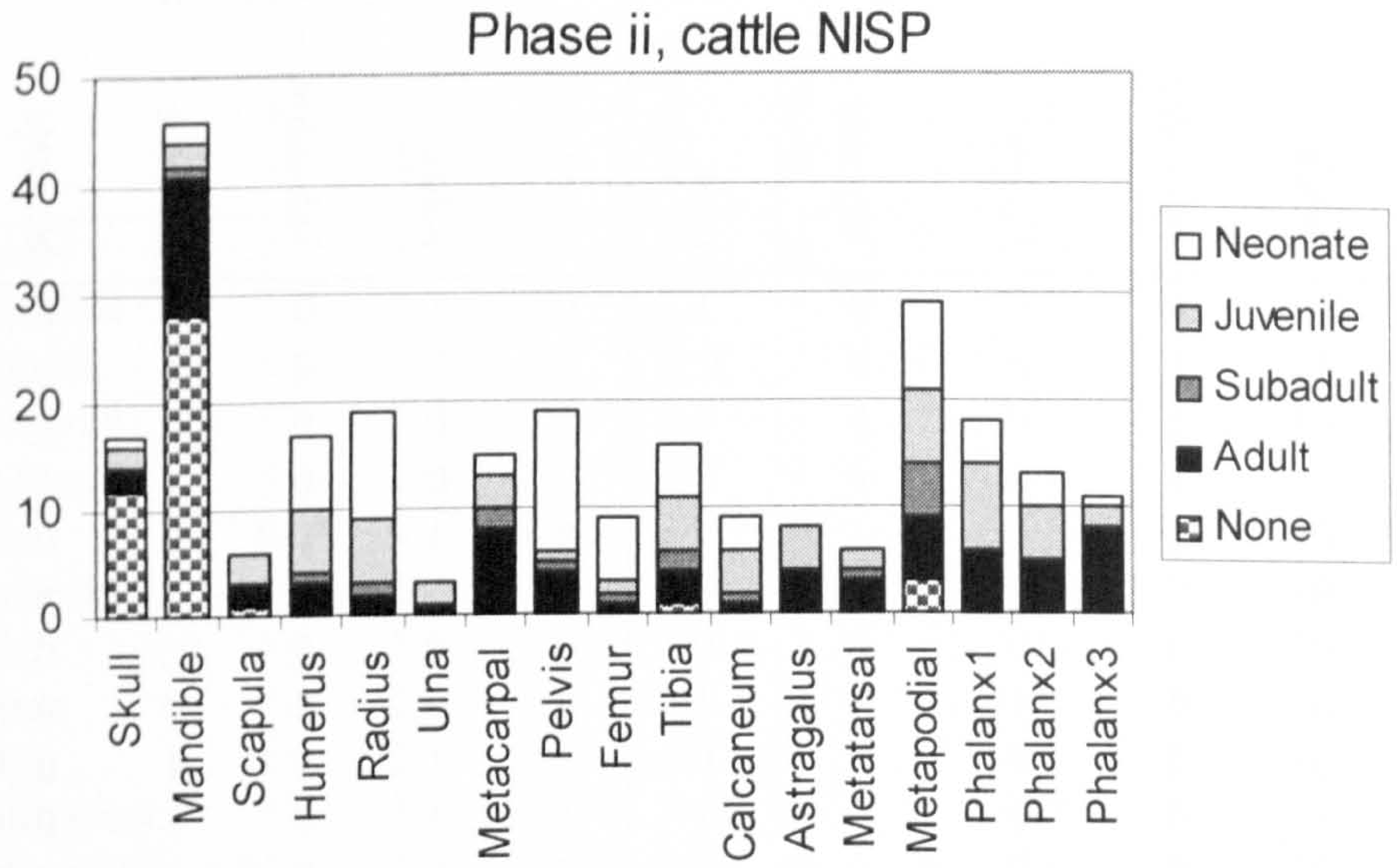
Table 6.12: Cattle MNE data, combined hand collected and sieved

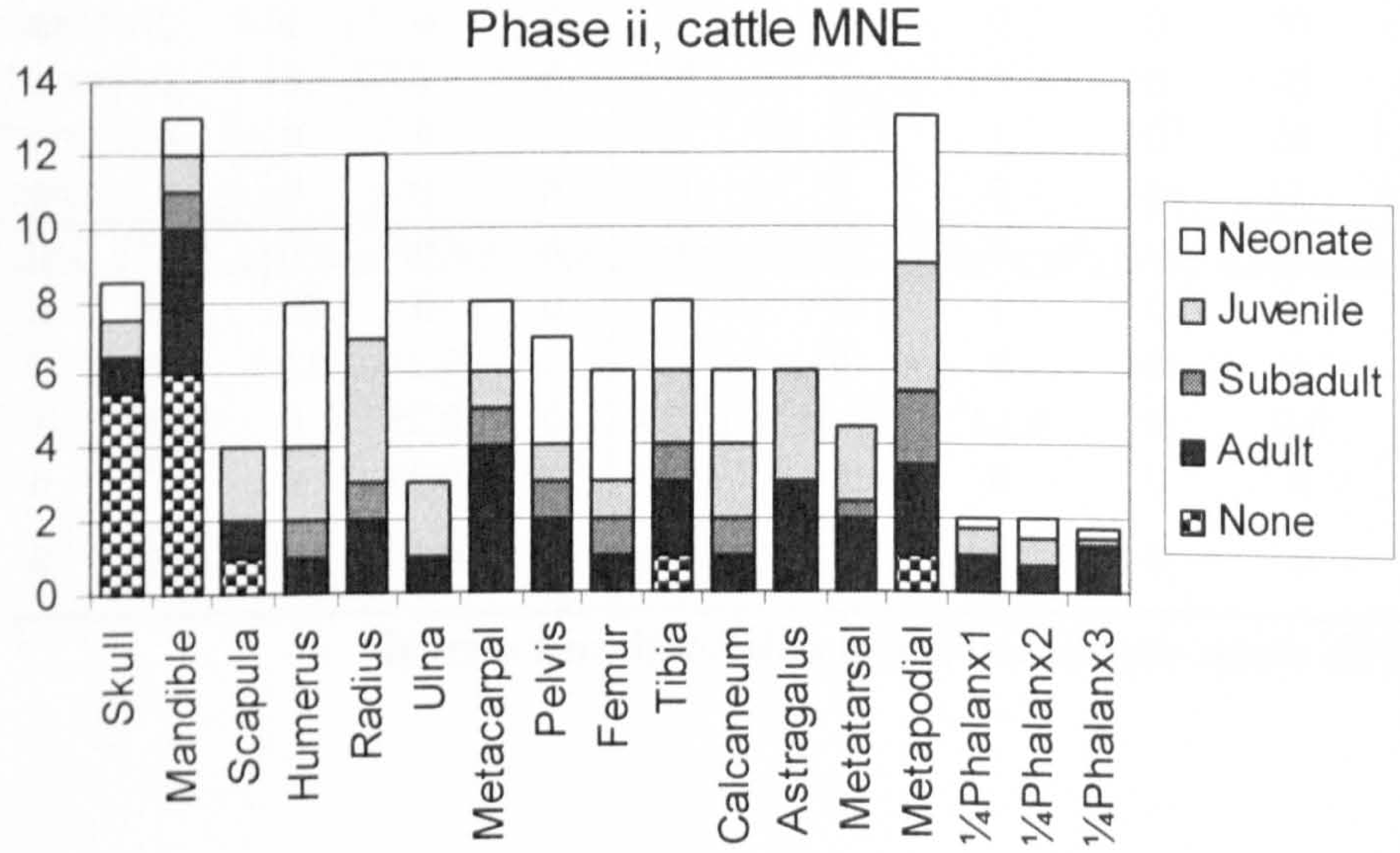
	Phase ii						Phase iii					
	None	Adult	Sub-adult	Juvenile	Neonate	total	None	Adult	Sub-adult	Juvenile	Neonate	total
Skull	2	1	0	1	0	4	3.5	3	0	2	0	8.5
Mandible	7	3	3	7	1	21	4	7	1	10	0	22
Scapula	2	3	2	3	1	11	1	4	3	10	4	22
Humerus	0	3	1	2	1	7	0	4	4	8	4	20
Radius	0	2	1	2	4	9	0	8	2	6	4	20
Ulna	0	0	0	3	0	3	1	0	0	5	0	6
Metacarpal	0	3	0	2	1	6	0	8	3	5	5	21
Pelvis	1	5	1	1	1	9	1	8	0	4	5	18
Femur	1	1	1	3	2	8	1	1	2	5	4	13
Tibia	0	3	1	2	1	7	0	6	4	5	4	19
Calcaneum	0	2	1	3	1	7	0	4	1	5	1	11
Astragalus	0	3	1	2	0	6	0	10	1	2	2	15
Metatarsal	0	5	1.5	1.5	1.5	9.5	0	5	1	1	2.5	9.5
Metapodial	0.5	1.5	1.5	2.5	2	8	0	0.5	5	2.5	1.5	9.5
¼Phalanx1	0.25	2.75	0.25	0.5	0.5	4.25	0	2.5	1.25	2	0.5	6.25
¼Phalanx2	0.25	2	0	0.5	0	2.75	0	1.25	0	1.25	0.25	2.75
¼Phalanx3	0.25	1.5	0.25	0	0	2	0	2.75	0	0.5	0.25	3.5

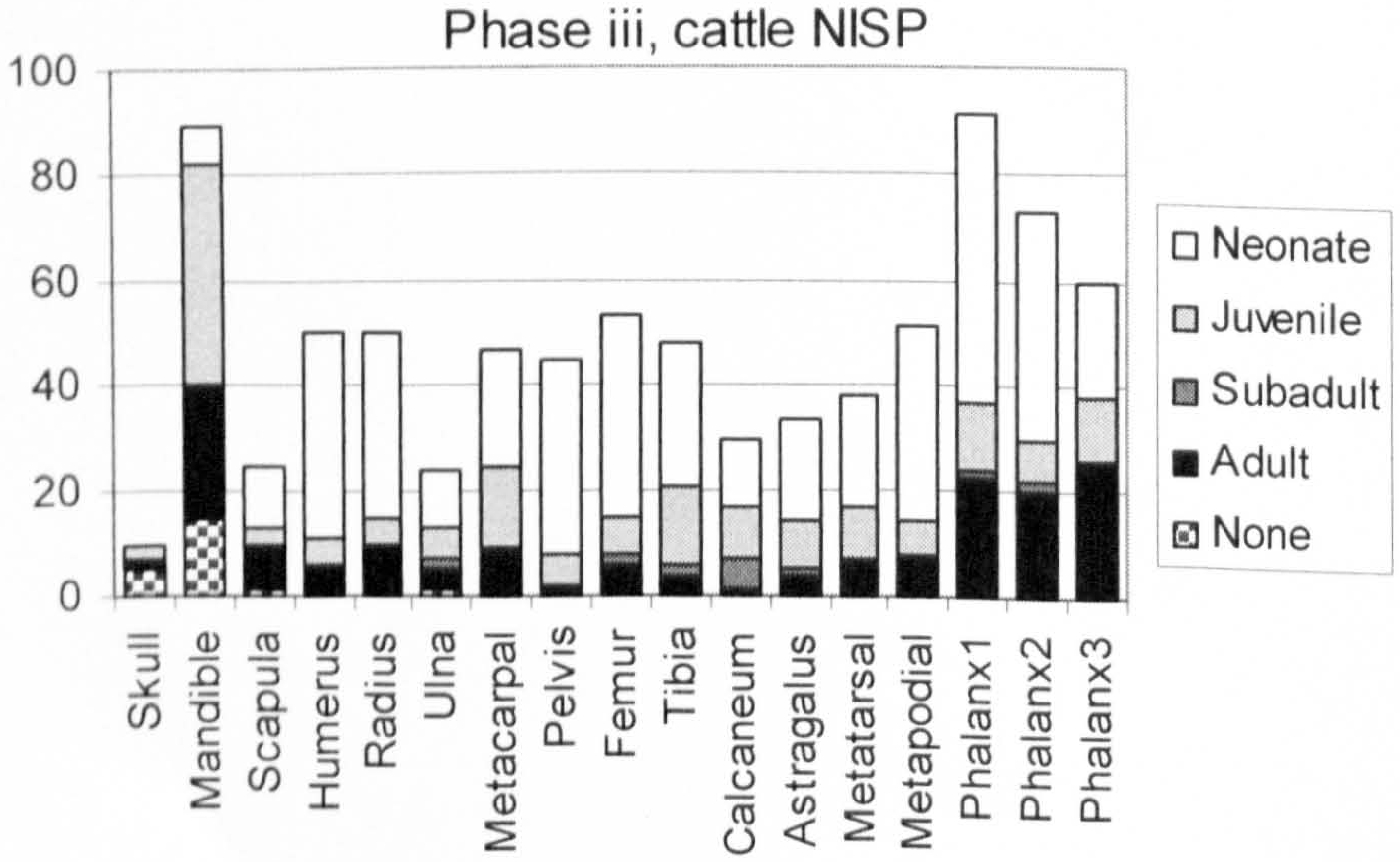
Table 6.13: Caprine MNE data, combined hand collected and sieved

	Phase ii						Phase iii					
	None	Adult	Sub-adult	Juvenile	Neonate	total	None	Adult	Sub-adult	Juvenile	Neonate	total
Skull	0	1	0	0	0	1	0	1	0	1	0	2
Mandible	0.5	1	1	0	0	2.5	1	2	0	1	0	4
Scapula	0	0	0	0	0	0	1	0	0	0	0	1
Humerus	0	1	0	1	0	2	0	0	0	1	2	3
Radius	0	0	0	0	1	1	0	1	0	0	0	1
Ulna	0	0	0	0	0	0	0	1	0	2	0	3
Metacarpal	0	0	0	0	0	0	0	0	0	0.5	0	0.5
Metacarpal 3	0	0	0	1	0	1	0	0	0	2	0	2
Metacarpal 4	0	0	0	0	0	0	0	1	0	1	0	2
Pelvis	0	1	0	1	0	2	1	1	0	3	0	5
Femur	0	0	0	0	0	0	0	0	0	1	0	1
Tibia	0	1	0	1	0	2	0	0	0	0	0	0
Calcaneum	0	0	0	0	0	0	0	0	1	2	0	3
Astragalus	0	0	0	0	0	0	0	1	0	0	0	1
Metatarsal	0	0	0	1	0	1	0	0	0	0	0	0
Metatarsal 3	0	1	0	0	0	1	0	0	0	0	0	0
Metatarsal 5	0	0	0	0	0	0	0	0	0	1	0	1
Metapodial	0	0	0	1	3	4	0	0	0.5	0.5	0	1
¼Phalanx1	0	0	0	0	0	0	0	0.25	0.25	0.25	0	0.75
¼Phalanx2	0	0.5	0	0.125	0.5	1.125	0	0.25	0	0.5	1	1.75
¼Phalanx3	0	0	0	0	0	0	0	0.25	0	0.75	0	1
¼Lateral Phalanx	0	0	0	0	0	0	0	0.25	0	0.25	0	0.5

Table 6.14: Pig MNE data, combined hand collected and sieved


Phase ii, cattle NISP
50
40
30
20
10
0
Skull
Mandible
Scapula
Humerus
Radius
Ulna
Metacarpal
Pelvis
Femur
Tibia
Calcaneum
Astragalus
Metatarsal
Metapodial
Phalanx1
Phalanx2
Phalanx3
Neonate
Juvenile
Subadult
Adult
None


Phase ii, cattle MNE
14
12
10
8
6
4
2
0
Skull
Mandible
Scapula
Humerus
Radius
Ulna
Metacarpal
Pelvis
Femur
Tibia
Calcaneum
Astragalus
Metatarsal
Metapodial
¼Phalanx1
¼Phalanx2
¼Phalanx3
Neonate
Juvenile
Subadult
Adult
None


Phase iii, cattle NISP
100
80
60
40
20
0
Skull
Mandible
Scapula
Humerus
Radius
Ulna
Metacarpal
Pelvis
Femur
Tibia
Calcaneum
Astragalus
Metatarsal
Metapodial
Phalanx1
Phalanx2
Phalanx3
Neonate
Juvenile
Subadult
Adult
None

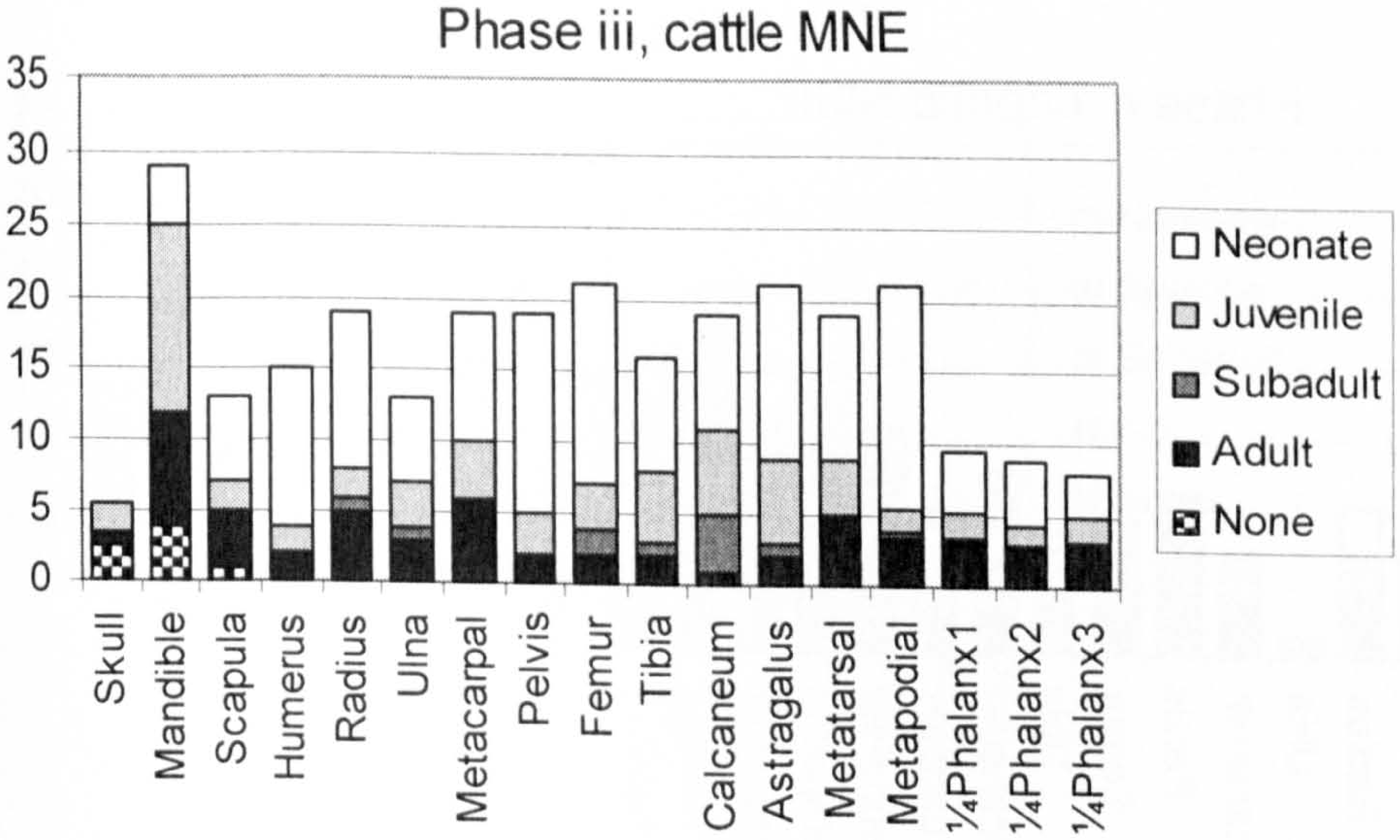
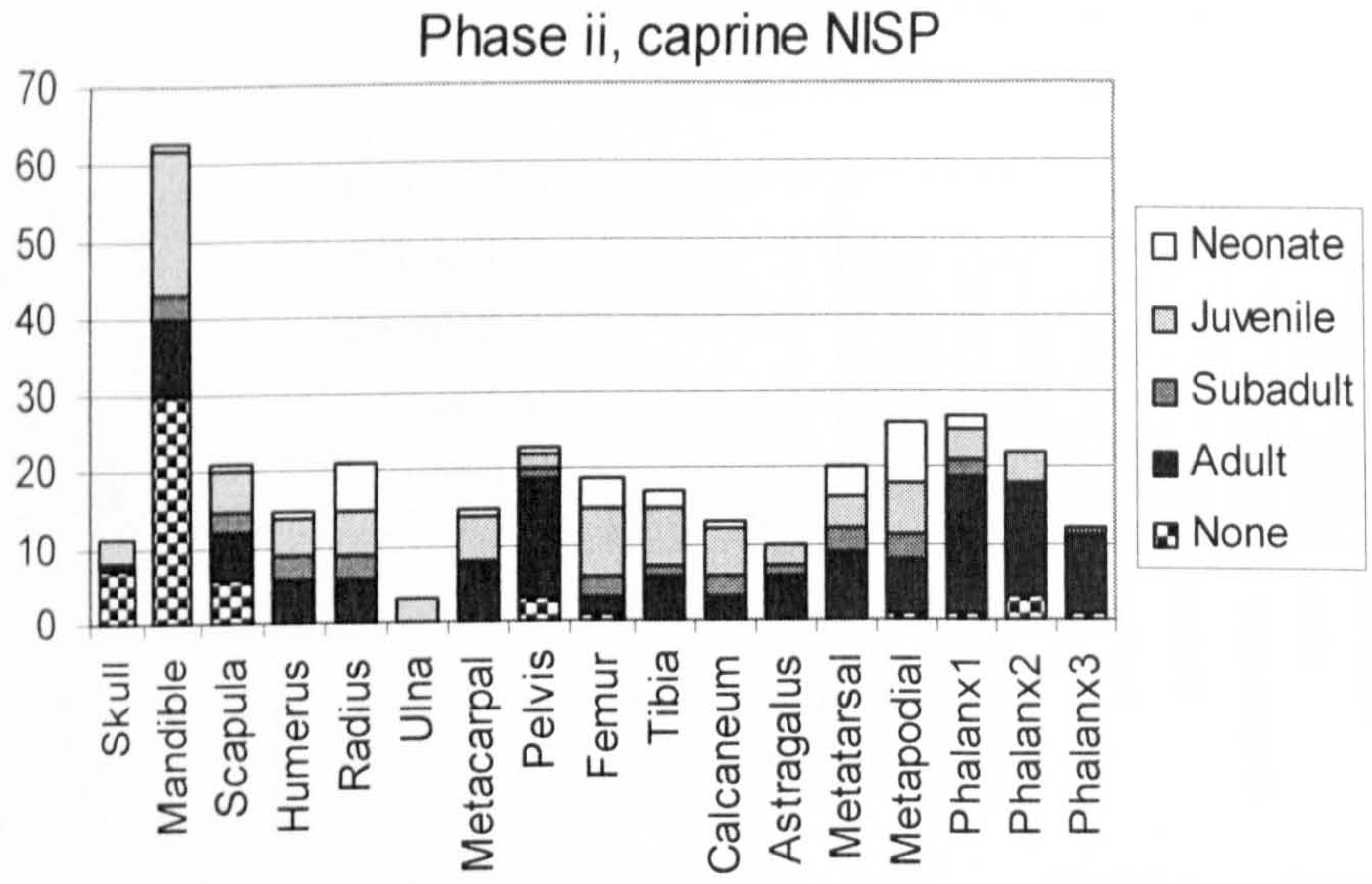
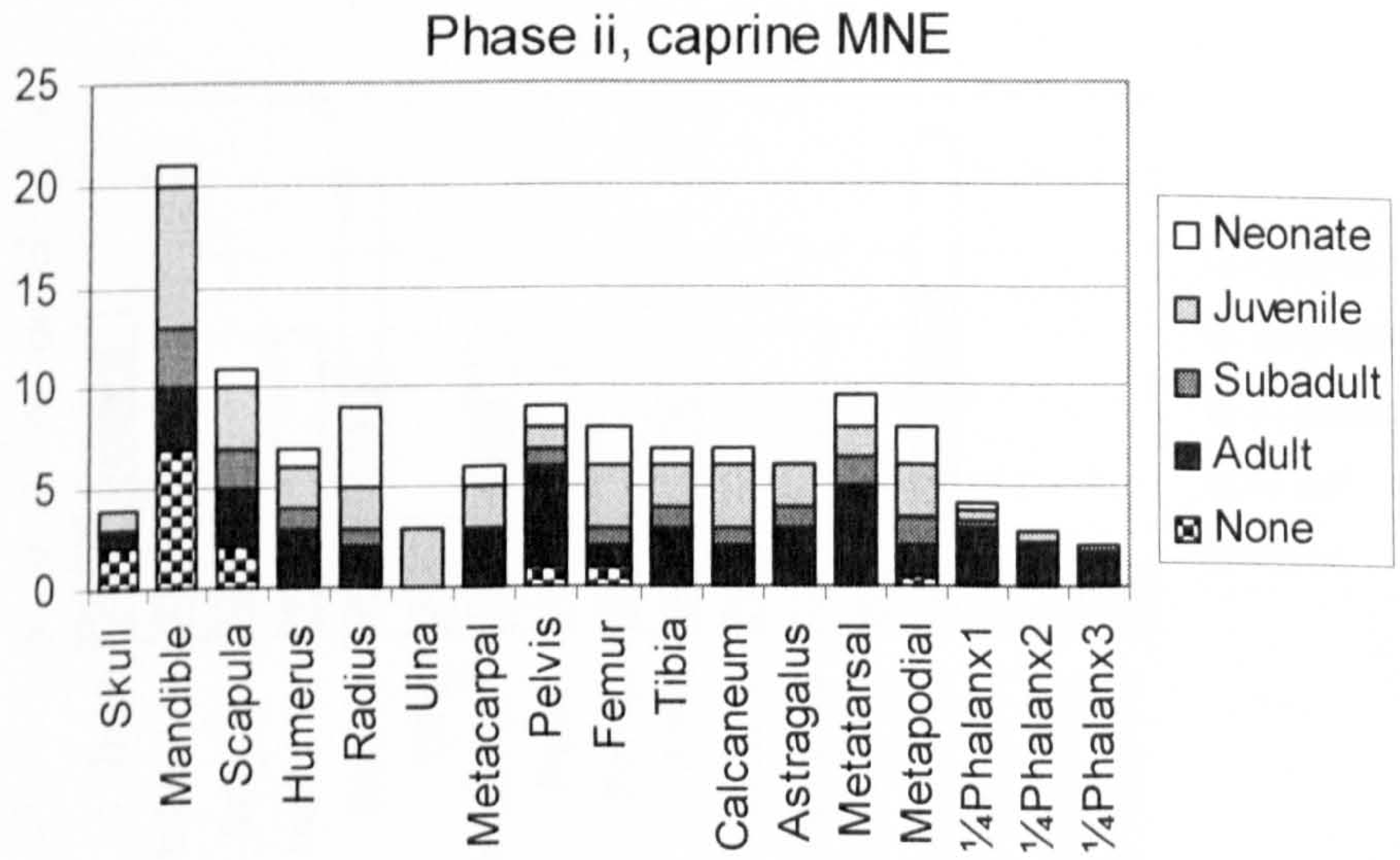
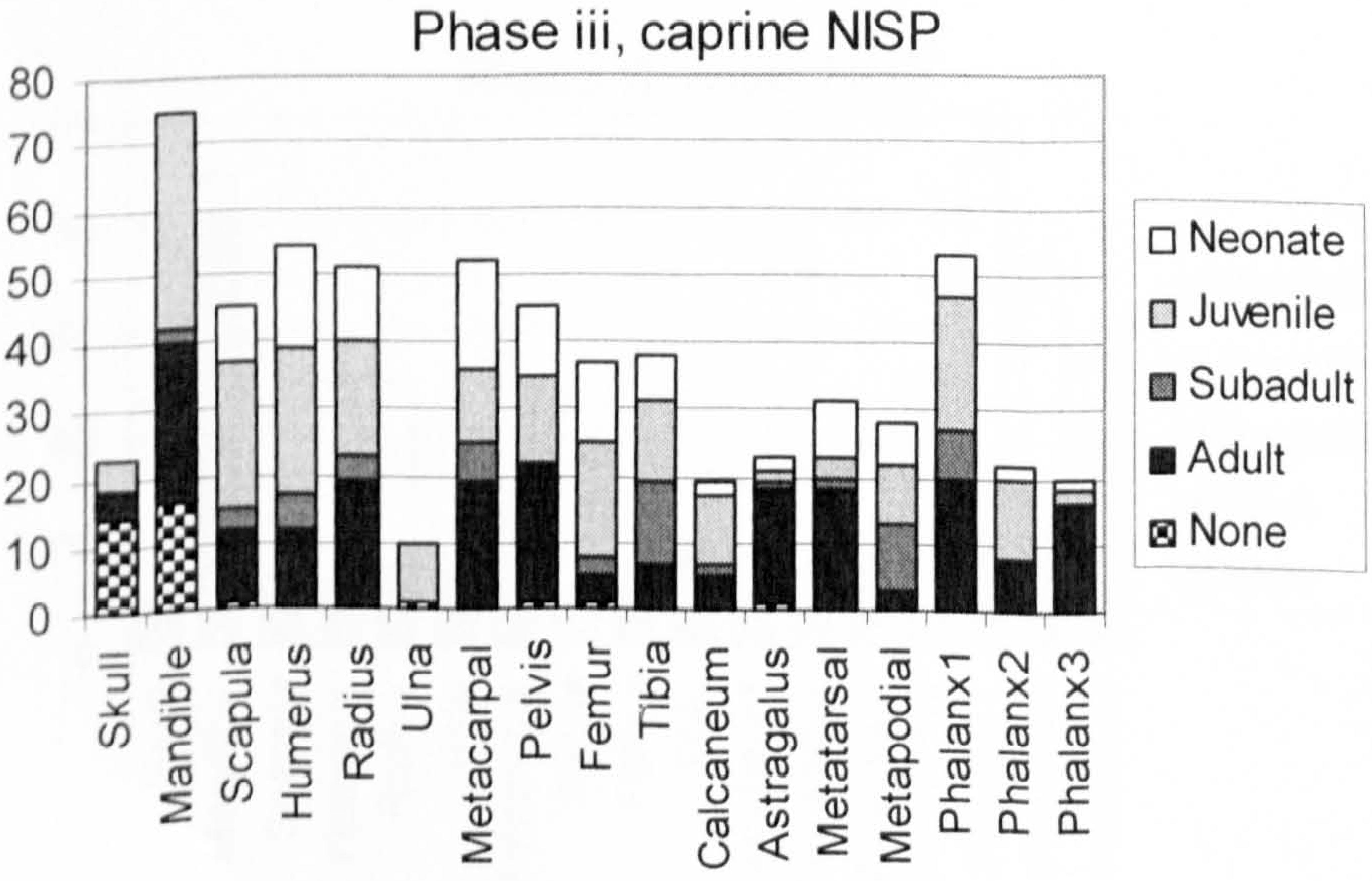


Figure 6.7: Cattle NISP and MNE, combined sieved and hand collected


Phase ii, caprine NISP
0
10
20
30
40
50
60
70
Skull
Mandible
Scapula
Humerus
Radius
Ulna
Metacarpal
Pelvis
Femur
Tibia
Calcaneum
Astragalus
Metatarsal
Metapodial
Phalanx1
Phalanx2
Phalanx3
□ Neonate
▨ Juvenile
▨ Subadult
■ Adult
▩ None


Phase ii, caprine MNE
0
5
10
15
20
25
Skull
Mandible
Scapula
Humerus
Radius
Ulna
Metacarpal
Pelvis
Femur
Tibia
Calcaneum
Astragalus
Metatarsal
Metapodial
¼Phalanx1
¼Phalanx2
¼Phalanx3
□ Neonate
▨ Juvenile
▨ Subadult
■ Adult
▩ None


Phase iii, caprine NISP
0
10
20
30
40
50
60
70
80
Skull
Mandible
Scapula
Humerus
Radius
Ulna
Metacarpal
Pelvis
Femur
Tibia
Calcaneum
Astragalus
Metatarsal
Metapodial
Phalanx1
Phalanx2
Phalanx3
□ Neonate
▨ Juvenile
▨ Subadult
■ Adult
▩ None

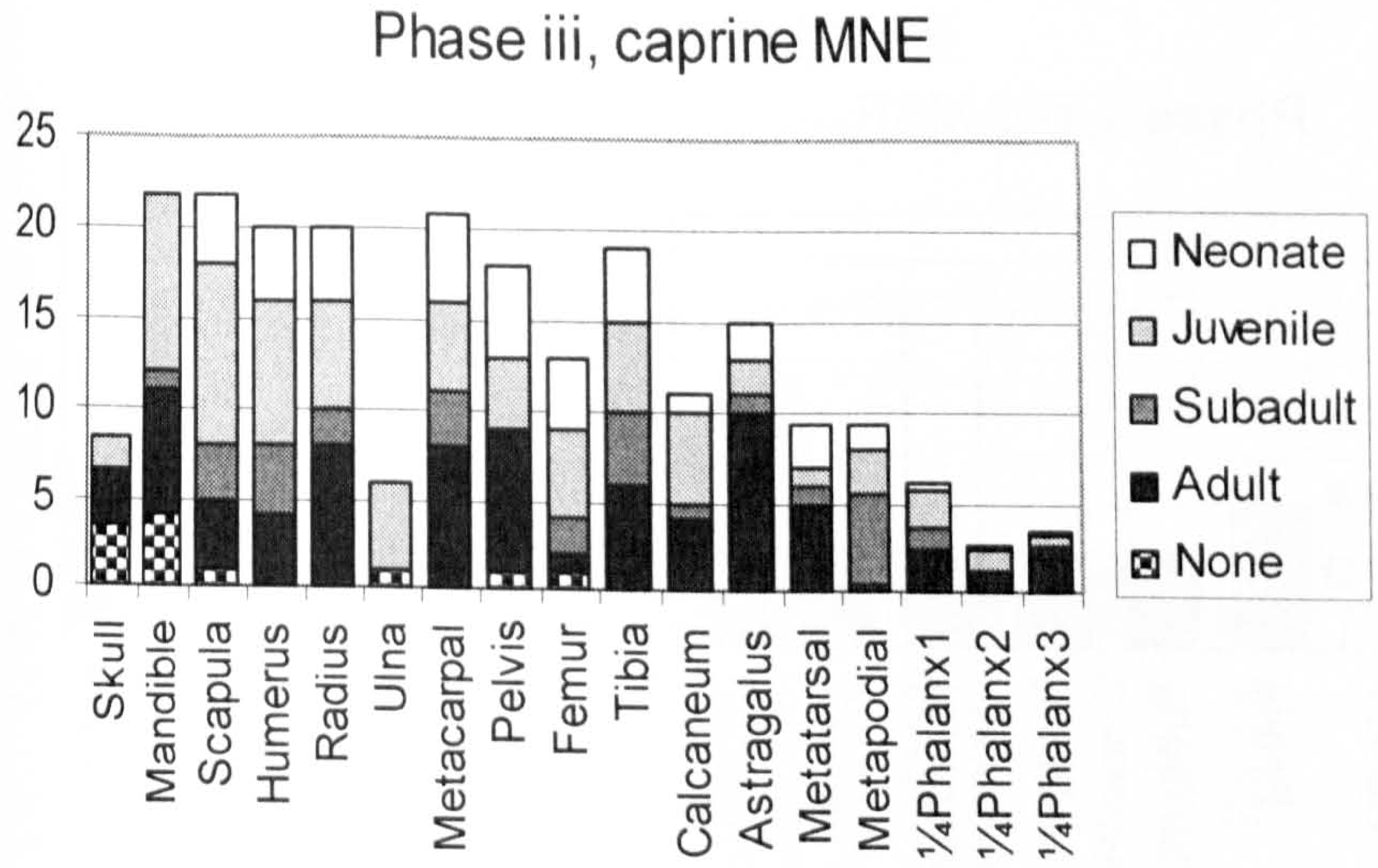
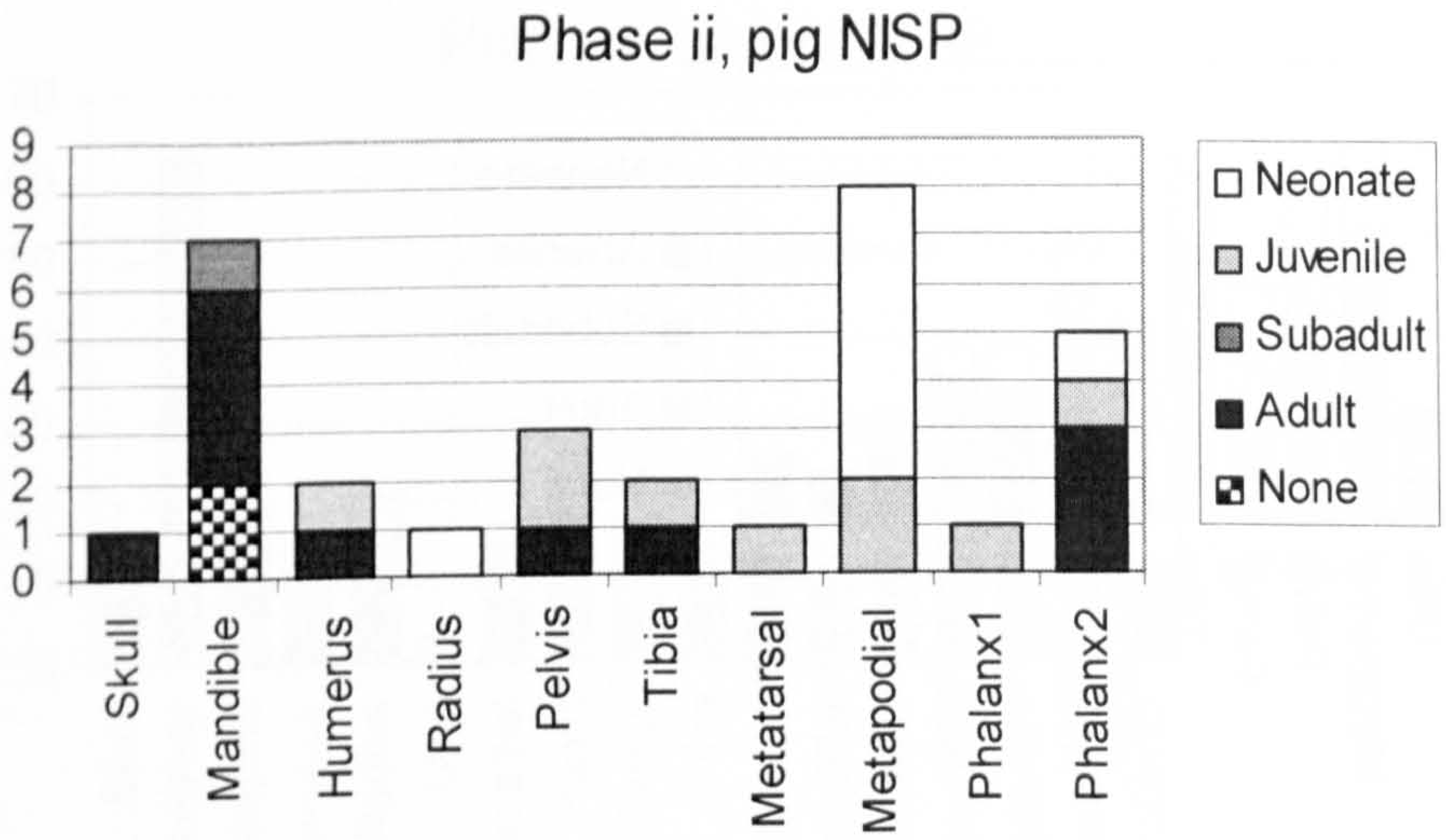
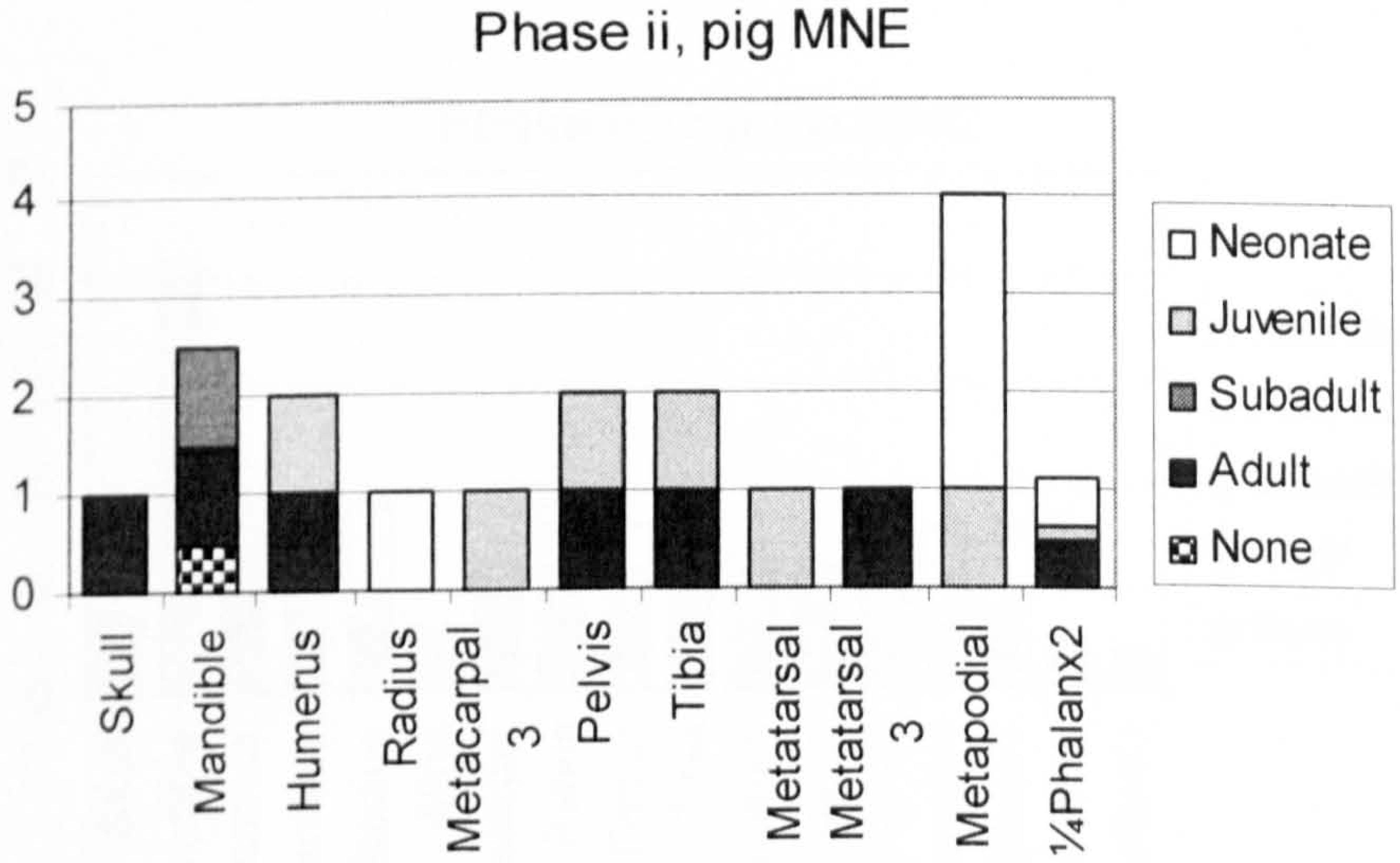
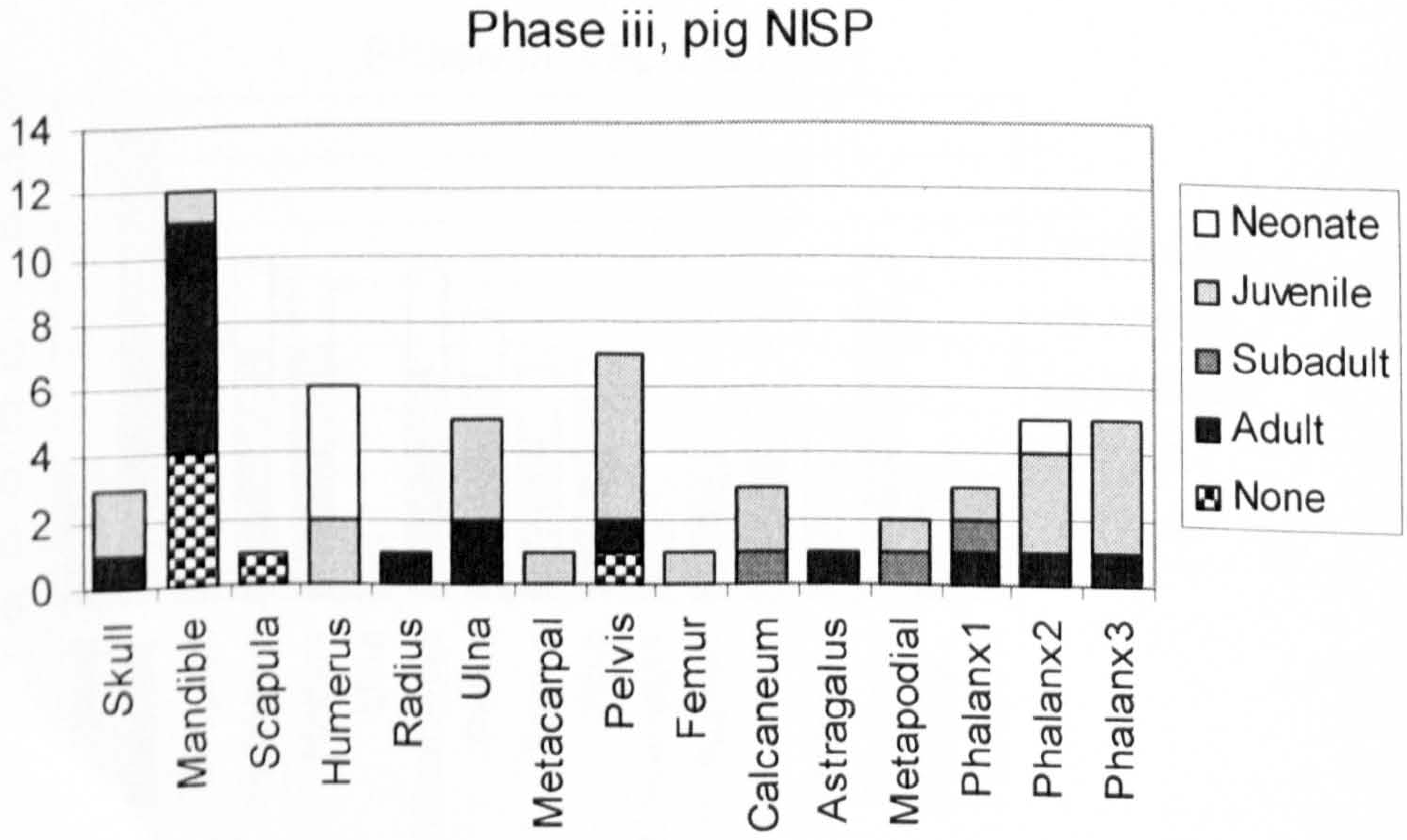


Figure 6.8: Caprine NISP and MNE, combined sieved and hand collected


Phase ii, pig NISP


Phase ii, pig MNE


Phase iii, pig NISP

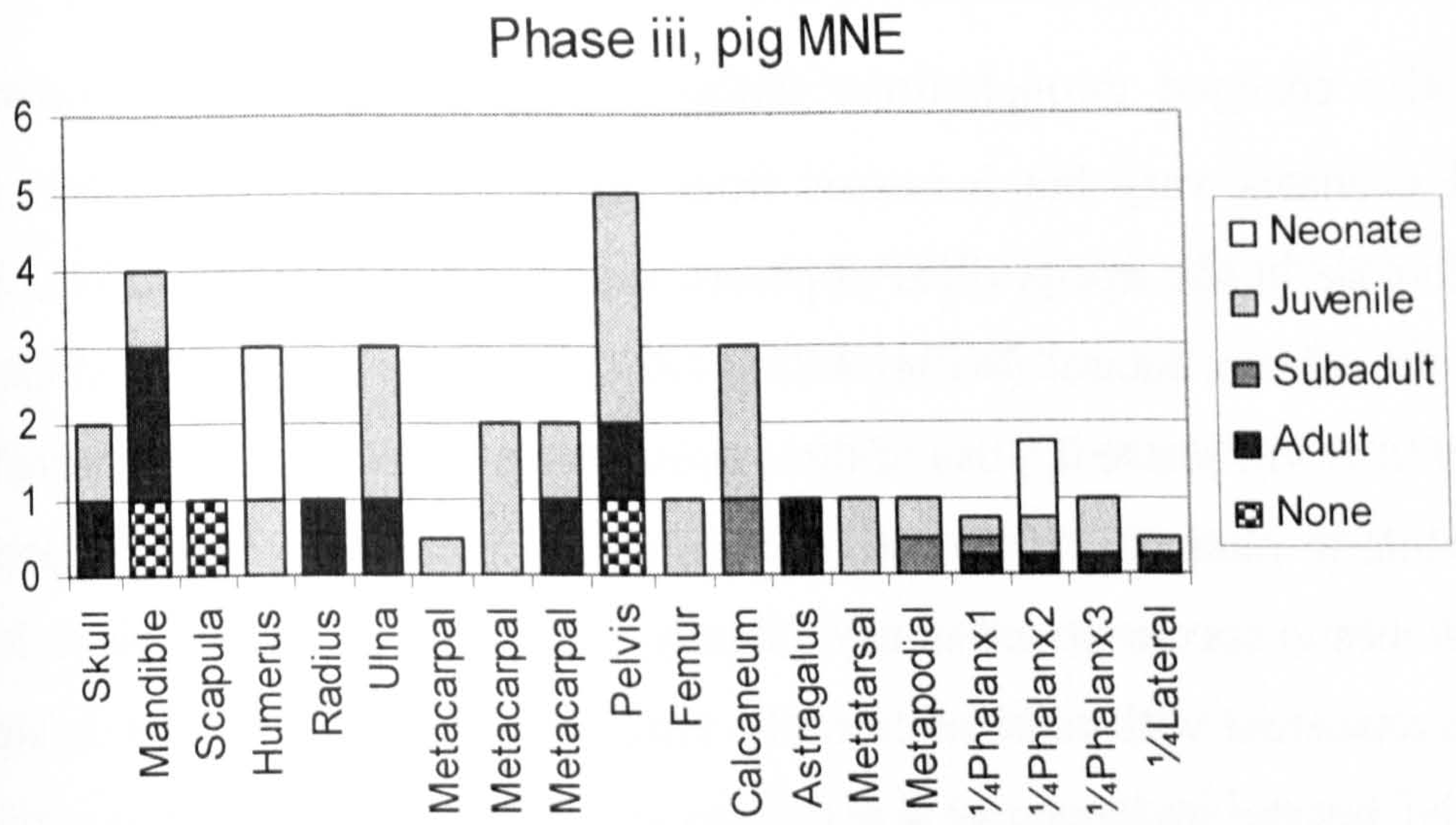


Figure 6.9: Pig NISP and MNE, combined sieved and hand collected

6.5 Ageing

Ages can be determined by epiphyseal fusion, dental wear, or by broad categories (adult, sub-adult, juvenile or neonate) reflecting size, fusion, texture and correlation with reference material. The latter method was applied to as many QC1 elements as possible, and can be used to broadly compare the mortality profiles of each species and phase (Table 6.15 to Table 6.17 and Figure 6.10). 'Adult' referred to fused, fully-grown and smoothly textured fragments; 'sub-adult' to just fused or fusing, at or very near adult size with an adult-like texture; 'juvenile' to unfused, below adult sized, well defined epiphyseal fusion surfaces, mostly smooth and solid texture; and 'neonatal' to small, roughly textured, fragile with very porous and undefined epiphyseal fusion surfaces. During the early stages of identification a set of well preserved neonatal elements from Quoygrew were identified, labelled and used for further reference because the young cattle in York's reference material were substantially larger. Cattle ages differ substantially between phases: adults slightly decreased from phase ii to phase iii, sub-adults remained at a constant low level, juveniles decreased substantially from phase i to iii, and neonates increased substantially from phase i to iii; there is a significant difference between phases ii and iii (Kolmogorov-Smirnov test: greatest difference 0.248, Z 3.226, significance 0.000; also significant for >4mm subset (0.438, 2.026, 0.001) and hand collected subset (0.232, 2.821, 0.000)). Over half of all cattle were neonatal in phase iii, with only 20% surviving to 'adult', while in phase ii about one third were neonatal and one third survived to 'adult'. Numbers for phase i were low, but indicate c. 20% were neonatal and a third reached the 'adult' category.

Caprine ages also changed through time: adults and sub-adults decreased, juveniles increased, and neonates vary but increased from phase ii to iii. Again, there is a significant difference in the age profiles of phases ii and iii (0.115, 1.588, 0.013); also significant for the >4mm dataset (0.134, 1.831, 0.002) and the hand collected dataset (0.117, 1.614, 0.011). In phase ii, 10% of the caprines were neonatal and just under half were 'adult', while in phase iii, 20% were neonatal and a third were 'adult'. Caprines were the only domestic species found in any quantity in the fish midden. In phase 2, the age profile was consistent with caprines from the farm mound, but with a slightly higher reliance on adults, but the small sample size negates any further study. Quantities for pig were small, so no significant patterning was observed (combined dataset comparing phases ii and iii: 0.188, 0.865, 0.443), but adults and neonates decreased through time while juveniles increased.

Fusion ages provide a more precise mortality pattern than that ascertained using general age categories (Table 6.18 to Table 6.20). Cattle and pig ageing followed Silver (1969), sheep ageing followed Moran and O'Connor (1994). Figure 6.11 provides a graphical representation of fusion ages for cattle by element, while Figure 6.12 combines the results from each element into one of four categories, thus reducing the variation seen when examining each element's fusion separately. Phase ii has more older cattle and fewer younger cattle than phase iii, but in both phases the percentage of fused elements is low, indicating that the assemblage contains a considerable number of young individuals. In phase iii, 60% of the 'very early' category – 7-10 months – were unfused, indicating a considerable proportion of the cattle were very young. The 'very early' category consists of only one element, the scapula, and as this occurs in smaller quantities in phase ii than phase iii, and any neonatal or juvenile is expected to be better preserved in phase iii so more likely to be identifiable in phase iii than in phase ii (see section 5.2.4), the apparent 0% fusion of the 'very early' category in phase ii may reflect element frequency rather than real ageing. The 'early' category includes elements that fuse between 12 and 18 months; 73% of the elements in phase ii and 79% in phase iii did not reach this age. Only 7% of all elements in phase ii and 5% in phase iii reached three years of age or later. Given that this ageing data combines hand collected and sieved material, and that smaller sized juvenile and neonatal cattle were under-represented by hand collection for all phases (see section 5.2.4), it is possible that the true unfused percentages for the 'very early' and 'early' categories are higher, and correspondingly the percentage fusion for the 'intermediate' and 'late' categories should be lower.

Figure 6.13 illustrates the caprine fusion ages by element; Figure 6.14 is a summary of this. For both phases ii and iii, approximately half the 'very early' elements are fused, decreasing to about 10% fusion for the latest fusing elements; about half the sheep did not reach 4.5-9 months, and only about 10% reached at least three years. The main difference is between the fusion rates for the 'early' category of about one year: about 60% of the elements in this category reached at least a year of age in phase ii, but only 40% did in phase iii. Evidence for pig fusion is presented in Table 6.20. Quantities were small, but the oldest individual present was represented by only one fused metatarsal (older than 2.25 years); approximately half the pigs survived their first year in phase ii, while only about a tenth survived to that age in phase iii.

Mandibular tooth wear provide a more detailed method of ageing (definitions in Table 6.21, data provided in Table 6.22 to Table 6.24, illustrated in Figure 6.15 to Figure 6.17); O'Connor's methods have been used (1989; 1991). Substantial differences between cattle age distributions are apparent between phases ii and iii: approximately half the cattle in phase ii survive to 'adult' stage (about four to eight years), but in phase iii only half the cattle survive to the 'juvenile' stage. About 40% of cattle in phase ii reach the 'elderly' stage (9 years or more), but fewer than 10% do in phase iii. The difference is significant between phases ii and iii (Kolmogorov-Smirnov test: 0.323, 1.466, 0.027). In contrast, the age distributions for caprines are similar between phases; no significant difference was observed (0.067, 0.291, 1.000). Approximately half the population reached the 'sub-adult' stage (c. late first year to two years old) for both phases ii and iii, although phase iii has fewer neonates and no elderly (seven years and older) caprines compared to phase ii. Patterning within the pig mandibular wear data is difficult to analyse because of the small sample size, and the extremely small size of neonatal pigs makes it unlikely their mandibles will have survived. No adult or elderly pigs were found. Approximately half the pigs survived to the 'juvenile/immature' category.

Horn core textures can be used to age cattle (Armitage 1982b); a total of 19 were recovered sufficiently whole, and these are summarised in Table 6.25. Horncore ageing is dependent on butchery practices (see section 6.6) and overall survival, which may account for the lack of neonatal material. However, one perinatal horncore bud survived and is included in Table 6.25 to indicate that some extremely young and delicate horncores could survive. Both phases ii and iii have predominately young adult (three to seven years old) to elderly (10 years and older) material identified.

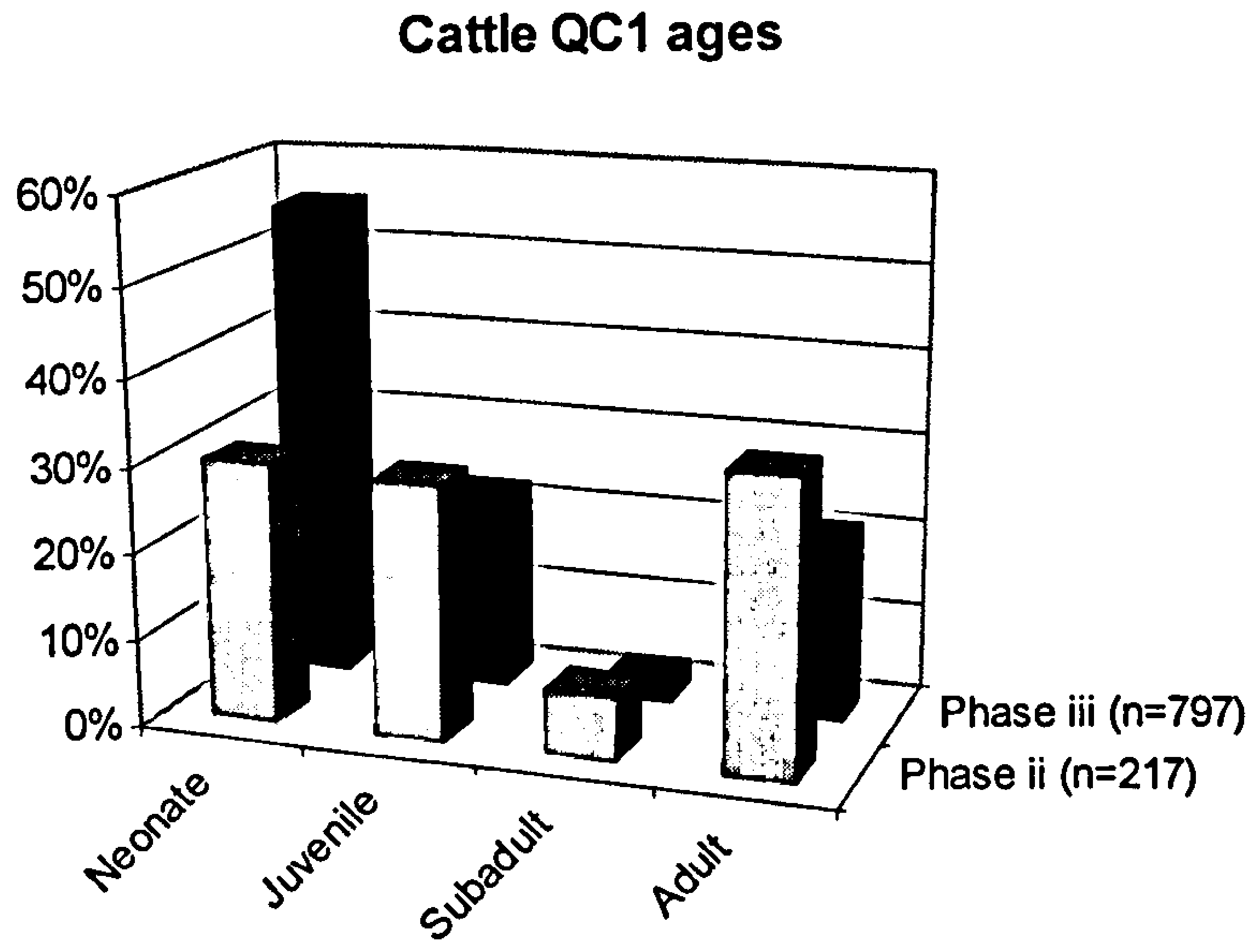
6.5.1 Summary

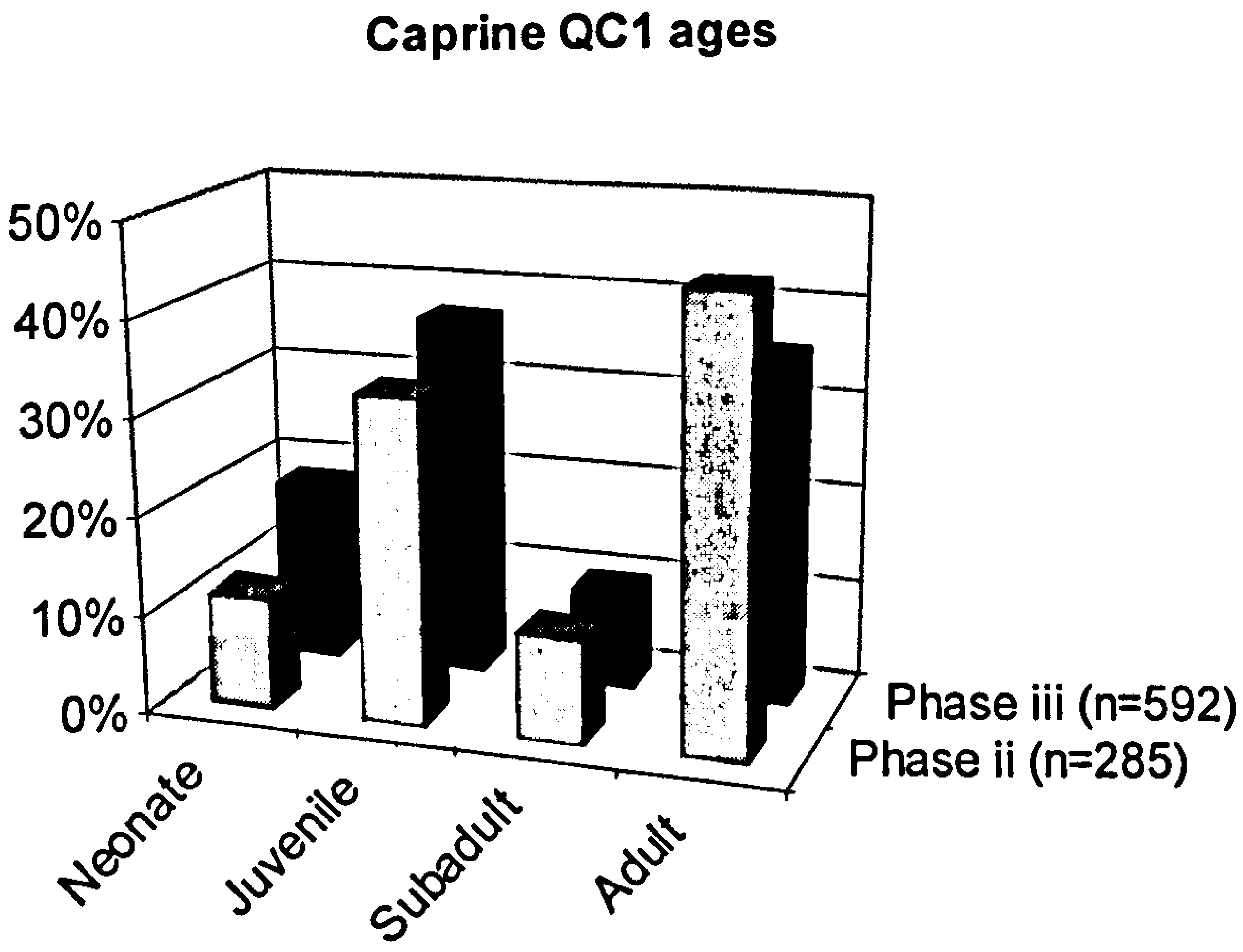
Using the different forms of ageing together, conclusions can be drawn regarding the mortality profiles of each species. Using the age categories recorded for all QC1 elements (neonatal—juvenile—sub-adult—adult) proved difficult, particularly the 'sub-adult' category that was chronically under-represented during recording (contrast Figure 6.10 with Figure 6.12). This is probably a methodological bias. Moreover, because different elements reach skeletal maturity at different ages, there is some blurring in the juvenile to adult categories, making this method of ageing difficult to compare to fusion or mandibular wear stages. Nevertheless, it is of value for the 'neonatal' category, and for phase i with its low sample size.

The sample size for phase i was very low, but taking the data at face value, about 20% of the cattle were neonatal and one third reached an adult age. In phases ii and iii the fusion and mandibular wear evidence present a somewhat conflicting picture. The presence of considerable quantities of neonates is indisputable given both the fusion and general ageing evidence, yet there are fewer mandibles than expected. This could be a taphonomic effect, with fewer extremely young mandibles surviving *and* containing enough teeth to provide an age – over 200 cattle or large mammal molar or premolar teeth fragments were found, none of which could be identified, and which were likely to be from younger cattle given the robustness of older cattle teeth and the paucity of any other large mammal species. It therefore appears that about three quarters of cattle in phases ii and iii were younger than 12-18 months, with slightly more neonates in phase iii than in phase ii. The proportion of adults in both phases was low, probably less than a quarter of the total cattle population at a conservative estimate, but given that adult bone survives better than young, this proportion was probably in reality lower. A few individuals reached ages of nine years and older, with some approaching 11 years or older. Significant differences in age were found between phases ii and iii, probably because fewer neonates died in phase ii and fewer individuals reached skeletal maturity in phase iii. The cattle population was probably exploited for both dairy and meat, though the emphasis on the very young with a few much older cattle is consistent with some models of a dairying economy (Mulville *et al.* 2005). Calves were probably killed when very young to allow greater quantities of milk for human consumption, as well as providing some meat, fine skins, and rennet for cheese making (see introduction to dairying in Chapter One and conclusions in Chapter Nine). The presence of some immature and sub-adult individuals at a prime age for meat consumption indicates the emphasis was not solely on dairying, and the possible pathological evidence for traction (see section 6.7.1) provides an additional use for cattle. This can also be assumed given ethnohistoric analogy (Fenton 1978).

Smaller sized and younger caprine fragments are known to be under-represented by hand collection (see section 5.2.4), but because the majority of ageing evidence only becomes large enough to analyse when combining sieved with hand collected material, this bias must be considered in any conclusions. Using the general ageing categories phase iii had slightly more neonates than phase ii, but based on tooth wear there is no significant difference between the phases. The tooth wear evidence suggests at least half the population reached the late first year to two years of age for both phases, which is confirmed by the 'early' (11-12 months) and to a lesser degree, 'intermediate' (23-30 months) fusion categories. In summary, this age profile probably reflects the multiple utility of caprines at Quoygrew. The majority died at an age indicative of meat consumption, though old enough to produce one or two year's worth of wool. A few adults and elderly caprines were kept for breeding purposes, while the presence of neonates could be indicative of natural deaths during the lambing season, or deliberate killing of one lamb in the case of twins (known ethnographically; cf. Berry 2000, 136). If natural neonatal deaths were incorporated into midden material, then either lambing took place close to the settlement, or dead lambs were brought back to the settlement.

Very little can be concluded about pig ages at Quoygrew. No evidence was found for adults or elderly pigs from fusion or tooth wear, but general age categories implied that about a third of elements were of mature appearance. Using fusion evidence, about half survived their first year in phase ii, whereas only 10% did in phase iii, but this difference may simply reflect the tiny sample sizes. Using tooth wear, about half survived to juvenile or immature ages. This observation is consistent with the use of pigs for meat prior to reaching skeletal maturity, although a few individuals must have been kept for breeding stock.





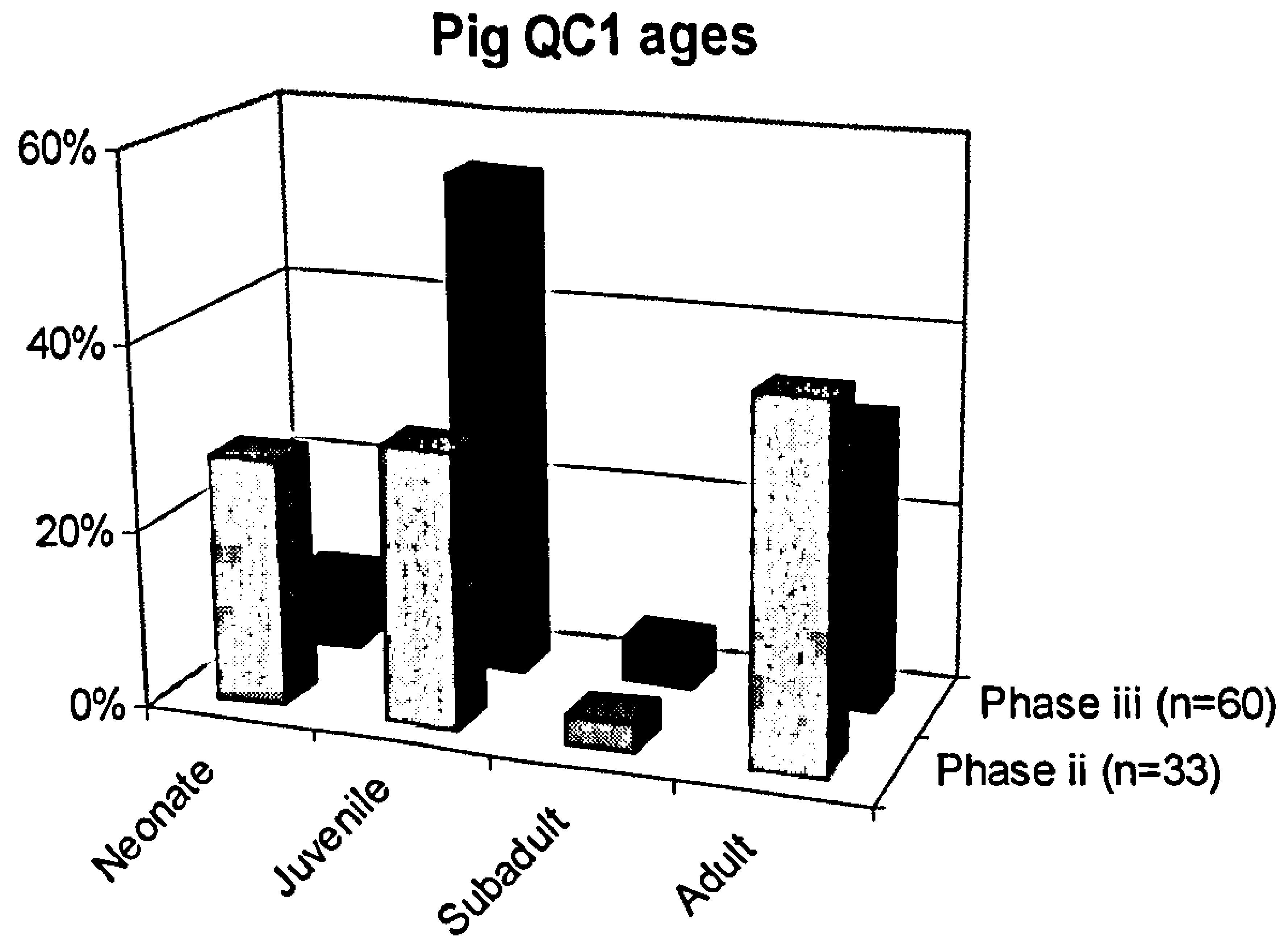


Figure 6.10: Cattle, caprine and pig QC1 age groups, combined hand collected and sieved

Element	Age group	Phase i		Phase ii		Phase iii	
		Count	%	Count	%	Count	%
Mandible	Adult	1	100%	13	72%	25	34%
	Sub-adult			1	6%		
	Juvenile			2	11%	42	57%
	Neonate			2	11%	7	9%
Scapula	Adult			2	40%	9	38%
	Sub-adult						
	Juvenile			3	60%	3	13%
	Neonate	1	100%			12	50%
Humerus	Adult	1	50%	3	18%	6	12%
	Sub-adult			1	6%		
	Juvenile	1	50%	6	35%	5	10%
	Neonate			7	41%	39	78%
Radius	Adult			2	11%	9	18%
	Sub-adult			1	5%	1	2%
	Juvenile			6	32%	5	10%
	Neonate			10	53%	35	70%
Ulna	Adult			1	33%	4	17%
	Sub-adult					2	9%
	Juvenile			2	67%	6	26%
	Neonate					11	48%
Metacarpal	Adult			8	53%	9	19%
	Sub-adult			2	13%		
	Juvenile	1	100%	3	20%	16	34%
	Neonate			2	13%	22	47%
Pelvis	Adult	1	100%	4	21%	2	4%
	Sub-adult			1	5%		
	Juvenile			1	5%	6	13%
	Neonate			13	68%	37	82%
Femur	Adult			1	11%	6	11%
	Sub-adult			1	11%	2	4%
	Juvenile	2	100%	1	11%	7	13%
	Neonate			6	67%	38	72%
Tibia	Adult			3	20%	4	8%
	Sub-adult			2	13%	2	4%
	Juvenile			5	33%	15	31%
	Neonate			5	33%	27	56%
Metatarsal	Adult			3	50%	7	18%
	Sub-adult			1	17%		
	Juvenile	1	50%	2	33%	10	26%
	Neonate	1	50%			21	55%
Astragalus	Adult			4	50%	4	12%
	Sub-adult					1	3%
	Juvenile			4	50%	9	26%
	Neonate					20	59%
Calcaneum	Adult			1	11%	1	3%
	Sub-adult			1	11%	6	20%
	Juvenile			4	44%	10	33%
	Neonate			3	33%	13	43%
Phalanx 1	Adult			6	33%	23	25%
	Sub-adult					1	1%
	Juvenile			8	44%	13	14%
	Neonate			4	22%	54	59%
Phalanx 2	Adult			5	38%	20	27%
	Sub-adult					2	3%
	Juvenile			5	38%	8	11%
	Neonate			3	23%	43	59%

Phalanx 3	Adult			8	73%	26	43%
	Sub-adult						
	Juvenile			2	18%	12	20%
	Neonate			1	9%	22	37%
Metapodial	Adult			6	23%	7	14%
	Sub-adult			5	19%	1	2%
	Juvenile			7	27%	6	12%
	Neonate			8	31%	37	73%
Total for all elements	Adult	3	30%	73	34%	165	21%
	Sub-adult			16	7%	18	2%
	Juvenile	5	50%	63	29%	176	22%
	Neonate	2	20%	65	30%	438	55%

Table 6.15: Cattle QC1 ages, combined hand collected and sieved

Element	Age group	Phase 2		Phase ii		Phase iii	
		Count	%	Count	%	Count	%
Mandible	Adult	1	100%	10	30%	24	41%
	Sub-adult			3	9%	2	3%
	Juvenile			19	58%	33	56%
	Neonate			1	3%		
Scapula	Adult			6	40%	11	25%
	Sub-adult			3	20%	3	7%
	Juvenile			5	33%	22	50%
	Neonate			1	7%	8	18%
Humerus	Adult			6	40%	12	22%
	Sub-adult			3	20%	5	9%
	Juvenile			5	33%	22	41%
	Neonate	1	100%	1	7%	15	28%
Radius	Adult	1	100%	6	29%	19	37%
	Sub-adult			3	14%	4	8%
	Juvenile			6	29%	17	33%
	Neonate			6	29%	11	22%
Ulna	Adult						
	Sub-adult						
	Juvenile			3	100%	9	100%
	Neonate						
Metacarpal	Adult	1	100%	8	53%	19	37%
	Sub-adult					6	12%
	Juvenile			6	40%	11	21%
	Neonate			1	7%	16	31%
Pelvis	Adult			16	80%	21	48%
	Sub-adult			1	5%		
	Juvenile			2	10%	13	30%
	Neonate			1	5%	10	23%
Femur	Adult	3	75%	2	11%	4	11%
	Sub-adult	1	25%	3	17%	3	8%
	Juvenile			9	50%	17	47%
	Neonate			4	22%	12	33%
Tibia	Adult			6	35%	7	18%
	Sub-adult			1	6%	12	32%
	Juvenile			8	47%	12	32%
	Neonate			2	12%	7	18%
Astragalus	Adult			6	60%	17	77%
	Sub-adult			1	10%	1	5%
	Juvenile			3	30%	2	9%
	Neonate					2	9%
Calcaneum	Adult			3	23%	5	26%
	Sub-adult			3	23%	2	11%
	Juvenile	2	100%	6	46%	10	53%
	Neonate			1	8%	2	11%
Metatarsal	Adult			9	45%	18	58%
	Sub-adult			3	15%	2	6%
	Juvenile			4	20%	3	10%
	Neonate	1	100%	4	20%	8	26%
Phalanx 1	Adult	1	100%	18	69%	20	38%
	Sub-adult			2	8%	7	13%
	Juvenile			4	15%	20	38%
	Neonate			2	8%	6	11%
Phalanx 2	Adult			15	79%	8	36%
	Sub-adult						
	Juvenile			4	21%	12	55%
	Neonate					2	9%

Phalanx 3	Adult			10	91%	16	80%
	Sub-adult			1	9%		
	Juvenile					2	10%
	Neonate					2	10%
Metapodial	Adult			7	28%	3	11%
	Sub-adult			3	12%	10	36%
	Juvenile	1	50%	7	28%	9	32%
	Neonate	1	50%	8	32%	6	21%
Total for all elements	Adult	8	53%	129	45%	209	35%
	Sub-adult	1	7%	30	11%	57	10%
	Juvenile	3	20%	94	33%	219	37%
	Neonate	3	20%	32	11%	107	18%

Table 6.16: Caprine QC1 ages by phase, combined hand collected and sieved

Age group	Phase i	Phase ii		Phase iii	
		Count	%	Count	%
Adult		13	39%	19	32%
Sub-adult	1	1	3%	3	5%
Juvenile		10	30%	33	55%
Neonate		9	27%	5	8%

Table 6.17: Pig QC1 ages by phase, combined hand collected and sieved

				Phase i				Phase ii				Phase iii				
Fusion category	Fusion age (Silver 1969)	Element		Fused	Unfused	Total	% fused	Fused	Un-used	Total	% fused	Fused	Fusing	Un-used	Total	% fused
Very early	7-10m	Scapula	glenoid		1	1	0		3	3	0	6		9	15	40
Early	12-18m	Humerus	distal	1	1	2	50	3	11	14	21	4		36	40	10
	12-18m	Radius	proximal					2	8	10	20	8		30	38	21
	18m	Phalanx 1	proximal					6	11	17	35	24	1	66	91	26
Intermediate	2-2.5y	Tibia	distal					2	5	7	29	3	1	29	33	9
	2-2.5y	Metacarpal	distal		1	1	0	2	4	6	33	4		23	27	15
	2-3y	Metapodials	distal					4	16	20	20	5		37	42	12
	2.25-3y	Metatarsal	distal		2	2	0		2	2	0	2		22	24	8
Late	3.5y	Femur	proximal		1	1	0		3	3	0	3	1	24	28	11
	3.5-4y	Femur	distal		1	1	0	1	7	8	13	1		32	33	3
	3.5-4y	Tibia	proximal					1	10	11	9			19	19	0
	3.5-4y	Humerus	proximal					1	3	4	25			22	22	0
	3.5-4y	Radius	distal						13	13	0	1		29	30	3
	3.5-4y	Ulna	proximal						2	2	0	2		17	19	11

Table 6.18: Cattle fusion ages, combined hand collected and sieved

				Phase 2				Phase ii					Phase iii				
Fusion category	Fusion age (Moran and O'Connor 1994)	Element		Fused	Unfused	Total	% fused	Fused	Fusing	Unfused	Total	% fused	Fused	Fusing	Unfused	Total	% fused
Very early	4.5-6m	Radius	proximal					5		4	9	56	15		8	23	65
	6-9m	Scapula	glenoid		1	1	0	4	5		9	44	14		16	30	47
	9m	Humerus	distal					5	1	2	8	63	8	3	22	33	24
Early	11-12m	Phalanx 1	proximal	1		1	100	17	1	8	26	65	20	3	27	50	40
Inter-mediate	23-30m	Tibia	distal					4		7	11	36	7	2	14	23	30
	23-30m	Metacarpal	distal	1		1	0	2		5	7	29	5		22	27	19
	23-30m	Metapodial	distal		1	1	100	3	2	14	19	16	1		24	25	4
	23-30m	Metatarsal	distal		1	1	100		1	6	7	0	2		9	11	18
	23-30m	Ulna	proximal							2	2	0			7	7	0
	23-30m	Calcaneum	proximal		2	2	0	2	1	9	12	17	3		14	17	18
Late	36-42m	Humerus	proximal						1	5	6	0	3		19	22	14
	36-40m	Radius	distal					2		11	13	15	2		17	19	11
	36-37m	Femur	proximal	1		1	100	1	1	6	8	13	2	1	14	17	12
	36-42m	Femur	distal	1	1	2	50	1	1	11	13	8	1		17	18	6
	40-45m	Tibia	proximal					1		6	7	14			15	15	0

Table 6.19: Caprine fusion ages, combined hand collected and sieved

Fusion Age (Silver 1969)	Element		Phase ii				Phase iii				
			Fused	Un-fused	Total	% Fused	Fused	Fusing	Un-fused	Total	% Fused
1y	Humerus	distal	1	1	2	50%			4	4	0%
1y	Radius	proximal		1	1	0%					
1y	Phalanx 2	proximal	3	2	5	60%	1		4	5	20%
2y	Metacarpal	distal		1	1	0%	1		3	4	25%
2y	Phalanx 1	proximal		1	1	0%	1	1	1	3	33%
2y	Tibia	distal		1	1	0%	1		1	2	50%
2-2.25	Metapodial	distal		7	7	0%				1	0%
2-2.5y	Calcaneum	proximal							2	2	0%
2.25y	Metatarsal	distal	1		1	100%			1	1	0%
3-3.5y	Ulna	proximal							1	1	0%
3-3.5y	Ulna	distal									
3.5y	Humerus	proximal		1	1	0%			5	5	0%
3.5y	Radius	distal									
3.5y	Femur	proximal							1	1	0%
3.5y	Femur	distal									
3.5y	Tibia	proximal							1	1	0%

Table 6.20: Pig fusion ages, combined hand collected and sieved

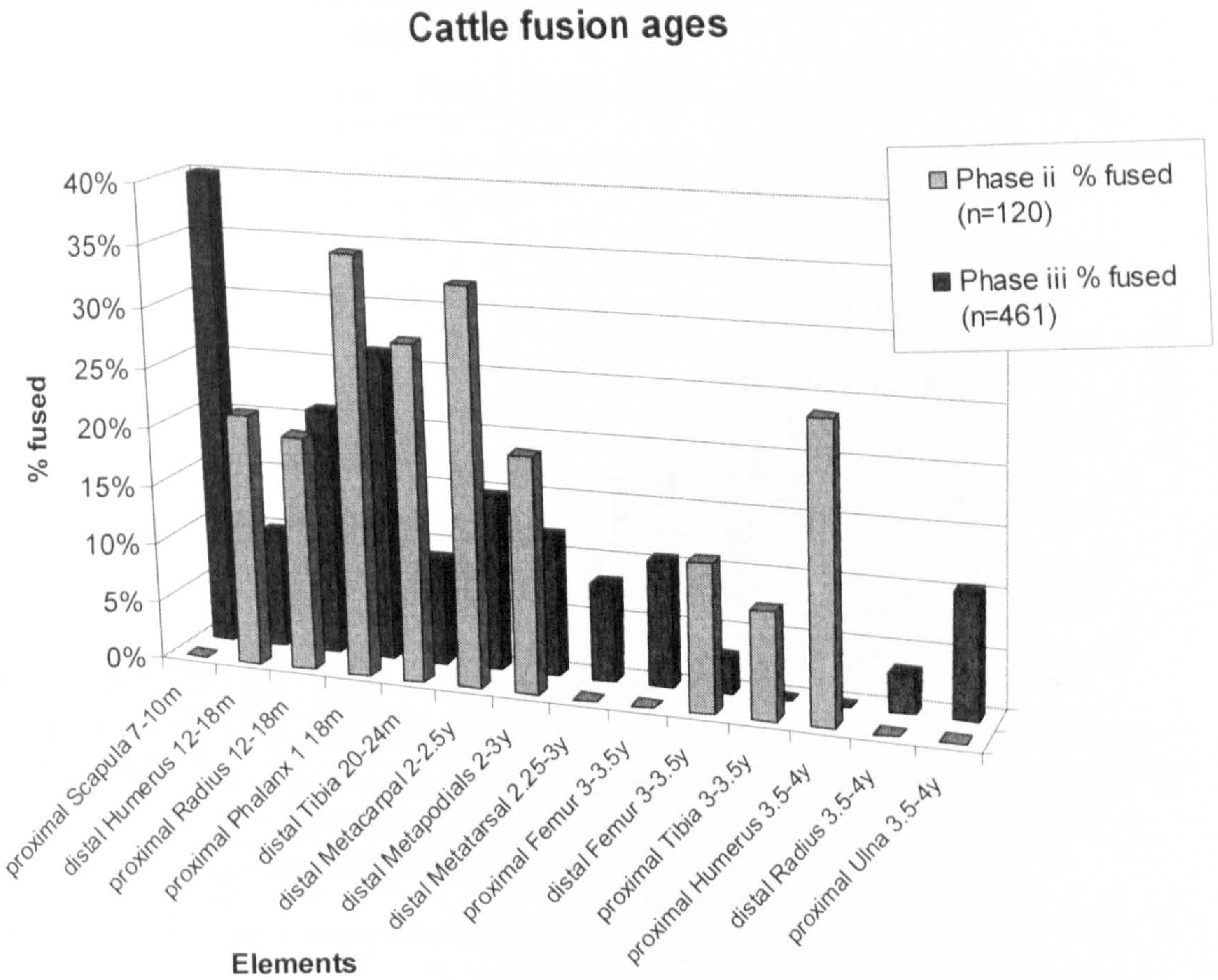


Figure 6.11: Cattle fusion ages by element, all data

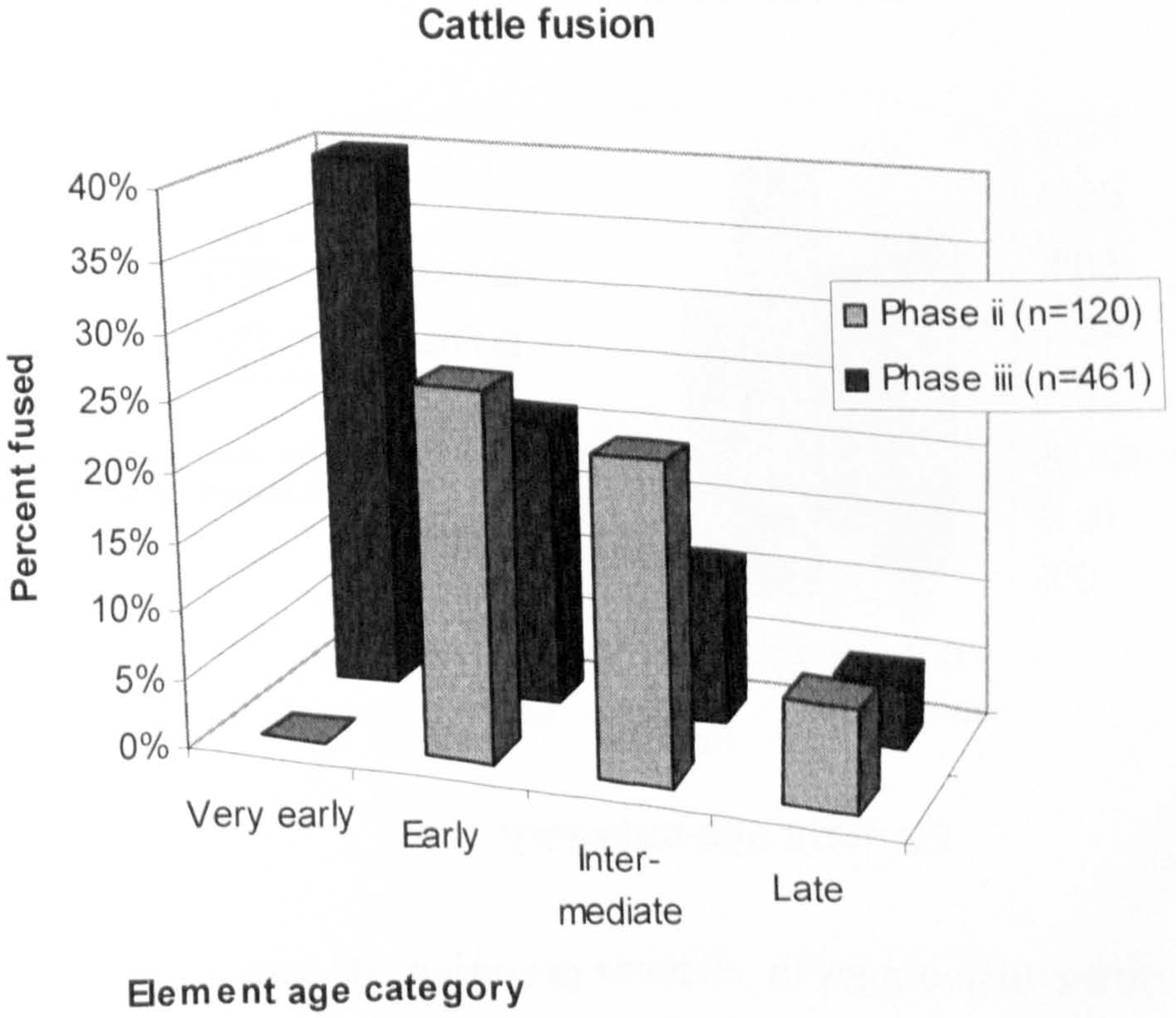


Figure 6.12: Cattle fusion ages by phase by element grouping, all data

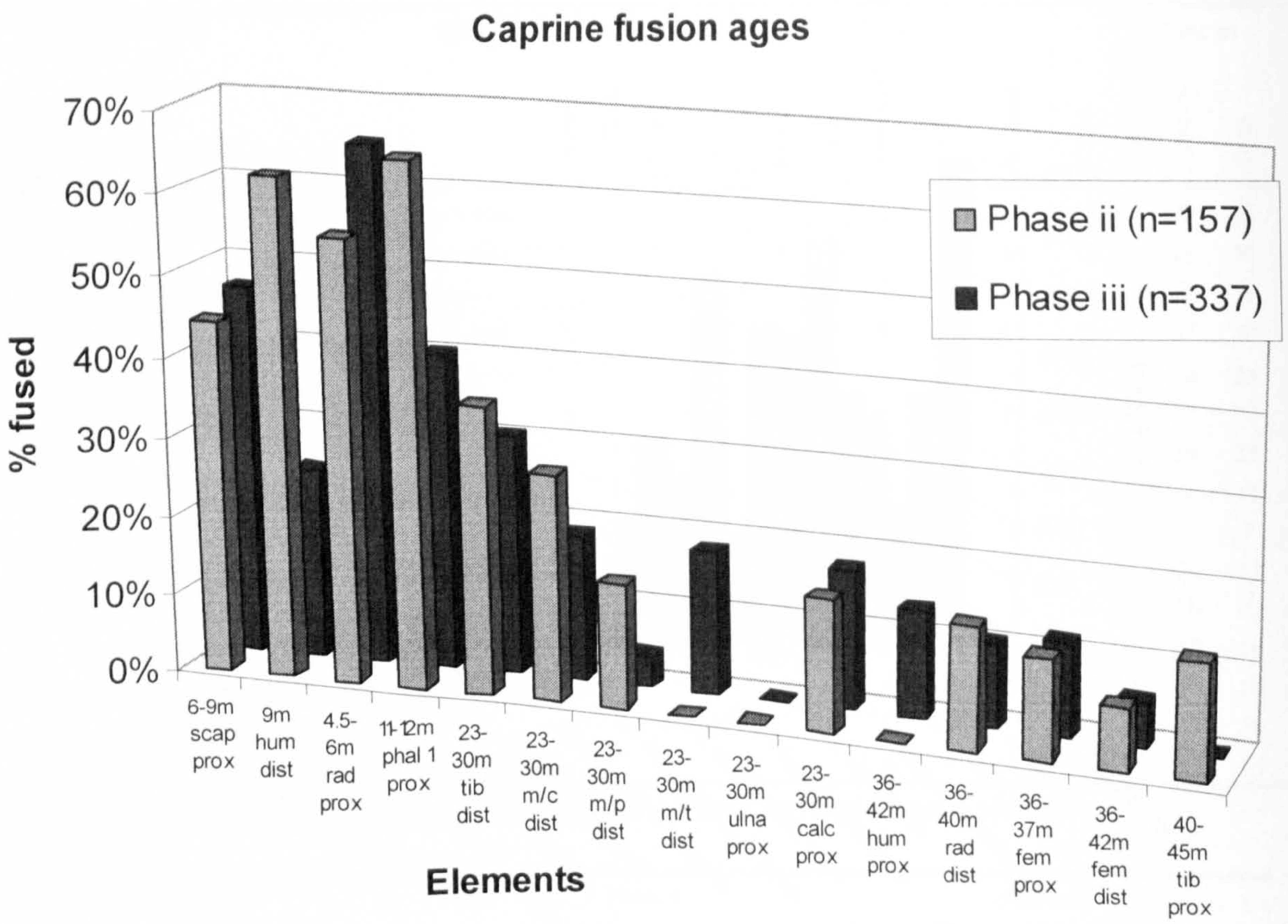


Figure 6.13: Caprine fusion ages by element, all data

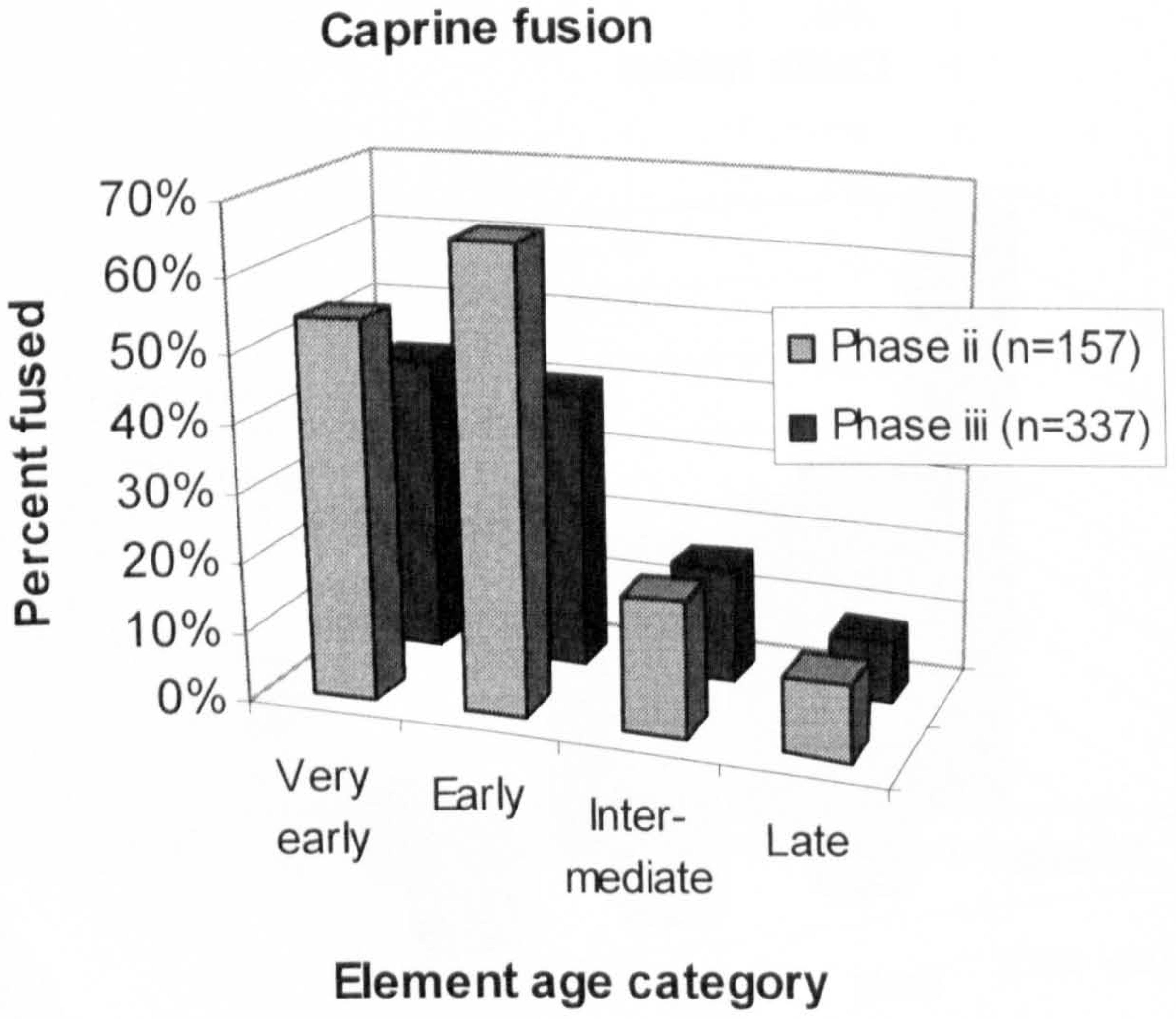


Figure 6.14: Caprine fusion ages by element grouping, all data

Age groups	Definition (following O'Connor 1989; 1991)	Cattle		Caprine			Pigs		
		Phase ii	Phase iii	Phase i	Phase ii	Phase iii	Phase i	Phase ii	Phase iii
Neonatal	No wear	3	14		3	1			
Juvenile	M1 not in wear	2	16		4	7			
(Juvenile/ Immature)*		3	4		1	2			
Immature	M1 in wear, M2 not in wear	1	3		5	5			
(Immature/ Sub-adult)*		2	2	1	3	1			1
Sub-adult	M2 in wear, M3 not in wear	1	4		13	17	1		3
(Sub-adult/ Adult)*								1	2
Adult	M3 in wear, not heavily worn	7	14		4	8	1	2	4
Elderly	M3 very worn	12	5		1				
Totals		31	62	1	34	41	2	3	10

*these categories were used for isolated teeth that could not be securely attributed to either group

Table 6.21: Tooth wear age definitions and counts

Tooth	Phase	Wear stages																
		PER	CPT	V	U	A	B	C	D	E	F	G	H	J	K	L	M	N
Dp4	ii					3		1							1			
	iii					7	18	2	1					1		1	1	
P4	ii								1		1	1	1					
	iii						1				1	2	1					
M1	ii						1				1		1					
	iii		3	12	1										1		1	
M2	ii									1			1		1			
	iii	1										1		1	1			
M1/M2	ii				3	1	1	1	1		1	1	1	1	4			
	iii		1		3	1	1							1	6	3		1
M3	ii						2	1	1					2	1			
	iii		1						1					2	2	1		

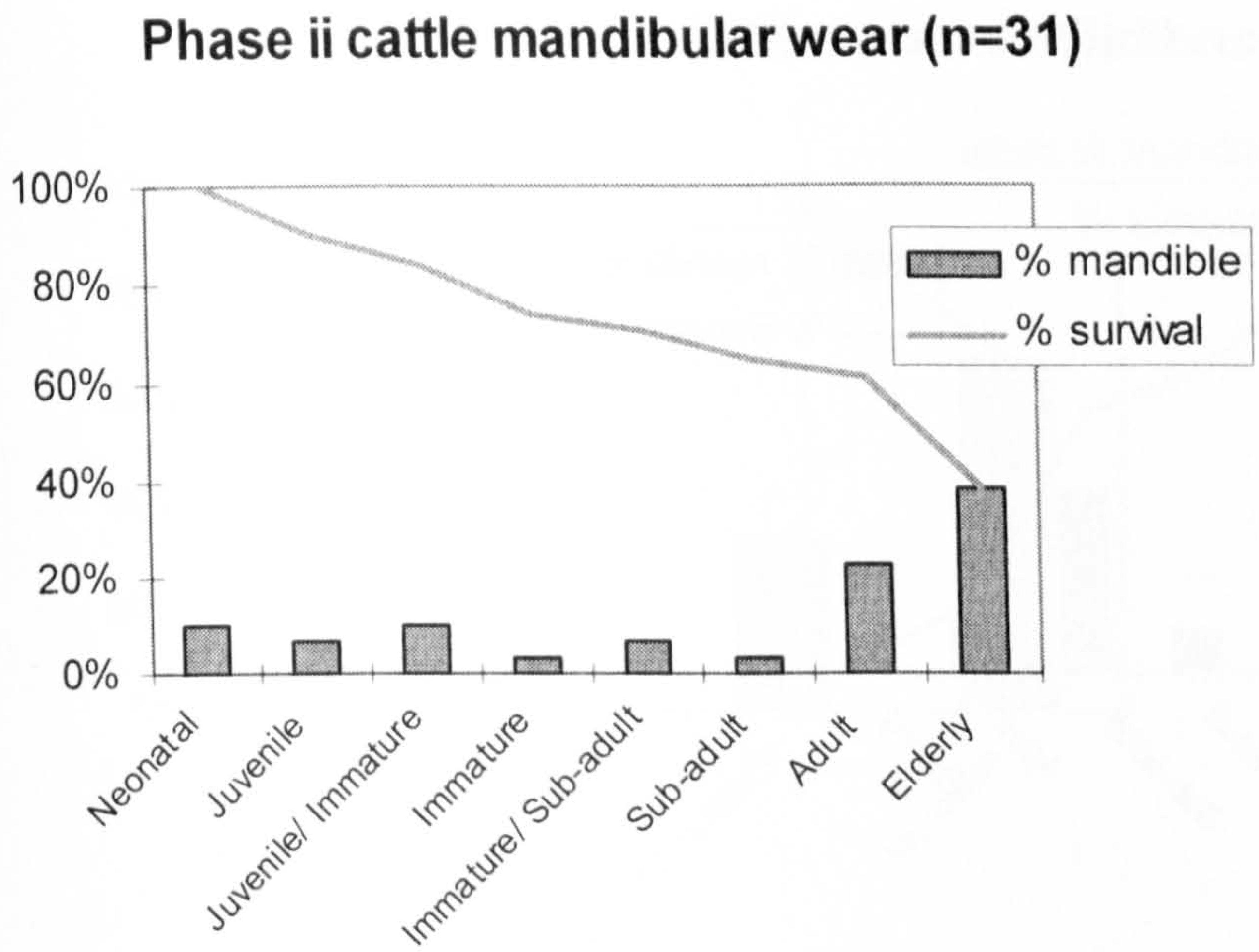
Table 6.22: Cattle tooth wear stages summary

Tooth	Phases	Wear stages																					
		CPT	V	U	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22
Dp4	ii			1					1	1	2						2		6				1
	iii			1							1	2			2	1	2		4	1	1	1	
	iii/v.ii							1															
P4	ii		1								1							1					
	iii													1	1			1					
M1	ii		2		1						1	4											
	iii	1	5						1	1	1	4	1										
M2	ii			1		2			2			1	1										
	iii		1	1				2	1			2		1			1						
M1/M2	i										1												
	ii			1		1	3	1	1		1	2											
	iii			2	1				2	2	3	2		1	1								
	iii/v.ii											1											
M3	i/ii			1																			
	ii	1	4	1					1						1								
	iii			3	1						1		2	1	1								

Table 6.23: Caprine tooth wear stages summary

Tooth	Phases	Wear stages										
		U	A	B	C	D	E	F	G	H	J	K
Dp4	iii							1				
P4	i			1								
	ii					1						
	iii				1	1		1				
M1	i							1				
	ii										1	
	iii					1	1					2
M2	i			1			1					
	ii				1							
	iii					1					1	
M1/M2	iii		1				1					
M3	i	1										
	ii				1	1						
	iii	1										

Table 6.24: Pig tooth wear stage summary



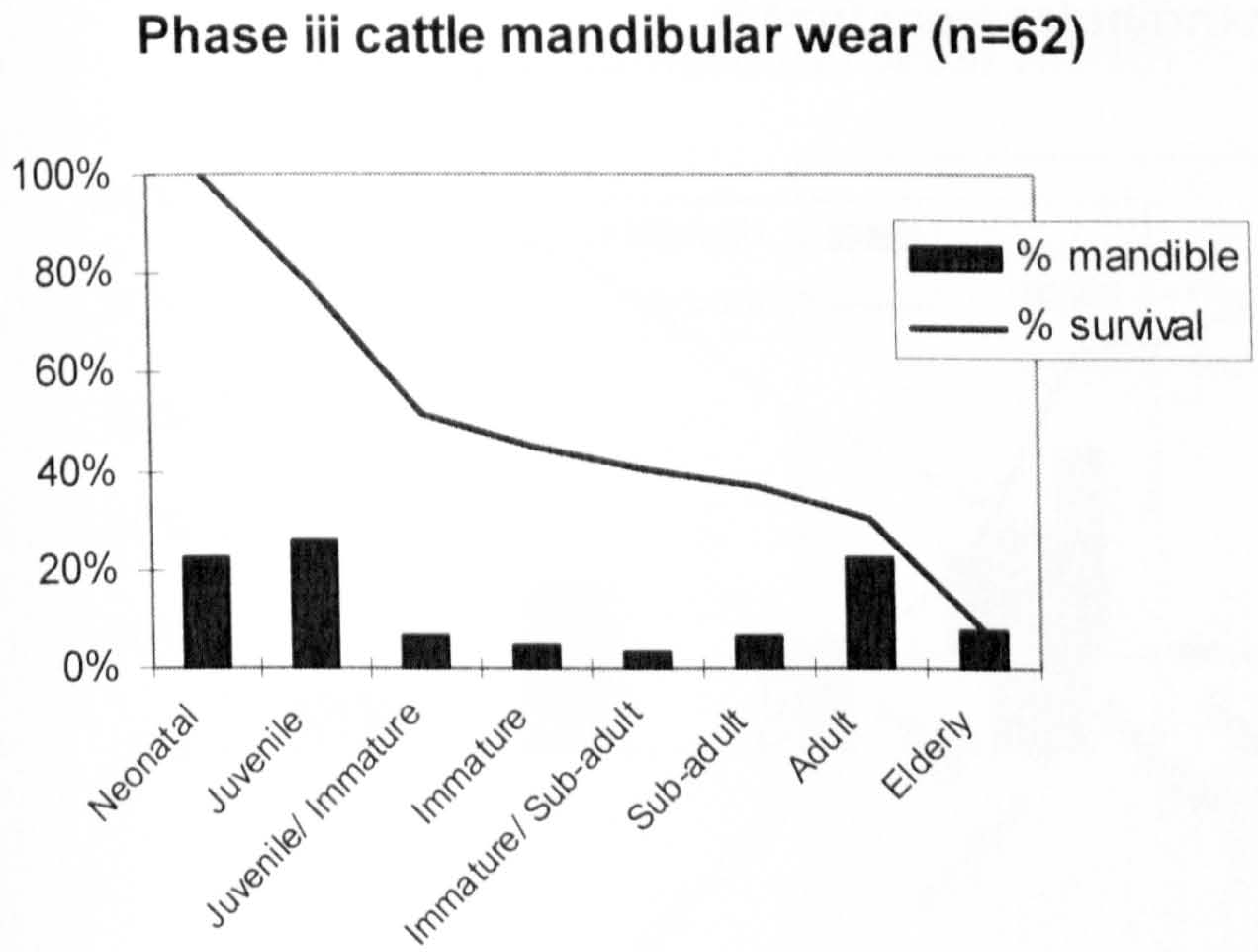
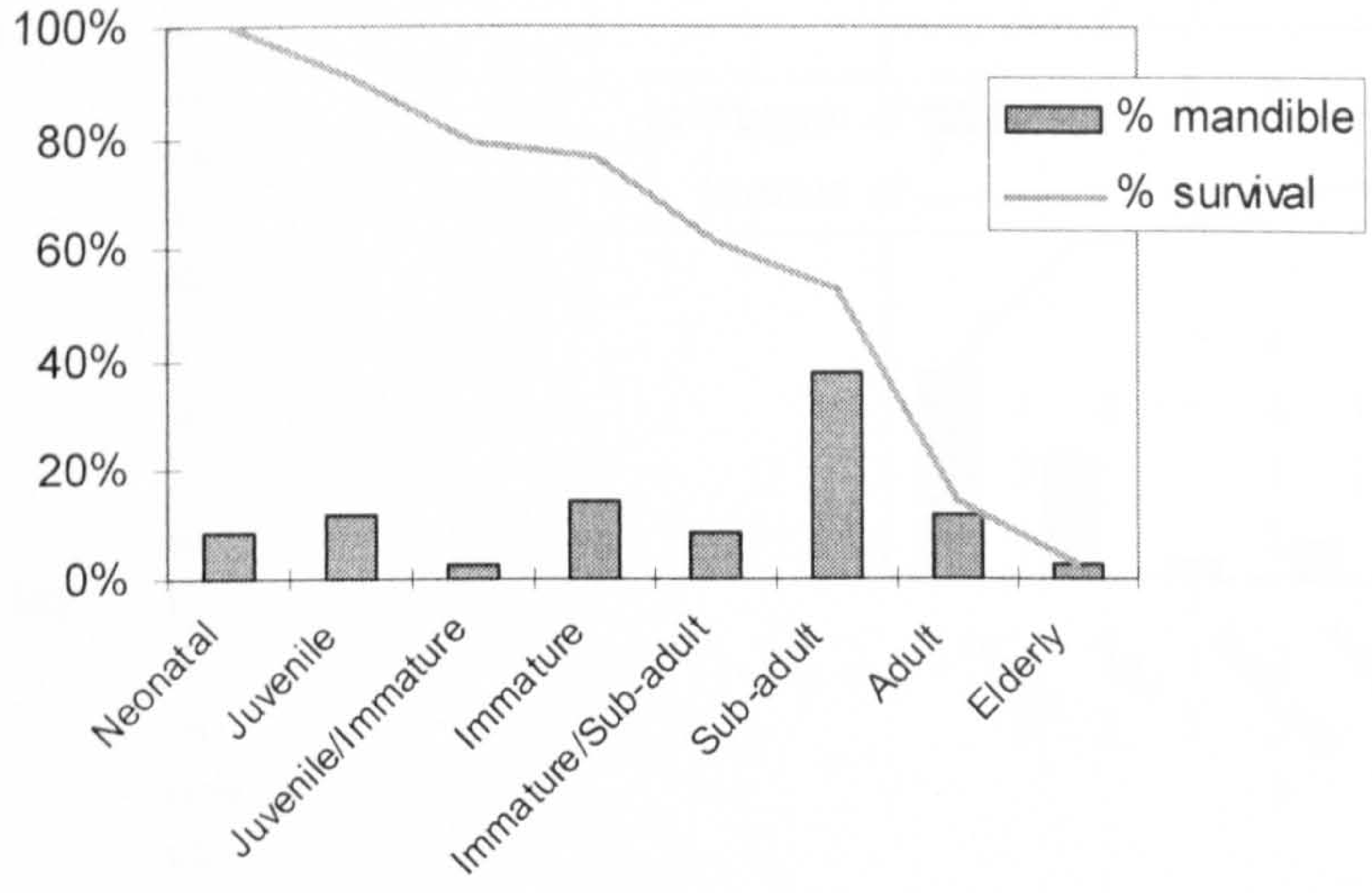


Figure 6.15: Cattle mandibular wear ages

Phase ii caprine mandibular wear (n=34)



Phase iii caprine mandibular wear (n=41)

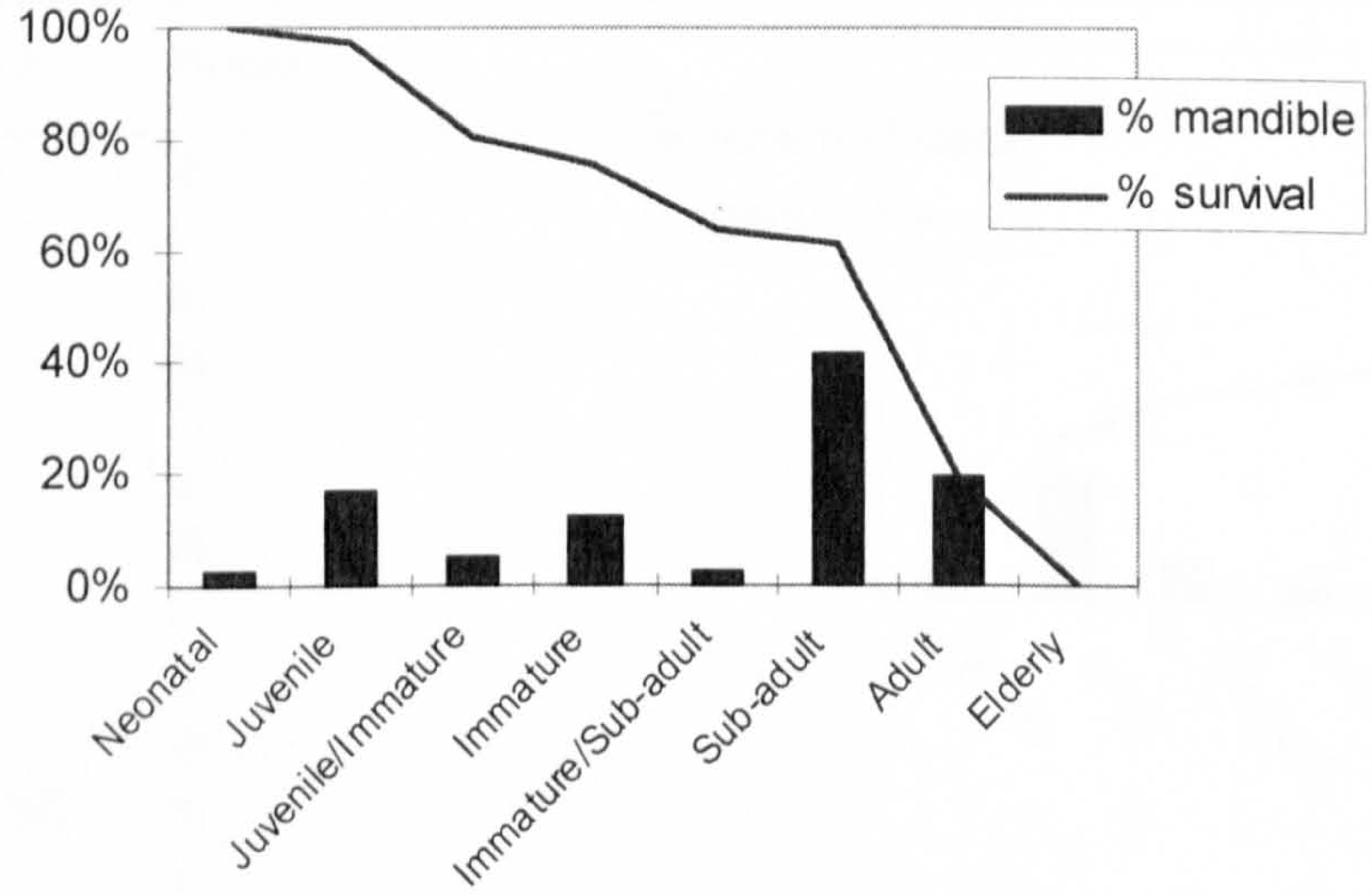


Figure 6.16: Caprine mandibular wear ages

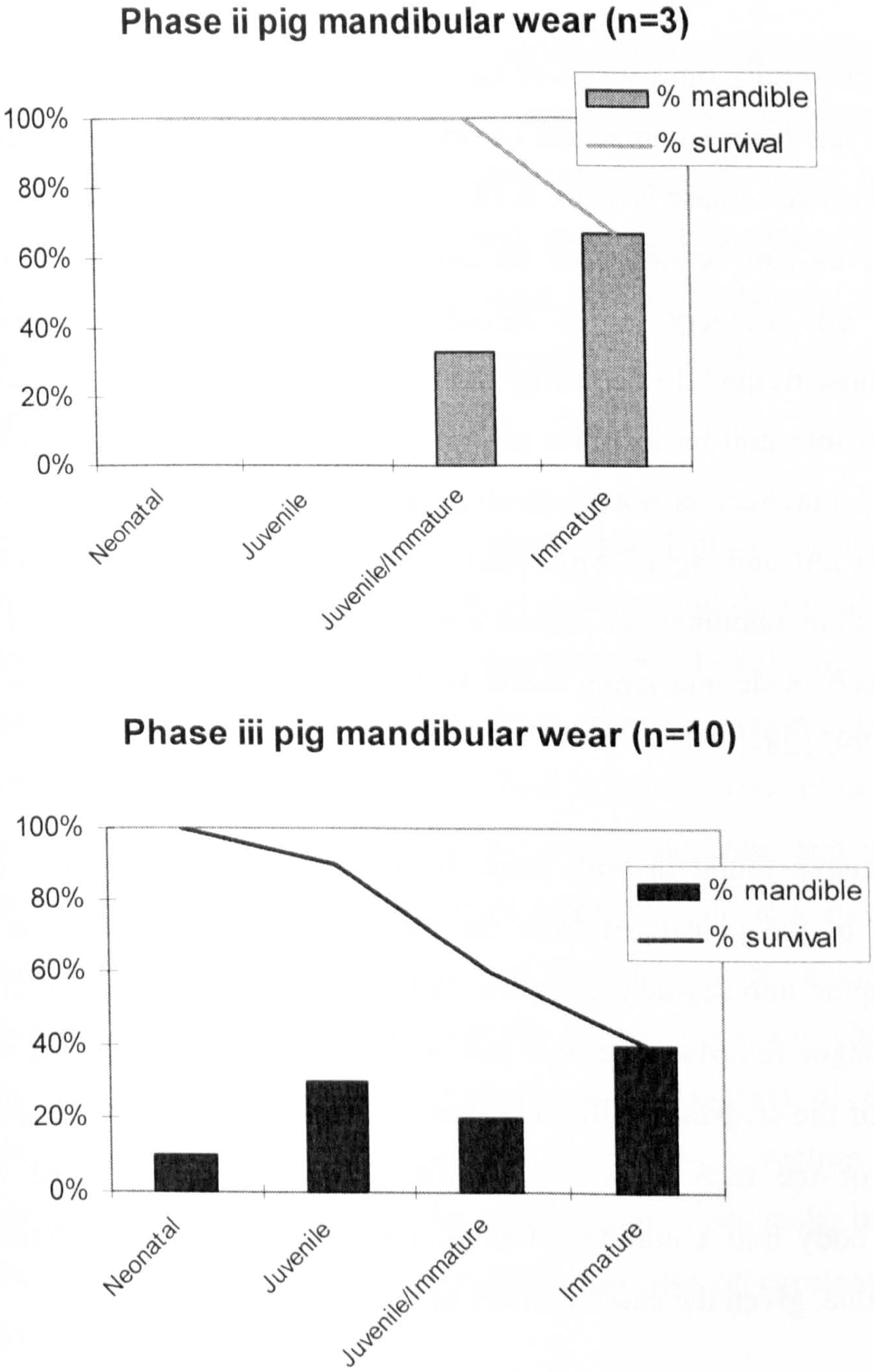


Figure 6.17: Pig mandibular wear ages

Phase ii Age category	Years	Quantity	Phase iii Age category	Years	Quantity
perinatal	0	1	young adult	3 to 7	1
juvenile	1 to 2	1	young adult-adult	3 to 10	2
sub-adult-young adult	2 to 7	1	adult	7 to 10	2
young adult	3 to 7	1	adult-elderly	7+	1
young adult-adult	3 to 10	1	elderly	10+	1
adult	7 to 10	1			
adult-elderly	7+	1			
elderly	10+	4			

Table 6.25: Cattle horncore ageing

6.6 Butchery

Butchery was recorded manually on a series of cards during the recording process. For cattle and caprines, this has been summarised on drawings of the complete skeleton for chop and knife marks for each phase (Figure 6.18 to Figure 6.27). Butchery marks did not occur as frequently as can be observed on contemporary urban sites (e.g. York, O'Connor 1989, 154); all butchery marks recorded are included on the summary drawings, not just the most frequently occurring marks. Metapodial butchery marks are divided equally between fore and back limbs; phalanx butchery is displayed entirely on the fore limb; sesamoid butchery is not illustrated; and unsided horncore butchery is equally divided between left and right. Full quantification by age for cattle, caprines, pigs, and large and medium mammals is provided in Table 6.26 to Table 6.30. Chop marks are defined as deep, wide and large, while knife marks are shallow, narrow and fine (Reitz and Wing 1999, 128-130).

Trends in cattle chop marks found in both phase ii and phase iii include: horn core removal, disarticulation of the phalanges from the metapodials, disarticulation at the elbow, butchery of the spine into segments, disarticulation at the hip, and removal of the mandible/decapitation/tongue removal. Phase ii also includes disarticulation at the wrist and shoulder, butchery of the scapula itself, and disarticulation at the knee, while phase iii includes separation of the neck vertebrae. These chops are all consistent with separation of the cattle body into a number of smaller pieces, and no real differences through time are observable, given the small number of marks.

Cattle knife marks are again similar through time. Both phases ii and iii show knife marks on the metapodials, phalanges and calcaneum, possibly indicating disarticulation and hoof removal. Knife marks on ribs and vertebrae could be indicative of preparing joints of meat for cooking, and reducing the larger pieces produced during chopping into more manageable pieces. The pattern of knife marks on the mandible in phase ii is also seen in the chop marks of phases ii and iii and could indicate decapitation, removal of the tongue or the removal of the mandible from the skull.

Most of the cattle butchery marks appear on adults or sub-adults (Table 6.26). This differs from the age profiles, particularly for the chop marks (see section 6.5), suggesting that butchery marks are more common on older animals. However, younger individuals may have required less chopping to disarticulate, resulting in less evidence on the bone, or chopping of younger material may have decreased the rate of identification possible. The presence of at least a few butchery marks on neonatal bone makes it likely that neonates were deliberately killed and used at Quoygrew (see the dairying debate, introduced in Chapter One and discussed in Chapter Nine). One unidentified neonatal mammal fragment from phase 2 displayed fine knife cuts, indicating that this trend probably extended into the fish midden.

Caprine chop marks found in both phase ii and phase iii are indicative of horn core removal, disarticulation of the vertebral column, and disarticulation at the hip, knee and ankle. Phase ii has additional evidence of removal of the mandible or decapitation and disarticulation at the shoulder and elbow, phase iii disarticulation at the wrist. Knife marks on caprines were infrequent. Phase ii has evidence of decapitation, division of the vertebral column, disarticulation at the elbow and knee, and removal of meat from the pelvis area. Phase iii has evidence of separation of the vertebral column into joints of meat, and disarticulation or removal of meat around the ankle joint. Again, the sheep butchery marks are too few in quantity to determine any chronological changes. All butchery marks are consistent with the disarticulation of the skeleton into smaller portions of meat, and then preparation and further reduction in size. Butchery marks were found on all ages, though the small sample sizes make interpretation difficult. No substantial differences from the mortality profiles of caprines were noted (see section 6.5).

Only five butchered pig elements were found (Table 6.28), possibly indicating decapitation (hyoid, mandible) and disarticulation (humerus, pelvis).

Large and medium mammal butchery patterns are not illustrated, but are quantified below (Table 6.29, Table 6.30). Given that all large mammal fragments are likely to be cattle, and most medium mammal fragments are likely to be caprine (which are in turn likely to be sheep), these fragments can augment the above pattern. Considerable quantities of butchery marks were found on rib and vertebral fragments for both sizes of mammal, providing further evidence of the primary division of the carcass into manageable joints of meat.

A small quantity of bones were found that were classed as 'worked', in that they were not artefacts, but they displayed more alterations than usually attributed to butchery. Included in these were a few instances of the bi-perforated sheep metapodials identified by Bigelow (1993), known from Norse and medieval settlements in Iceland and Greenland. This appears to be the first evidence for this custom in Orkney, and places Quoygrew firmly within the larger North Atlantic Norse cultural tradition. Appendix Four illustrates the worked bone from Quoygrew, including the few bi-perforated metapodials.

In summary, evidence is indicative of non-specialised butchery of the carcass into a number of separate pieces, followed by further processing. Overall levels of butchery are low, however, leaving open the possibility that large joints of meat were cooked on the bone.

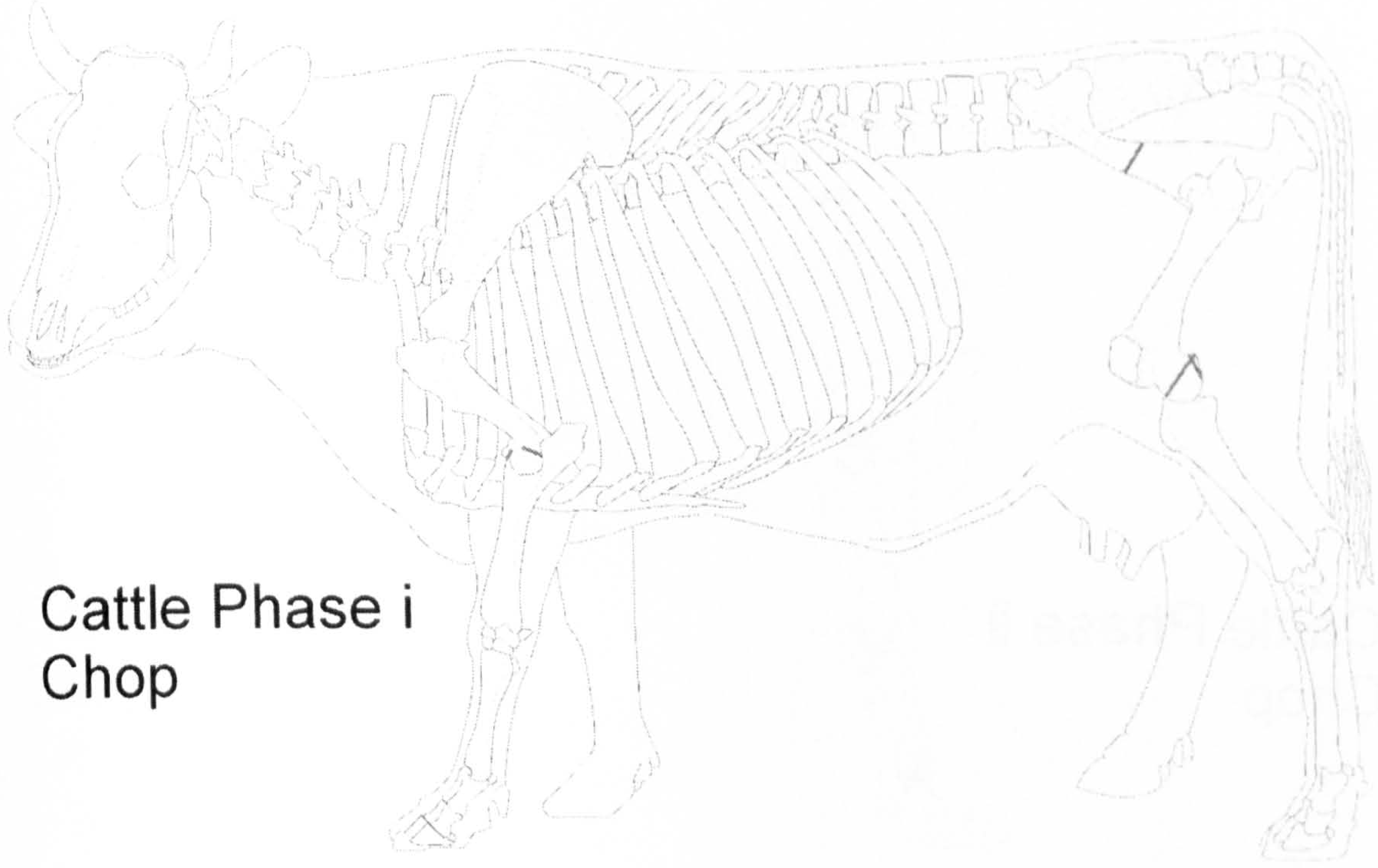


image source for all mammal butchery diagrams:
http://www.archeograph.com/ressources-graphiques/faune.php

Figure 6.18: Phase i cattle chop summary

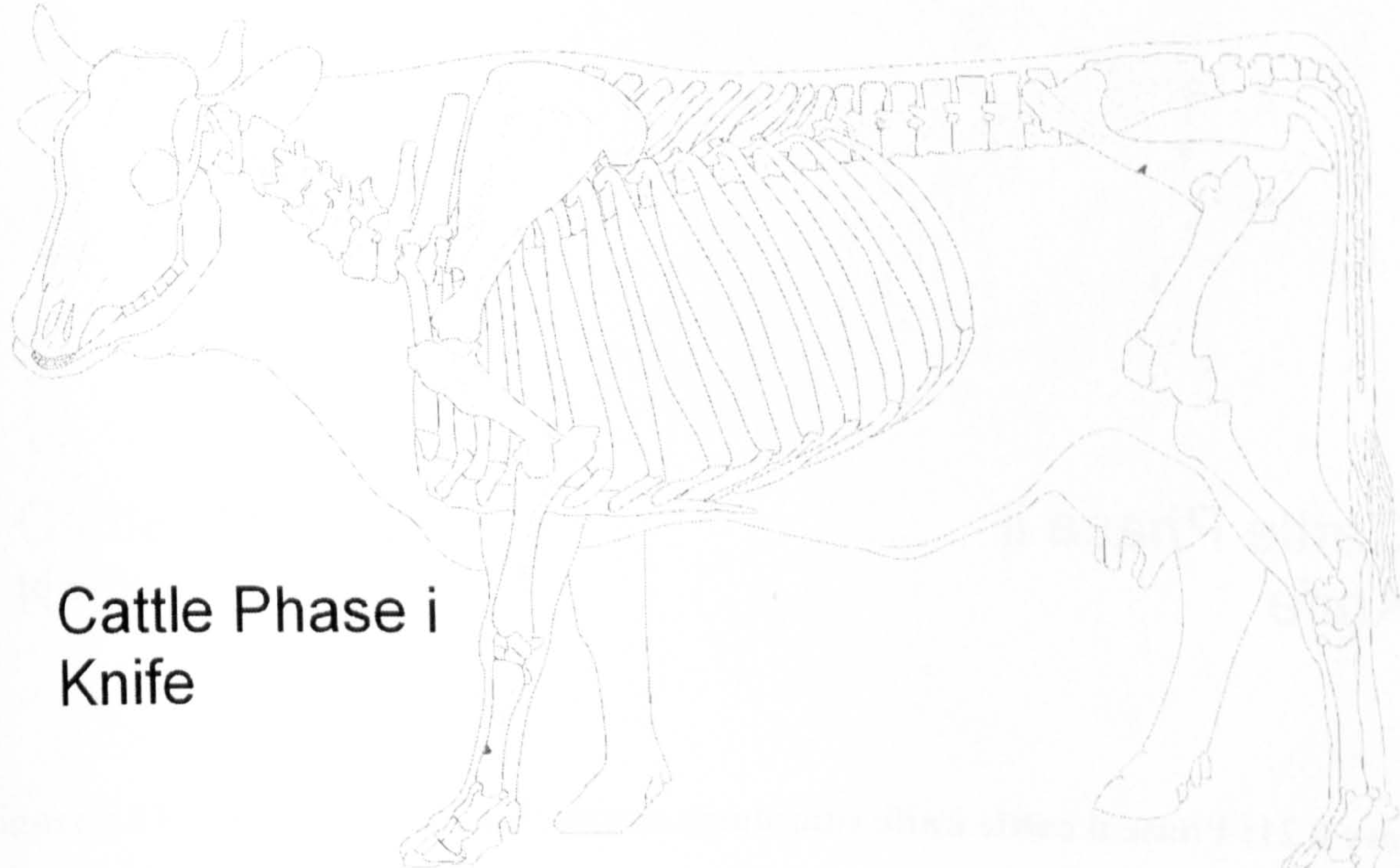


Figure 6.19: Phase i cattle knife summary

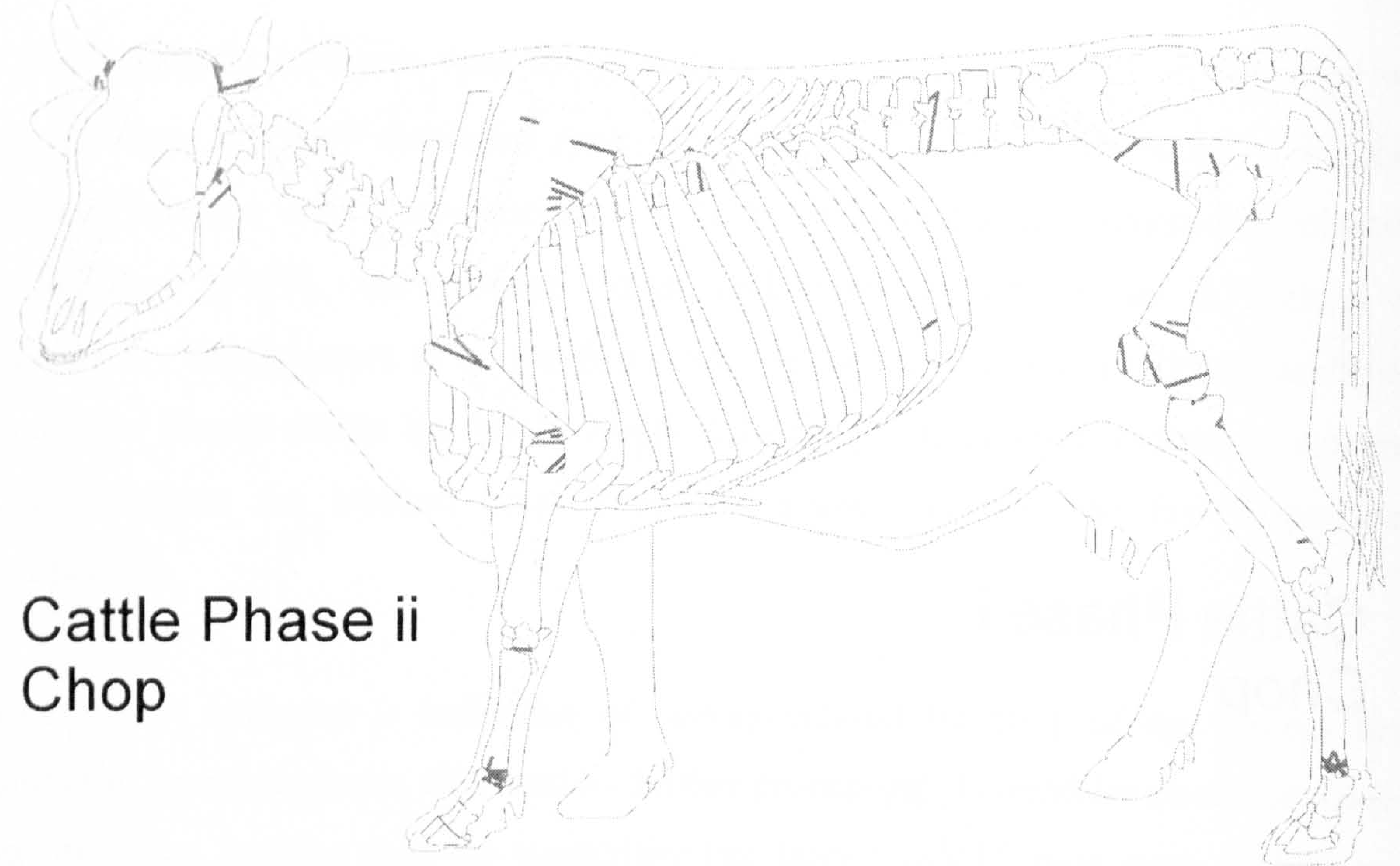


Figure 6.20: Phase ii cattle chop summary

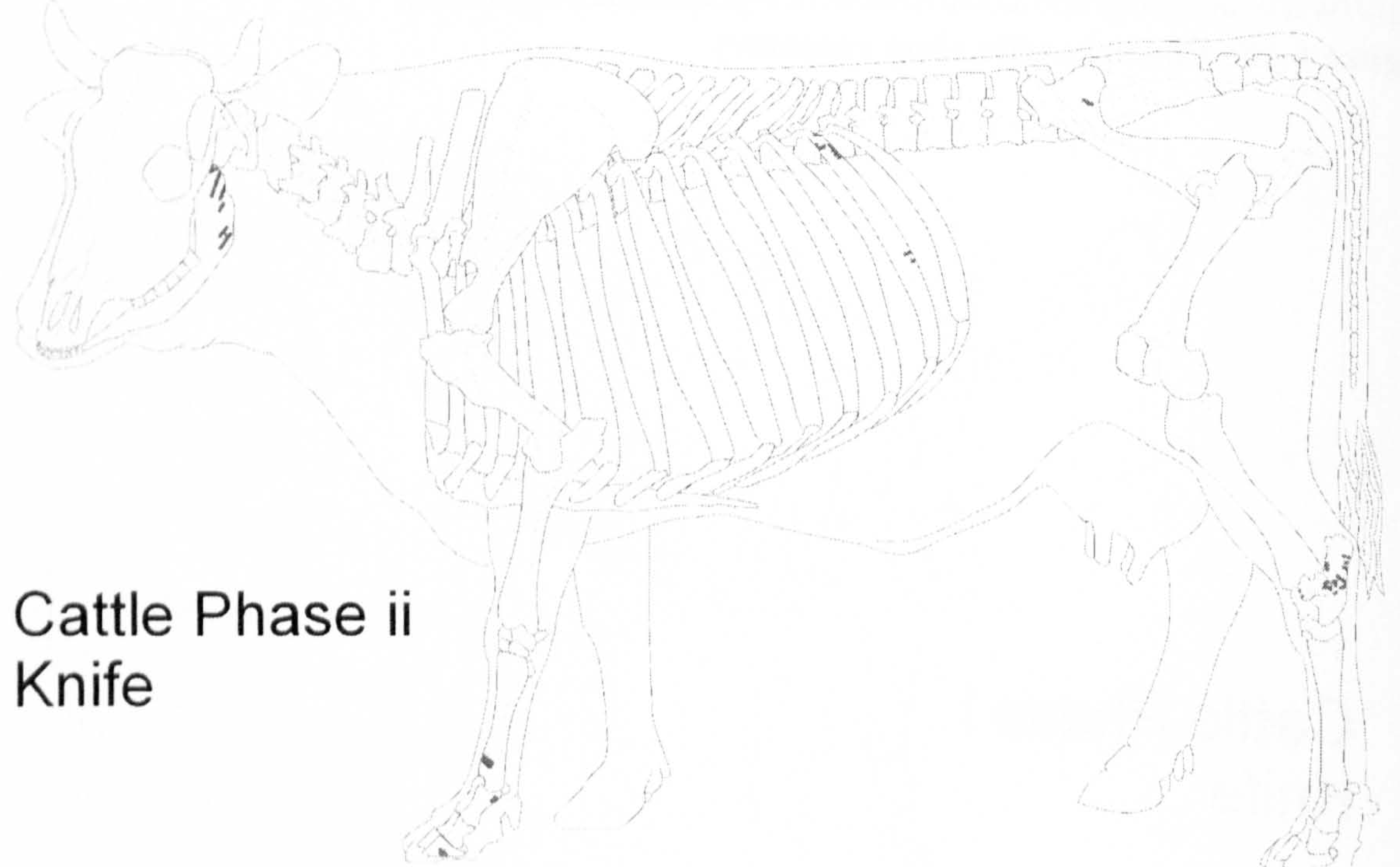


Figure 6.21: Phase ii cattle knife summary

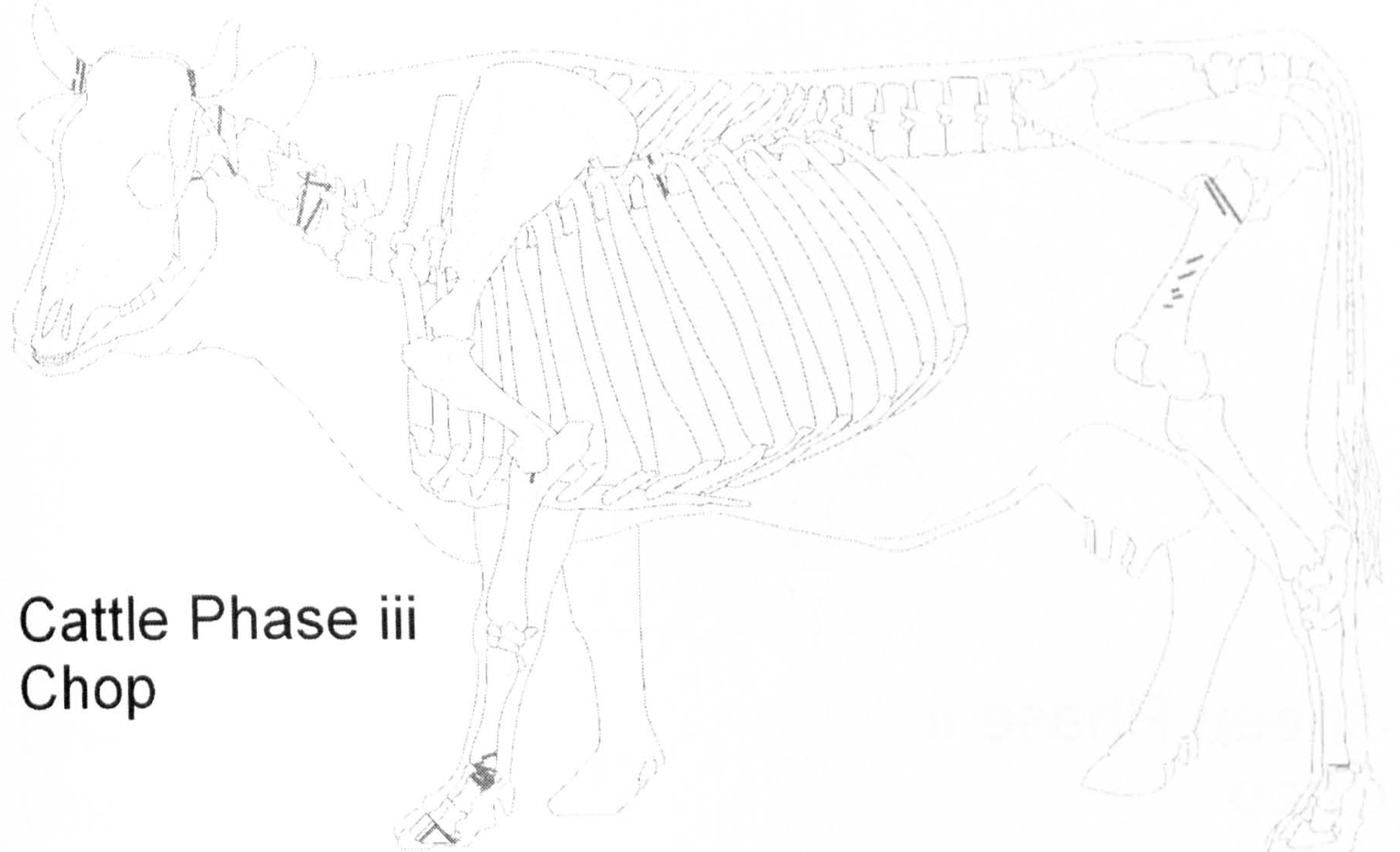


Figure 6.22: Phase iii cattle chop summary

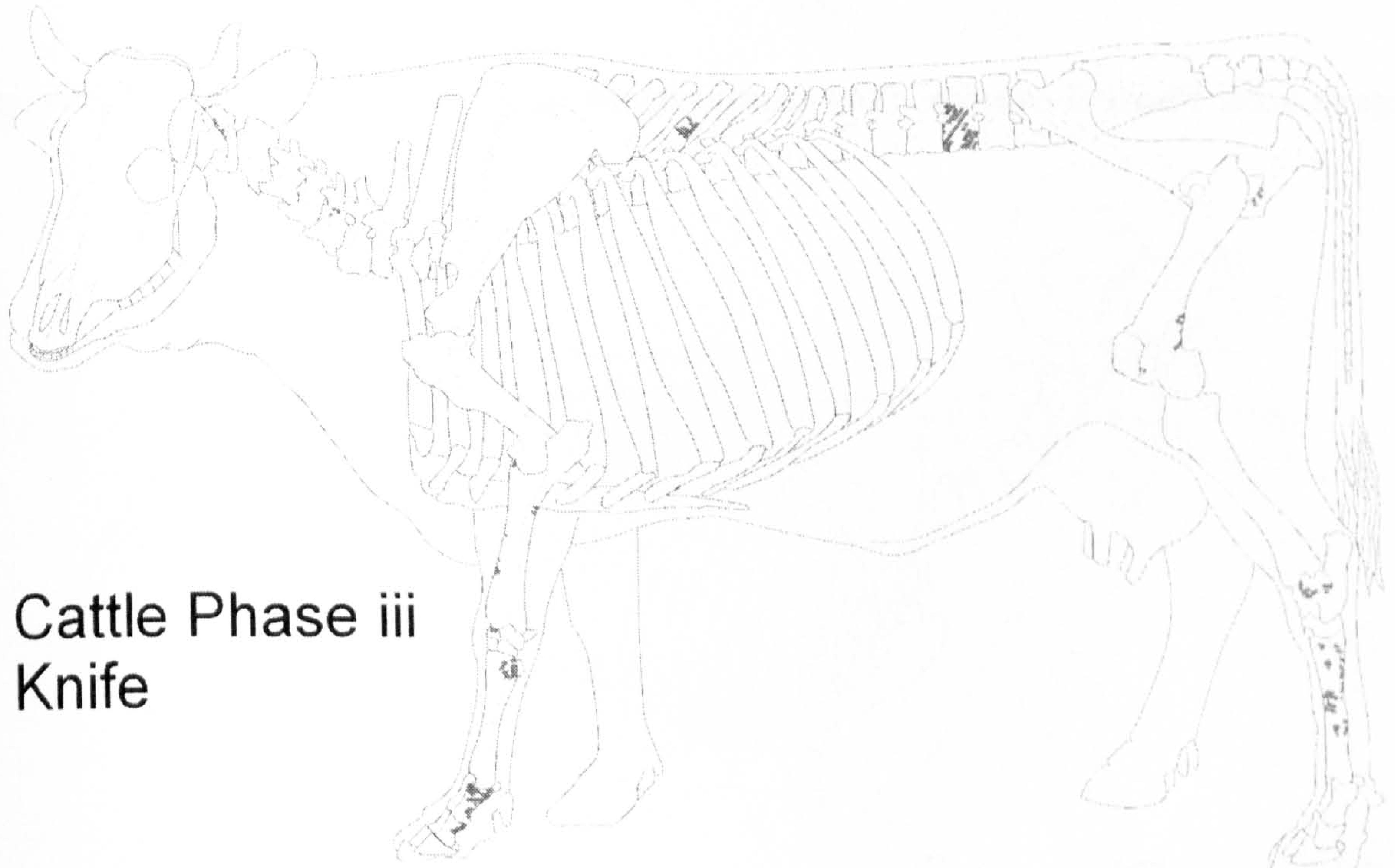


Figure 6.23: Phase iii cattle knife summary

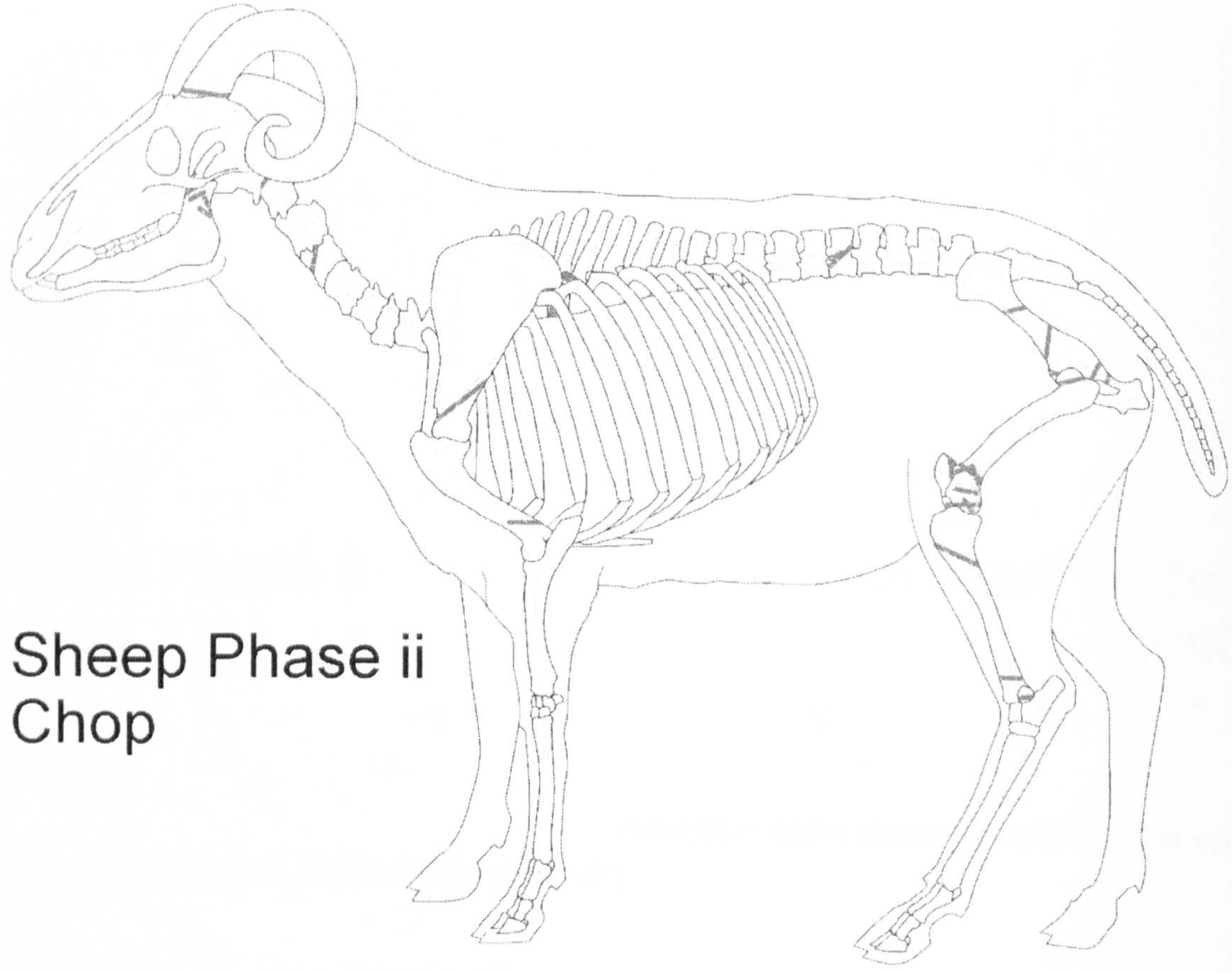


Figure 6.24: Phase ii caprine chop summary

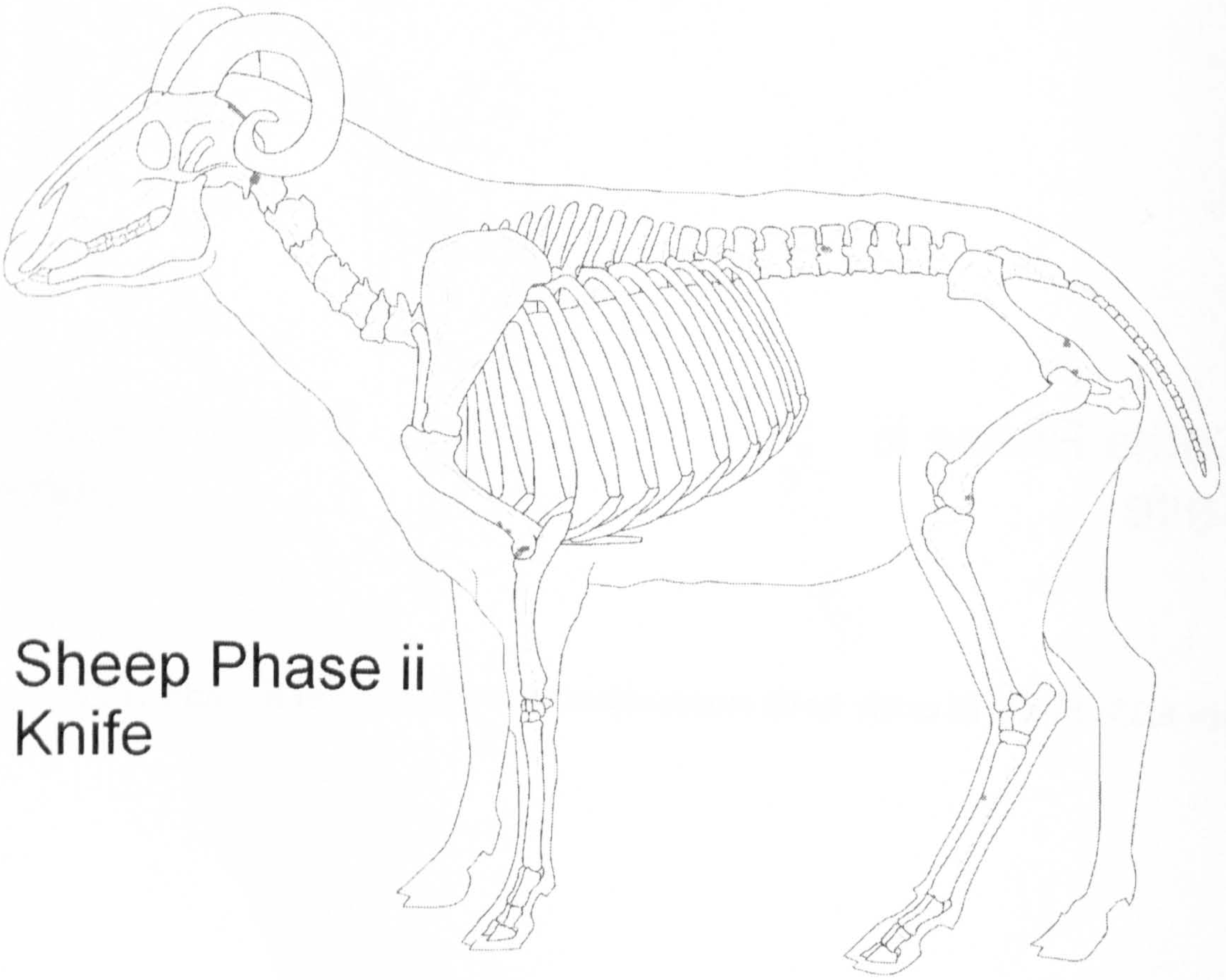


Figure 6.25: Phase ii caprine knife summary

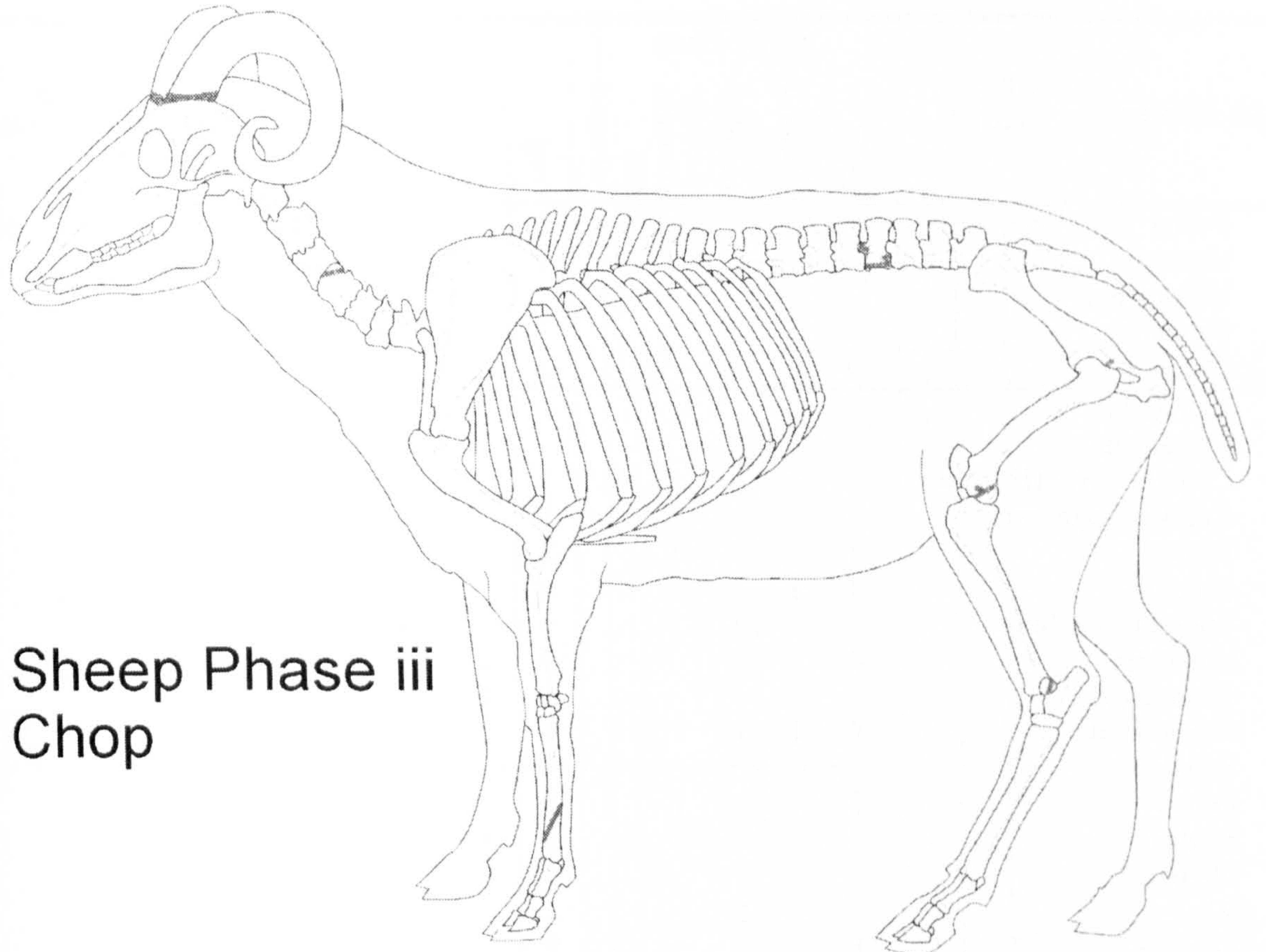


Figure 6.26: Phase iii caprine chop summary

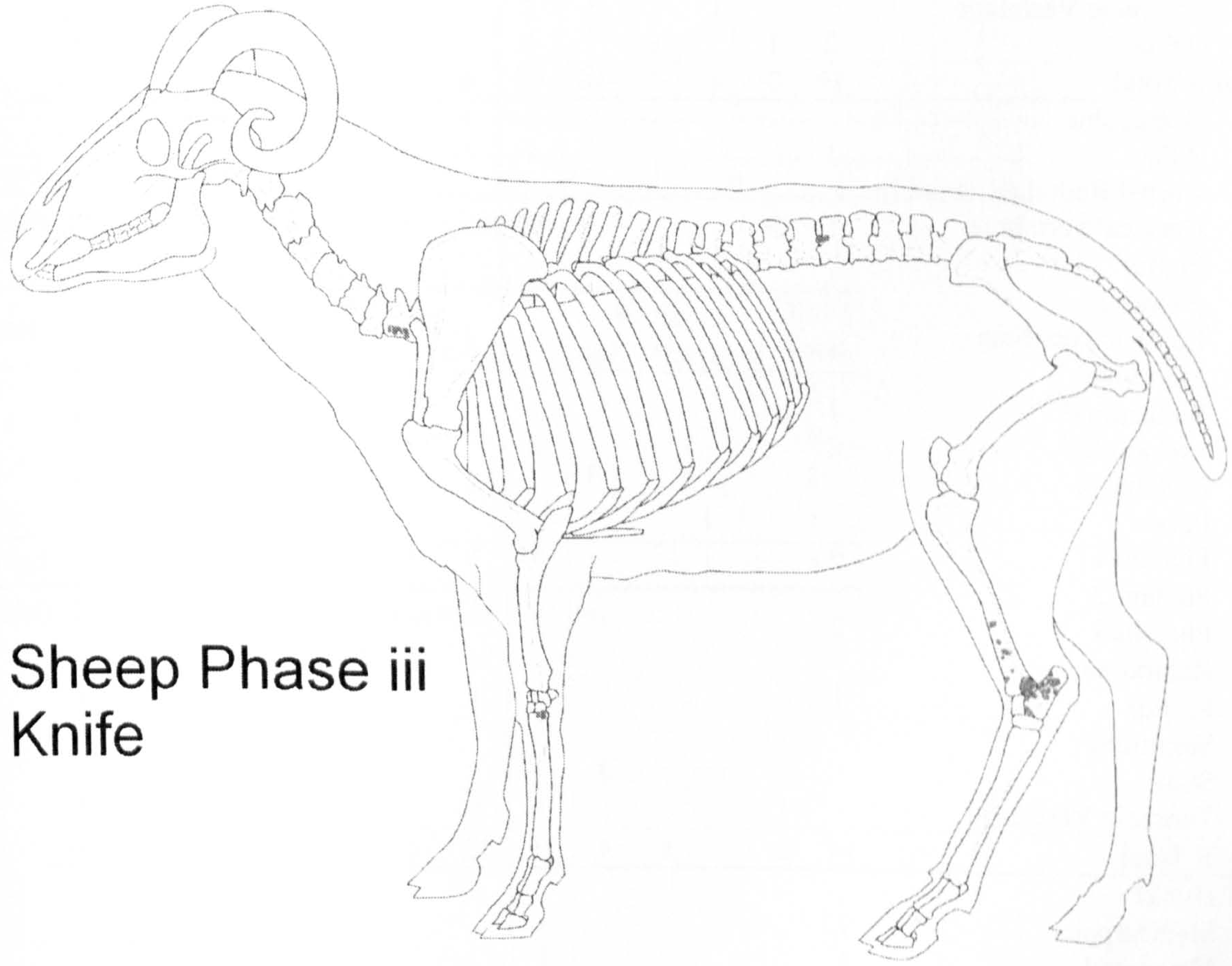


Figure 6.27: Phase iii caprine knife summary

Phase	Element	Chop						Knife						Grand total
		Adult	Sub-adult	Juvenile	Neonatal	Not aged	Total	Adult	Sub-adult	Juvenile	Neonatal	Not aged	Total	
i	Femur			1			1							1
	Humerus	1					1							1
	Metacarpal									1			1	1
	Pelvis	1					1	1					1	2
Phase i Total		2		1			3	1		1			2	5
ii	Astragalus							1		2			3	3
	Calcaneum									1			1	1
	Carpal Fourth (Hamate)					1	1							1
	Cranial Fragments					1	1					1	1	2
	Femur	1			1		2							2
	Humerus	3	1				4							4
	Lumbar vertebrae			1			1							1
	Mandible	4					4	2					2	6
	Metacarpal							1					1	1
	Metapodial	4	1	1		2	8							8
	Patella					1	1							1
	Pelvis	2			1		3	1					1	4
	Phalanx1	2					2	1					1	3
	Phalanx3							2					2	2
	Rib			1			1			1			1	2
	Scapula	1				1	2							2
	Sesamoid					4	4							4
	Skull					5	5							5
	Thoracic Vertebrae			1		1	2							2
	Tibia	2	1		1		4		1			1	2	6
Phase ii Total		19	3	4	3	16	45	8	1	4		2	15	60
iii	Astragalus							1	1	1	1		4	4
	Atlas	1					1	1					1	2
	Carpal Radial (Scaphoid)											1	1	1
	Cervical vertebrae	1	1				2		1				1	3
	Femur	1			1		2			2			2	4
	Humerus	1					1							1
	Lumbar vertebrae							1					1	1
	Mandible					1	1							1
	Metacarpal	1					1							1
	Metapodial	2					2							2
	Metatarsal							2			1		3	3
	Pelvis										1		1	1
	Phalanx1	4					4	5	1				6	10
	Phalanx2							1	1				2	2
	Phalanx3	2					2							2
	Radioulna											1	1	1
	Radius	1					1	1			1		2	3
	Sesamoid											3	3	3
	Skull					3	3							3
	Thoracic Vertebrae		1				1	1					1	2
Phase iii Total		14	2		1	4	21	13	4	3	4	5	29	50
iii/v.ii	Hyoid											1	1	1
	Metacarpal	1					1							1
	Metatarsal	1					1							1
Phase iii/v.ii Total		2	0	0	0	0	2	0	0	0	0	1	1	3
Grand total		37	5	5	4	20	71	22	5	8	4	8	47	118

Table 6.26: Cattle butchery summary

Phase	Element	Chop					Knife						Grand Total
		Adult	Sub-adult	Juvenile	Not aged	Total	Adult	Sub-adult	Juvenile	Neonatal	Not aged	Total	
ii	Astragalus			1		1							1
	Axis				1	1					1	1	2
	Cervical vertebrae	1				1							1
	Femur	1	1	3	1	6			1			1	7
	Humerus	1				1	1					1	2
	Lumbar vertebrae			2		2					1	1	3
	Mandible	2			1	3							3
	Metatarsal		1			1	1					1	2
	Patella				1	1							1
	Pelvis	2		1	1	4	1					1	5
	Scapula		1			1							1
	Skull				1	1			1			1	2
	Thoracic Vertebrae			1		1							1
	Tibia	1		1		2							2
ii Total		8	3	9	6	26	3		2		2	7	33
iii	Astragalus	1				1	2			1		3	4
	Calcaneum						1		2			3	3
	Cervical vertebrae			1		1							1
	Femur		1			1							1
	Lumbar vertebrae	2	1			3					1	1	4
	Metacarpal	1				1			1			1	2
	Pelvis	1				1							1
	Skull				5	5							5
	Thoracic Vertebrae								1			1	1
	Tibia							1				1	1
iii Total		5	2	1	5	13	3	1	4	1	1	10	23
iii/v.ii	Axis						1					1	1
Grand total		13	5	10	11	39	7	1	6	1	3	18	57

Table 6.27: Caprine butchery summary

Phase	Element	Chop		Knife		Grand Total
		Adult	Sub-adult	Adult	Not aged	
i	Mandible		1			1
ii	Humerus	1				1
	Pelvis	1		1		2
iii	Hyoid				1	1
Grand total		2	1	1	1	5

Table 6.28: Pig butchery summary

		Chop				Knife	
Phase	Element	Adult	Juv-enile	Not aged	Total	Not aged	Grand total
ii	Humerus	1			1		1
	Mandible			1	1		1
	Pelvis	1			1		1
	Radius		1		1		1
	Rib			10	10	3	13
	Sacrum			1	1		1
	Shaft			3	3	1	4
	Shaft and cancellous			4	4		4
	Thoracic Vertebrae			2	2		2
	Vertebra			1	1	1	2
ii Total		2	1	22	25	5	30
iii	Cranial Fragments			2	2	3	5
	Mandible	1			1		1
	Rib			4	4	8	12
	Sacrum			1	1	1	2
	Scapula	1			1		1
	Shaft			1	1	1	2
	Shaft and cancellous			3	3	2	5
	Thoracic Vertebrae					1	1
	Vertebra			1	1	1	2
iii Total		2		12	14	17	31
Grand Total		4	1	34	39	22	61

Table 6.29: Large mammal butchery summary

		Chop				Knife				
Phase	Element	Adult	Juvenile	Not aged	Total	Adult	Juvenile	Not aged	Total	Grand Total
ii	Rib			27	27	1		18	19	46
	Scapula	1			1					1
	Vertebra		1		1					1
ii Total		1	1	27	29	1		18	19	48
iii	Lumbar vertebrae							1	1	1
	Rib		1	1	2		2	29	31	33
iii Total			1	1	2		2	30	32	34
iii/v.ii	Rib							1	1	1
Grand Total		1	2	28	31	1	2	49	52	83

Table 6.30: Medium mammal 1 butchery summary

6.6.1 Marrow and grease extraction

Fragmentation levels in mammal bones can relate to the processing of bone for marrow extraction or grease, and the degree to which these processes are differentially applied through time and space could have a direct influence on rates of identification and fragmentation, beyond that attributed to non-human taphonomic factors. Recording of

Quoygrew mammal followed a modified and simplified version of Outram's method of determining bone fat exploitation (Outram 1998; 1999; 2001; 2002; 2003; 2004; see Chapter Two for further details).

Figure 6.28 summarises the evidence for marrow extraction, for large mammal (cattle and horse sized) and medium mammal 1 (sheep and pig sized) long bones. Within each phase, elements are ranked by the proportion of fragments with very fresh fractures. Also included are proportions of fragments with moderately fresh fractures, not fresh fractures, and proportion of whole – unbroken diaphysis – fragments. The mandible is included because it has a marrow cavity similar to that of long bones (Outram 2004, 75). Within the large mammals, more elements had 'very fresh' fractures in phase iii than in phase ii, but proportions of 'moderately fresh' fracture were slightly higher in phase ii. Similar elements were targeted in phases ii and iii, namely those that were easiest to fracture and that produced the most marrow. No large mammal phalanges displayed any signs of 'very fresh', 'moderately fresh', or 'not fresh' fracturing, suggesting that the small quantity of marrow found inside them was not worth the energy expenditure in exploiting it.

Medium mammal elements show more variation in marrow fragmentation. Phase iii has a wider variety of elements with high proportions of 'very fresh' breakage than phase ii, possibly indicating an increase in marrow exploitation from phase ii to phase iii. Again there is a concentration on elements that contain the most marrow, with little usage of the phalanges. The mandible is one element that would require a moderate to substantial amount of effort to fracture for only a moderate return of fat (based on ethnographic data summarised in Outram 2004, 76); its exploitation in phase ii is low but is higher in phase iii, further evidence of an increase in utilisation of medium mammal marrow. Figure 6.29 illustrates the proportions of marrow exploitation for unidentified shaft fragments not included in Figure 6.28; again these are divided into 'very fresh', 'moderately fresh', 'not fresh', and 'not applicable' (mainly unidentified bone of cetacean or phocid type and without a marrow cavity). The proportion of 'very fresh' fractures rises steadily from phase i to phase iii, further evidence of the trend observed in elements identified to large or medium mammal. This also provides an indication of marrow extraction in phase 2, which appears consistent with the later phases of the farm mound.

If fresh fractures had been caused by carnivore gnawing – an alternative explanation to marrow exploitation – a high correlation between very fresh fractures and gnaw marks would be expected. However, in the entire assemblage only eight fragments were recorded as 'very freshly fractured' with carnivore gnawing, and 31 as 'freshly fractured' with carnivore gnawing. These quantities are extremely low, and represent only a very minor and insignificant contribution to the pattern.

Grease exploitation requires more effort than marrow extraction because cancellous bone material needs to be comminuted, possibly stored until an adequate supply is accumulated, boiled, cooled and then skimmed (Outram 2004, 76). Again there is a hierarchy of elements: long bone epiphyses produce the highest quality fat; ribs, vertebral and cranial elements the least. There is no easy way to determine fracture freshness in cancellous tissue as there is for cortical bone, but fragment sizes and fragmentation can be used to indicate grease extraction.

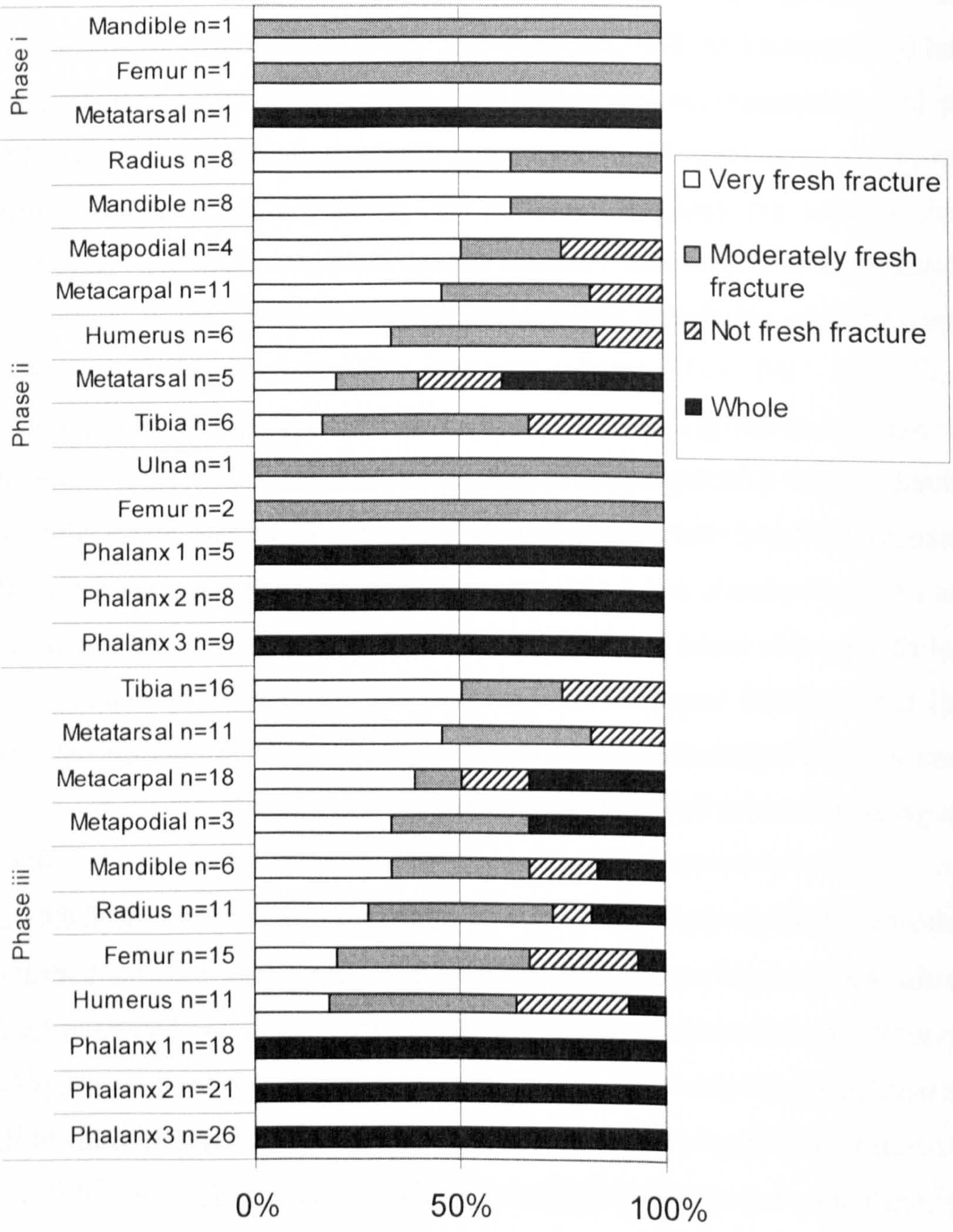
The most likely set of elements to use for grease extraction are the long bone epiphyses (Figure 6.30). If these were exploited, they would need to be broken into pieces prior to rendering to allow the grease to leave the epiphyses. A high percentage of fragmented epiphyseal bone would therefore be expected, with a correspondingly low percentage of unfragmented epiphyseal bone. If epiphyses were used for large scale grease production, it would be expected that almost no epiphysis would remain intact, as was observed at the Norse farm of Sandnes, Greenland. There, complete epiphyses were almost negligible in quantity, interpreted as high levels of grease exploitation (Outram 2001, 408). All of the epiphyseal fragments from Quoygrew were measured on a 2cm scale of size categories, and the proportion of fragmented and unfragmented cancellous bone was calculated for each of these, as summarised in Figure 6.30. Within the large mammal subset, no size category is fragmented to over 50% (i.e. at least half of the fragments in each size category are complete unbroken epiphyses, or fully fused and only broken open at the marrow cavity, thus not exposing the cancellous tissue inside the epiphysis) and the smallest size, <30mm has a very low percentage of grease extraction potential for both phases. Values for medium mammal 1 long bone cancellous tissue were even lower, indicating little reliance on this form of fat.

If vertebrae were used for grease extraction, it would be expected that few vertebrae would survive complete, and fragment sizes would be consistently small. Figure 6.31 indicates the percentage of fragmented vertebrae, divided into large and medium mammal by fragment size. For large mammals, the wide range of size categories present, plus the low percentage scores for the smallest size category, suggest vertebrae were not used for grease extraction. Medium mammal vertebrae are naturally smaller than large mammal, and the size category resolution was probably insufficient to identify more subtle variation. However, because many medium mammal vertebrae were unfragmented, it is unlikely that they were used for grease extraction.

If ribs were used for grease extraction, a substantial proportion would be highly fragmented. Figure 6.32 depicts rib fragment size for large and medium mammals from both recovery methods. For large mammals, a variety of sizes are found with a peak at 51-70mm for both phases, and a very low proportion of small fragment sizes. Medium mammal ribs are also found in a variety of sizes, with a peak in the 31-50mm category. Phase iii tends towards larger rib fragment sizes for both large and medium mammals, consistent with the taphonomic results discussed in section 5.2.4. In sum, ribs were not used for grease extraction in any phase.

In conclusion, although there is evidence of marrow extraction from elements that are high in fat and easy to exploit, the inhabitants of Quoygrew did not appear to use epiphyses, vertebral elements or ribs for grease. Marrow extraction increased for caprine and pig sized mammals through time from phase ii to phase iii. As discussed previously in 6.2.3, carnivore damage to the assemblage was very low, making it unlikely that any of these conclusions have been wrongly attributed to human action.

Large mammal marrow, all ages, both hc and >4mm



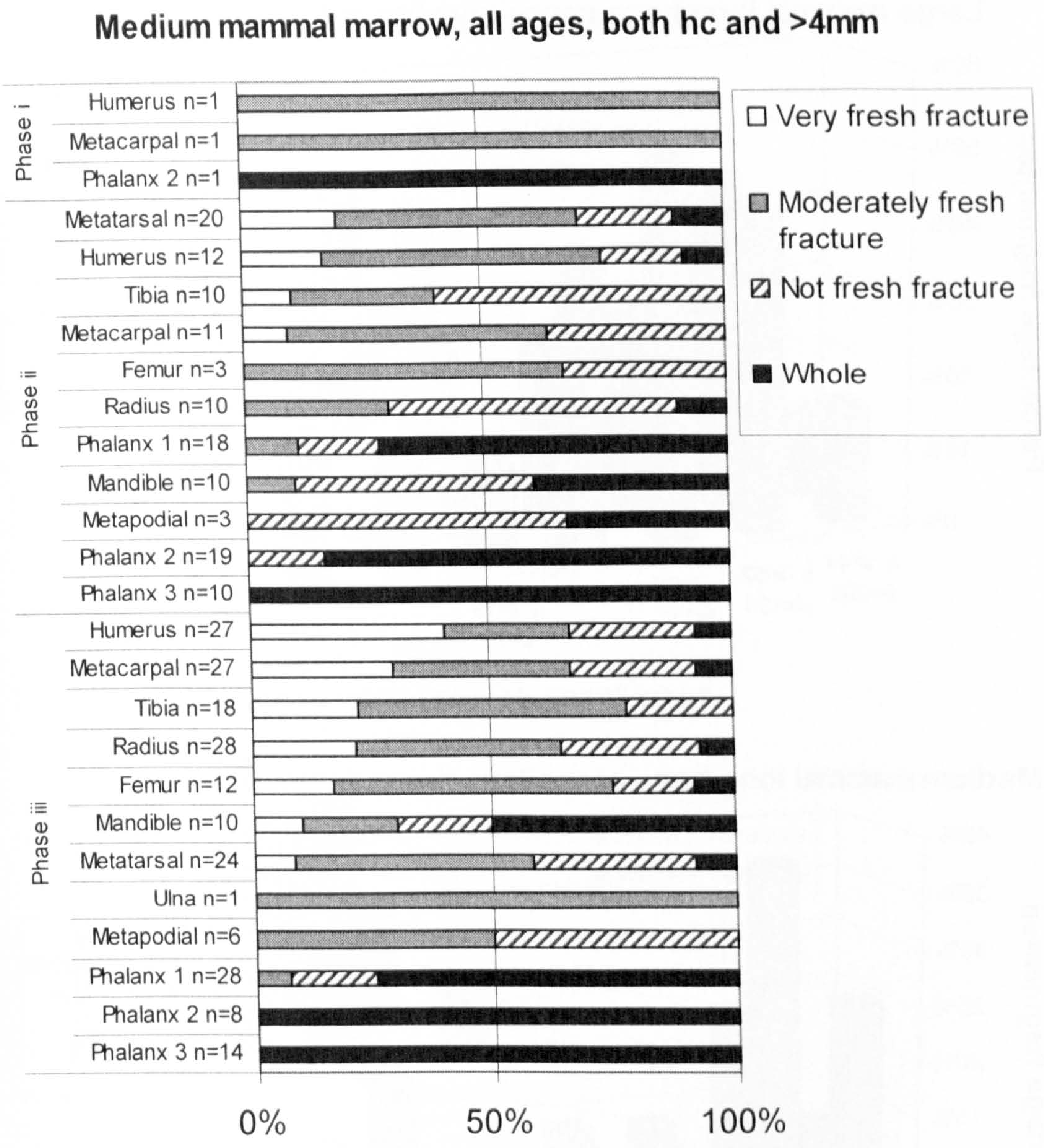


Figure 6.28: Marrow extraction by element, large and medium mammals

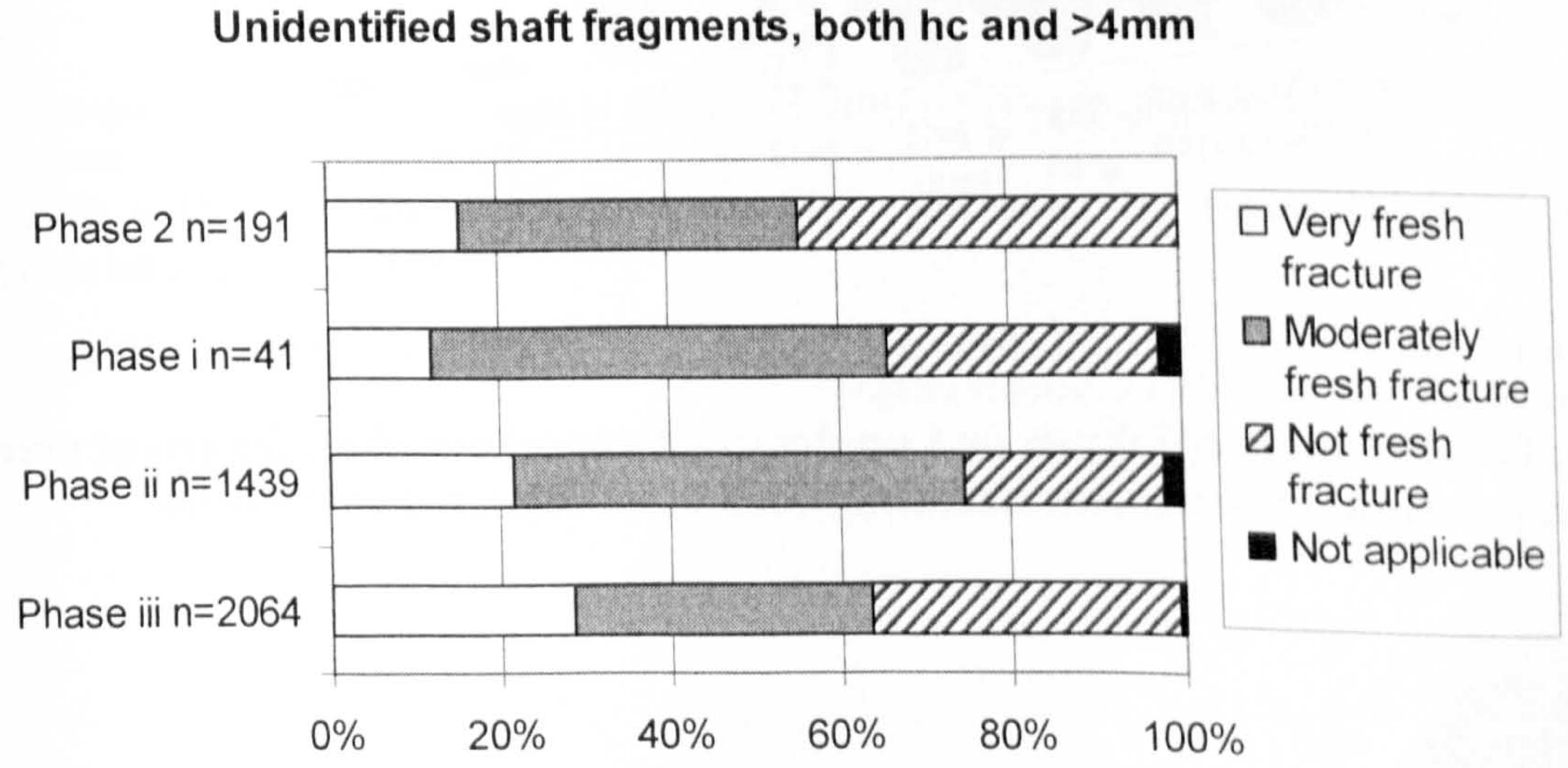
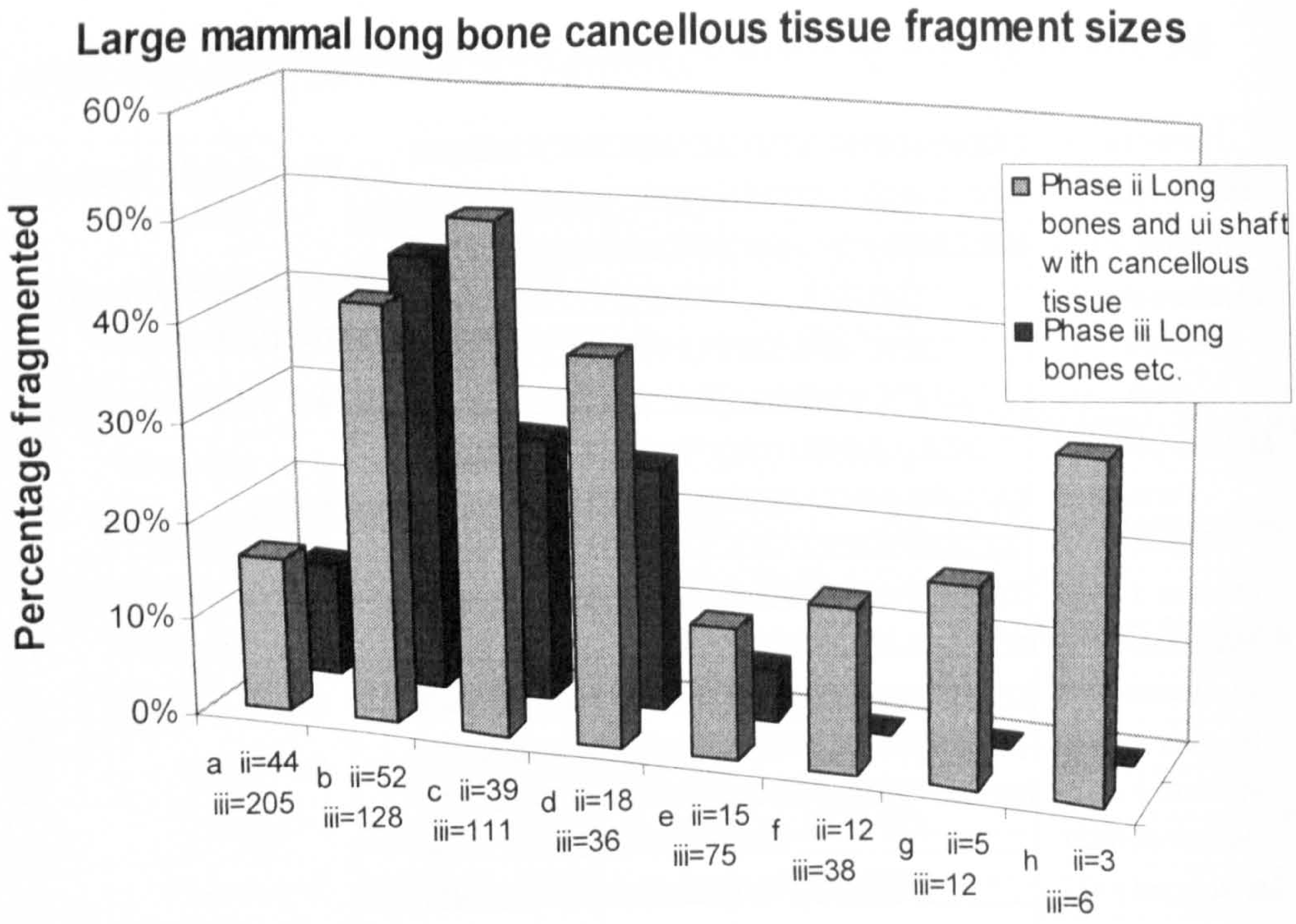
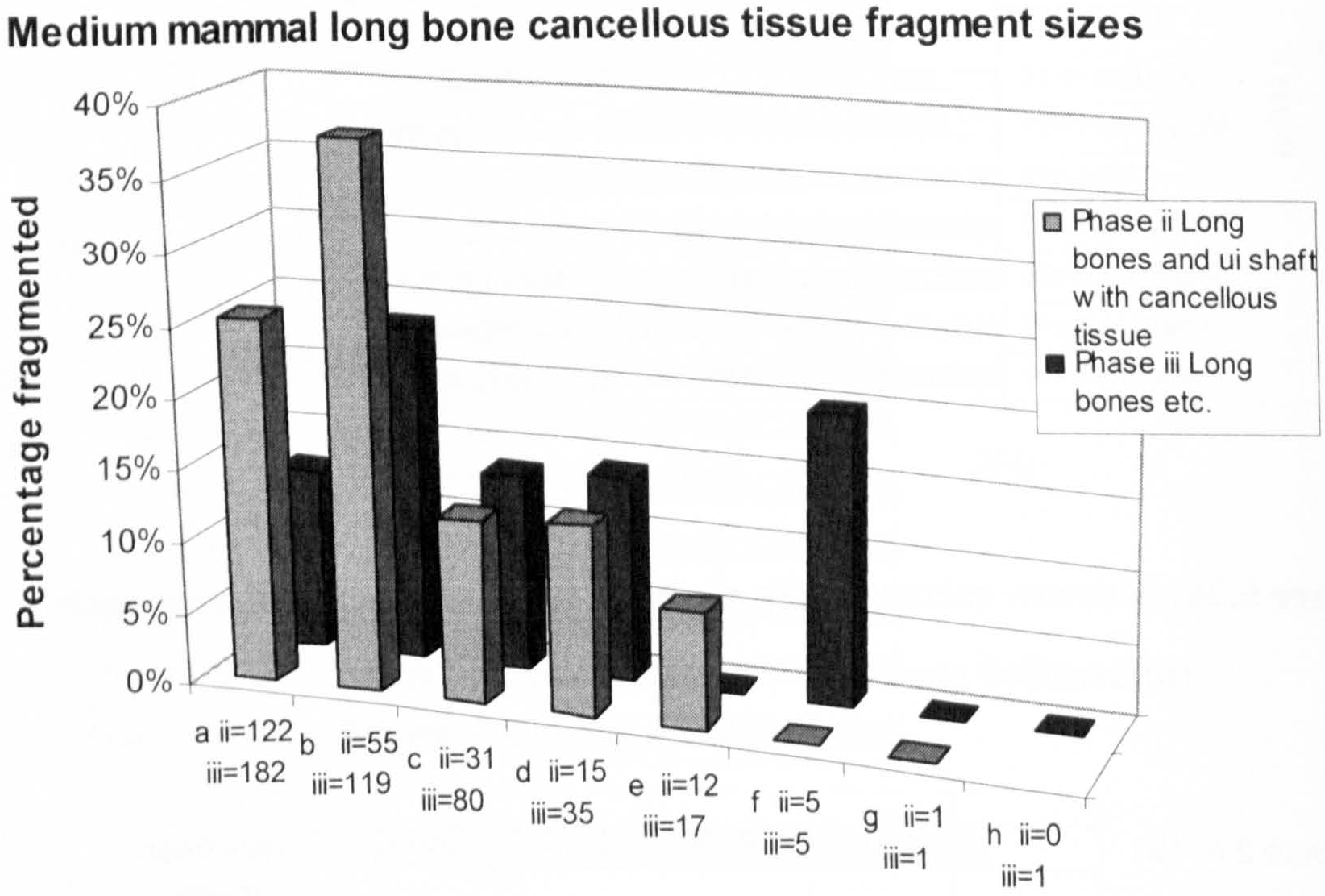


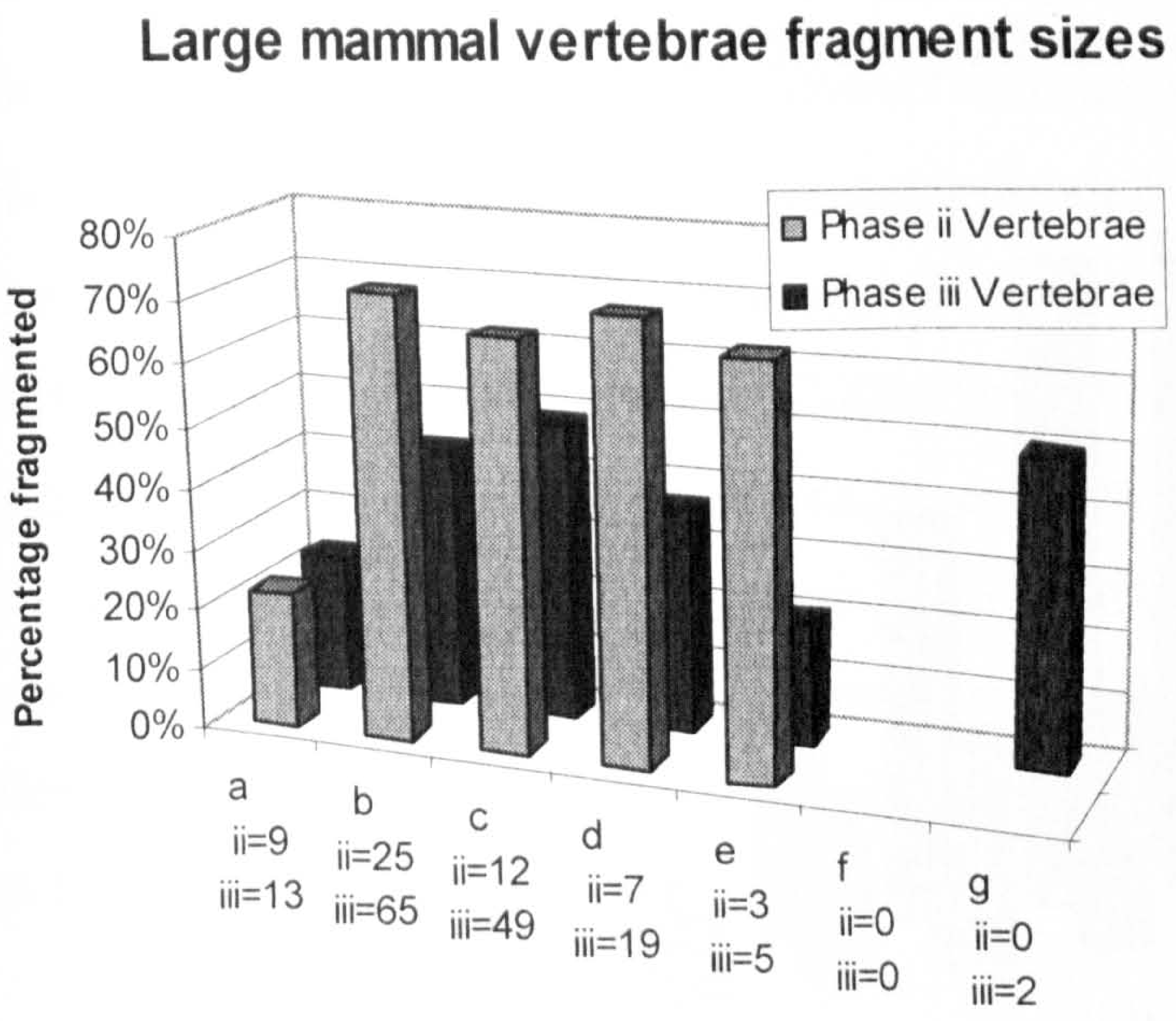
Figure 6.29: Marrow extraction for unidentified shaft fragments

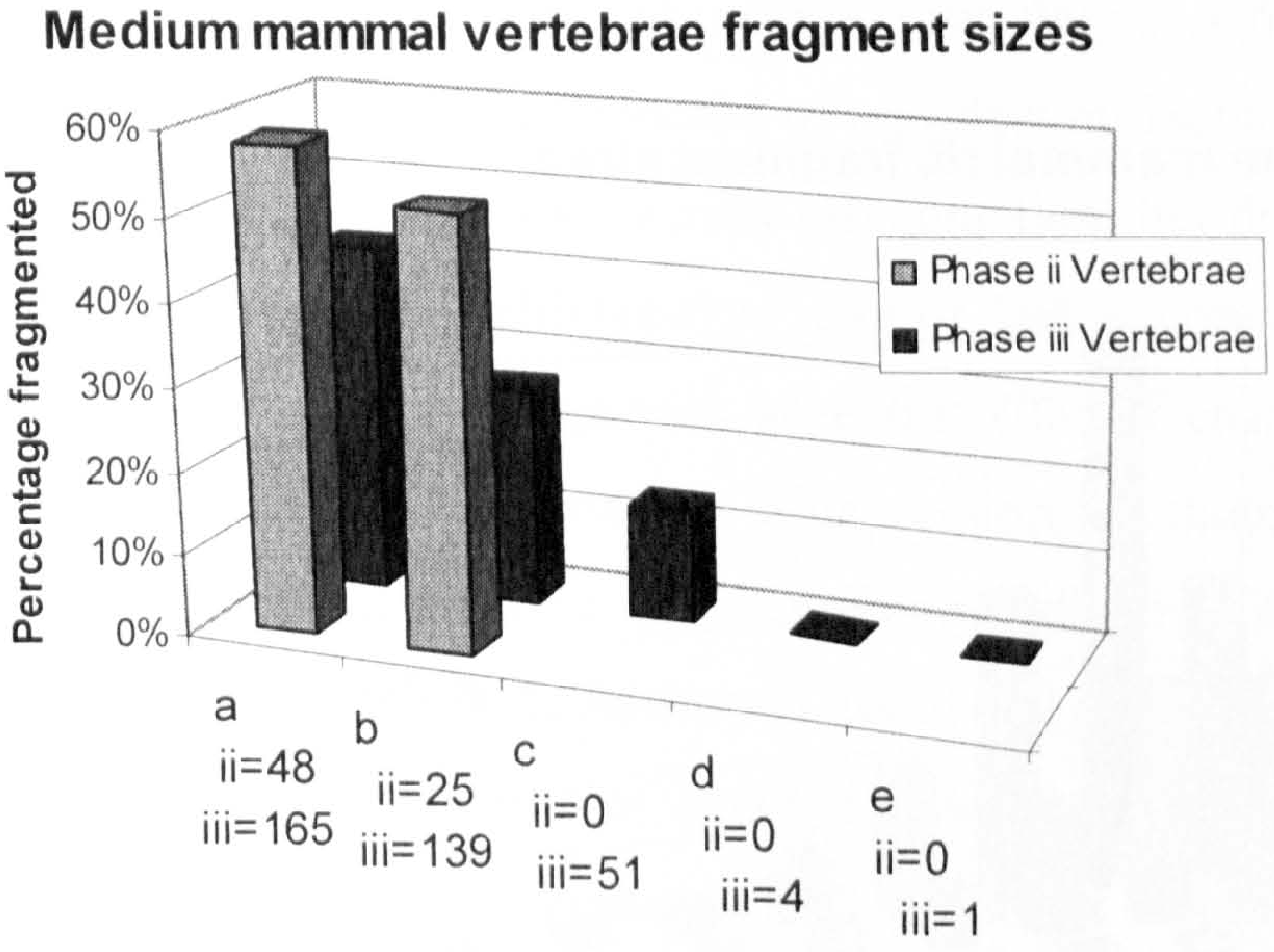




a <30mm; b 31-50mm; c 51-70mm; d 71-90mm; e 91-110mm; f 111-130mm; g 131-150mm h >150mm; counts indicate total quantities for each size category

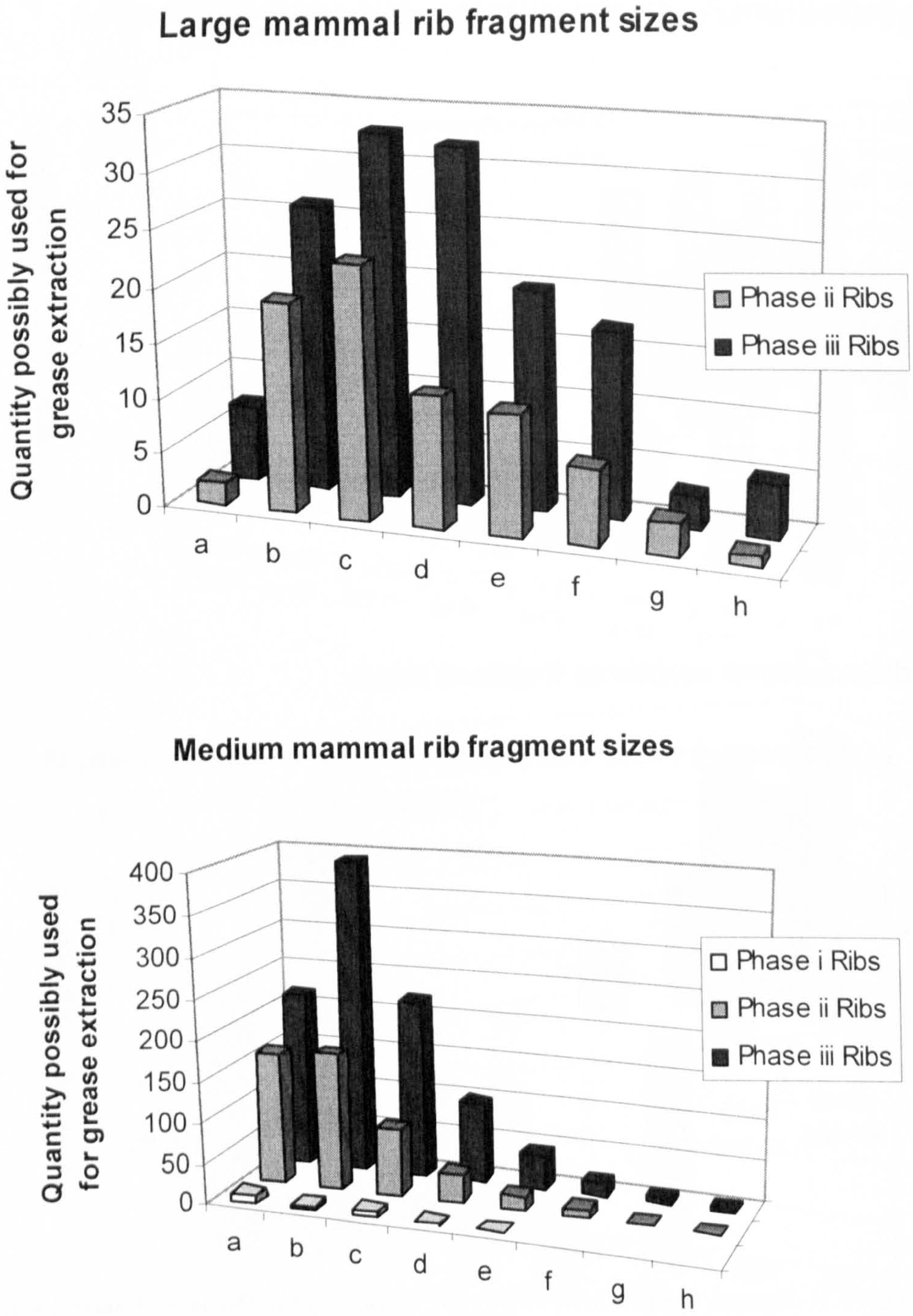
Figure 6.30: Long bone epiphysis and unidentified cancellous shaft fragment grease extraction potential by fragment size, combined hand collected and >4mm





a <30mm; b 31-50mm; c 51-70mm; d 71-90mm; e 91-110mm; f 111-130mm; g 131-150mm h >150mm; counts indicate total quantities for each size category

Figure 6.31: Vertebrae grease extraction potential by fragment size, both hand collected and >4mm



a <30mm; b 31-50mm; c 51-70mm; d 71-90mm; e 91-110mm; f 111-130mm; g 131-150mm h >150mm

Figure 6.32: Rib potential grease extraction by fragment size, combined hand collected and >4mm

6.7 *Pathologies*

6.7.1 Cattle and large mammal

Phase ii pathologies include evidence for stress, possibly caused by traction and found on an adult distal metapodial with a widened condyle and slight eburnation of the articular surface (Fabis 2005, 60; Groot 2005, 53). An arthropathy on an adult first phalanx was probably indicative of osteoarthritis following Baker and Brothwell's (1980, 115) definition. It was manifested as extensive eburnation of the proximal, lateral articular surface, with medial exostoses and limited grooving of the distal articular surface. This pathology may also have been the result of stress to the joints caused by traction (Baker and Brothwell 1980, 115; Johannsen 2005; Telldahl 2005). Several adult phalanges from this phase had depressions of type one, two or three (Baker and Brothwell 1980, 109-112) including two first phalanges, two second phalanges and one third phalanx. These depressions have been found throughout many archaeological deposits but are not fully understood. They may in fact not be pathological in nature (Baker and Brothwell 1980, 109-112; O'Connor 2000, 100).

In phase iii, an adult caudal vertebra contained an anomaly on the neural spine (slight thickening and flattening to dorsal) of unknown aetiology. A fragment, possibly a large mammal neural spine, contained evidence of an infection including a surface reaction of about 15mm in size resulting from a mild inflammation, but this was healing at time of death. A large mammal herbivore-type incisor has a congenital anomaly: a slight infolding towards the buccal edge with an extra pillar of enamel (DR Brothwell pers. comm. 2004). One horn core contains a depression of 'thumbprint' type. One adult second phalanx has a splayed joint surface possibly indicative of stress caused by traction (Baker and Brothwell 1980, 115, Johannsen 2005) and six adult first phalanges contained arthropathies, including a series of small medial-lateral depressions on the proximal articular surface; eburnation of both proximal and distal articular surfaces; eburnation of the proximal articular surface; extra bone growth and slight eburnation on the proximal articular surface and extra bone growth to the anterior proximal region of the diaphysis; pitting on the distal articular surface; and severe osteoarthritis in the form of grooves, eburnation and extra bone growth of the proximal articular surface. Two adult second phalanges displayed arthropathies, one in the form of extra bone growth around the proximal articulation, the other as extra bone growth around the distal articular surface; and one third phalanx displayed an arthropathy manifesting as extra bone growth around the articular surface. Finally, several phalanges contained type one, two or three depressions (Baker and Brothwell 1980, 109-112): 12 adult first phalanges, ten second phalanges, eight third phalanges, and in addition, one second phalanx displays definite osteochondrosis on its distal articular surface.

In phase iii/v.ii, one lumbar vertebra has eburnation on the lateral side of the proximal articular surface. In phase 2, a third phalanx has an arthropathy manifesting as a slight groove on the articular surface.

In conclusion, most cattle pathologies are joint-based and are found in adults. Changes of this type are age-related, but may also be the result of stresses caused by working, including traction. No evidence of dental pathologies was found, and there was no evidence of teeth lost pre-mortem, despite the substantial assemblage studied. The one horncore with a thumbprint type depression is similar to one noted on sheep, and could be indicative of poor health (Albarella 1995). Only one bone fragment showed signs of a minor and healing infection, indicating general good health.

6.7.2 Caprines

In phase ii, one sub-adult mandibular condyle has a roughened and coarse texture suggestive of an arthropathy. In phase iii, two mandibles contain teeth with calculus deposits, and one contains teeth lost pre-mortem. One adult proximal radius has extra bone growth and eburnation as a result of a trauma leading to severe arthritis. One juvenile tibia shows evidence of an infection including extra bone growth to posterior of the mid-shaft region (presumably periostitis, because the original bone surface was not broken). Finally, one adult astragalus has a grooved and polished articular surface. In phase iii/v.ii, one adult mandible contains teeth with calculus deposits.

Overall health of the caprines was good, though with more evidence of dental problems than in the cattle assemblage. There was one incidence of infection and one of trauma leading to arthritis, but with fewer incidences of arthropathies compared to the cattle.

6.7.3 Pig

In phase i, one adult isolated premolar has enamel hypoplasia probably indicative of poor health during development (Murphy 2005, 18), while in phase ii, one adult isolated premolar has a twisted and bulging "grossly deformed" root (DR Brothwell, pers. comm. 2004), possibly due to early trauma or infection of the mandible. The tooth also has calculus built up around it and possible hypoplasia. In phase iii one juvenile calcaneum has evidence for an infection and inflammation around the Achilles tendon insertion. Overall, evidence for pig pathologies was very limited.

6.8 Other species

6.8.1 Cat

The cat remains tend towards older, fully adult individuals in phase ii, though with the addition of some juveniles in phase iii. There were no butchery marks or pathologies. Metrical data suggested the one measurable element was from a domestic cat (TP O'Connor pers. comm.), but no other attempt was made to separate domestic from wild cats. It is likely these were domestic cats living at the settlement and were disposed of in the midden upon death.

Phase 2
One probable identification of a canine tooth

Phase ii
One canine tooth
One adult mandible, with teeth barely worn suggesting young adult
One adult scapula, fully fused
One adult ulna, distally fused
One adult atlas, fully fused
One cat-sized adult rib fragment
One adult pelvis, fully fused
One adult tibia, fully fused
One adult fibula, distally fused

Phase iii
One adult skull
One canine
One adult mandible, with teeth barely worn suggesting young adult
One adult mandible
One adult scapula, fully fused
Two sub-adult humeri, proximally fusing Both left side
One adult humerus, fully fused
One juvenile radius, distally unfused
One adult third metacarpal, fully fused
One adult vertebra
One sub-adult lumbar vertebra, but colour is contrasting to rest of context, so possibly intrusive
Two adult pelves
One sub-adult femur, distally unfused
One adult tibia, fully fused, one adult tibia fused distally, and one adult tibia fused proximally; MNI of two

Phase iii/viii
One sub-adult femur, unfused distally

Table 6.31: Cat summary

6.8.2 Dog

Evidence for carnivores was indicated by both carnivore gnawing found on a variety of species and elements, and by dog bones themselves. The latter were very limited in quantity, possibly indicating that most dog remains were not incorporated into the middens, in contrast to the cats. Both adults and juveniles were present, ranging in size from small to large, and the presence of a baculum is indicative of at least one male. Carnivore gnawing appears focused on sea mammals, perhaps reflecting their exploitation for skin or oil, with undesired meat being used to feed dogs. However, the greater density and general robustness of sea mammal bone, compared to terrestrial mammal, may result in better survival following gnawing and thus greater rates of identification (Lyman 1994, 236). Conversely, ethnohistoric accounts from the Northern Isles indicate seal meat was used for human consumption only if nothing else was available, though this may not have been practiced in the 9th to 13th centuries (Fenton 1978, 525), thus indicating that the inhabitants of Quoygrew derived sufficient food from domestic species and fish. Acid etching was present on only five fragments, including the dog tibia discussed below. One caprine fragment from phase ii and three from phase iii were acid etched, along with one unidentified fragment from phase iii. No butchery was recorded on dog bones.

Phase ii
One cranium fragment, from a small individual
One adult scapula, from a large individual

Phase iii
One adult mandible
One baculum
One juvenile metatarsal, unfused proximally
One probable adult tibia, fused distally, but acid etched, thus loosing some identifiable features

Phase iii/viii
One adult metapodial, fused distally
One adult first phalanx

Table 6.32: Dog summary

Species gnawed	Phase i		Phase ii		Phase iii		Phase iii/viii	
	Count	% of species gnawed	Count	% of species gnawed	Count	% of species gnawed	Count	% of species gnawed
Cetacean			1	25.0%				
Cattle	1	7.1%	17	4.6%	28	2.4%	1	11.1%
Large mammal			12	3.9%	5	1.2%		
Medium mammal 1			18	2.7%	7	0.5%		
Pig			2	1.4%	4	3.1%		
Seal			1	33.3%	4	14.3%		
Sheep/goat			34	7.1%	41	4.4%		
Sheep					2	6.5%		
Unidentified mammal			9	0.1%	16	0.2%		

Table 6.33: Dog gnawing

6.8.3 Seal

Seals were not identified to species because of insufficient reference material for seals of a variety of age groups. Age groups were limited to juvenile or adult on the basis of fusion and, to a lesser degree, reference material. Some fragments may be neonatal, but the lack of reference material has limited these identifications.

The age profiles indicate exploitation of juveniles, possibly reflecting their ease of capture compared to fully grown adults. Some evidence of disarticulation was observed, including flipper removal and mandible removal, and substantial butchery of a carcass was represented in phase i by the splitting of a sacrum down the midline. Seals show much higher than usual quantities of butchery and carnivore gnawing, compared to other species, possibly indicating their use as dog food (see section 6.8.2). Seal products could be used for human needs, including fat for lighting, skins, or as food when no other alternative was available (Fenton 1978, 525). Seals are currently found in the waters just off Quoygrew, and breeding grounds are currently located around Westray (Berry 2000, 95).

Phase i
One juvenile sacrum, chopped down midline dorsal-ventral

Phase ii
One juvenile fibula, unfused epiphyses
One adult metapodial, with carnivore gnawing
One juvenile metapodial, unfused proximal epiphysis, chopped towards the proximal epiphysis in a direction almost parallel to the metapodial shaft

Phase iii
Two juvenile mandibles, one with a small knife mark on the proximal edge of the ramus, running anterio-posteriorally (horizontal to the tooth row), about 5mm long, and located about one third of the distance up the ramus from the tooth row
Two deciduous teeth
One unidentified tooth
One juvenile scapula, unfused epiphysis
One juvenile humerus, unfused proximal epiphysis, with root etching, possibly used for grease extraction (i.e. fractured exposing the cancellous tissue)
One juvenile radius, unfused proximal epiphysis
One adult ulna, possibly used for grease extraction
One juvenile cervical vertebra, unfused epiphyses
Two rib fragments, both with carnivore gnawing, one possibly used for grease extraction
One juvenile pelvis
One juvenile femur, unfused epiphyses
One juvenile fibula, chopped twice at one end to make a crude point
One sub-adult metapodial, proximally unfused but fused distally
One juvenile phalanx, proximally unfused but fused distally
One juvenile or adult phalanx, proximally fused
One adult first phalanx, fully fused
One juvenile second phalanx, unfused proximal epiphysis
Four unidentified shaft and cancellous fragments, one with carnivore gnawing, one chopped, and two possibly used for grease extraction
Three unidentified fragments matched to reference material (carpals, tarsals, epiphyses etc), one with carnivore gnawing, one chopped

Table 6.34: Seal summary

6.8.4 Cetaceans and other sea mammals

Cetaceans were not identified to species because of the paucity of remains, their lack of diagnostic features, and the lack of a comprehensive reference collection; similar problems have been encountered by other zooarchaeologists working on Scottish coastal sites (Mulville 2002, 38). Some fragments were identified only to 'sea mammal' on the basis of texture or overall size. Where possible these fragments were classed as large or small, but the lack of reference material and high fragmentation has made this extremely difficult. These remains could be the result of strandings or deliberate capture. Aside from the one pathological specimen (see Table 6.35), few conclusions can be drawn. Carnivore gnawing was recorded on two fragments, providing further evidence that sea mammals were possibly used for dog food more frequently than domestic species.

Phase ii
Six sea mammal ribs
Four cetacean ribs, two of which were gnawed by carnivores
One unidentified cetacean fragment

Phase iii
One cetacean mandible from a species considerably larger than a porpoise
One cetacean rib c 37cm long, from a small whale
One sea mammal rib
One juvenile cetacean vertebra
One cetacean vertebra
One small cetacean sternum Pathologically malformed: manubrium asymmetrical and only fused to next segment on right side, with a marked gap to left side of area of fusion between two segments
Six unidentifiable cetacean fragments

Table 6.35: Cetacean and sea mammal summary

6.8.5 Horse

Only juvenile horse bones were found in phase ii, while phase iii contained both adults and juveniles. A butchered astragalus in phase ii could be indicative of disarticulation for skinning or bone working, and thus is not concrete evidence of butchery for food. However, the evidence for marrow extraction from both phase ii and iii would suggest at least opportunistic use of dead horses, if not deliberate butchery. No carnivore gnawing was observed. The incidence of pathologies was unusually high in phase iii, although all specimens could originate from the same individual, possibly suggestive of a long lived working adult.

Phase ii
An unfused distal tibia epiphysis of sub-adult size and an adult-sized astragalus were found in the same context and articulate together; the astragalus had very faint knife marks on it
One juvenile radius, unfused proximal epiphysis; bone fracture indicates potential fresh marrow extraction
One juvenile radial carpal

Phase iii
Two incisors, one with deformed roots
One adult atlas, epiphysis fused
One adult humerus, distally fused, with potential fresh marrow extraction
One carpal
One central tarsal, with extra lipping around edge suggestive of navicular bone disease; could benefit from X-ray for diagnosis
One pair of adult articulating tarsals with spavin: fused and partially collapsed tarsals with extra bone growth
One juvenile third phalanx of very small size, similar to a modern Shetland pony (CJ Johnstone pers. comm. 2004)

Phase iii/vii
One adult metatarsal, fused proximally, and possibly used for grease extraction as fractured revealing the cancellous tissue

Table 6.36: Horse summary

6.8.6 Human

One deciduous canine tooth was recovered from a sample in phase iii. No other human remains were found in the area G midden, suggesting the dead were disposed of elsewhere and that this deciduous tooth did not have any special meaning as human remains.

6.8.7 Rabbit

Two definite and one probable rabbit identifications were made in area G, indicating minimal disturbance by burrowing. The probable identification was a different colour than all others in that context, and was from a horizon that was covered but left for a year between excavation seasons. One further identification was found in phase 2, and two more in phase 7.

6.8.8 Red deer

One probable and one definite identification of red deer were made, both in phase ii. One definite adult distal tibia was recovered, fractured when freshly dead and very indicative of marrow extraction. The probable identification was of a small fragment of juvenile unfused femur, again indicative of marrow extraction. All teeth and metapodials were double checked by other zooarchaeologists who had more experience of red deer, but no other fragments were found. This is consistent with red deer exploitation at other sites of this period in the Northern Isles, as introduced in Chapter One and discussed further in Chapter Nine.

6.8.9 Small mammals

A total of 30 vole bones were identified from the hand collected or >4mm sieved fraction from area G, all but three of them identifiable as the Orkney vole. Substantial quantities were recovered from the 2-4mm fraction of area G. Given that no other vole species have been found on Orkney, all voles are likely to be of this species. They are equally distributed between phases ii and iii. One element was a juvenile femur; all others are mandibles or isolated teeth. A number of other small mammals were also found, summarised in Table 6.37.

Species	Phase 2			Phase i	Phase ii				Phase iii				Grand total
	2-4 mm	>4 mm	Total	2-4 mm	2-4 mm	>4 mm	Hc	Total	2-4 mm	>4 mm	Hc	Total	
Orkney vole				1	72	15		87	6	14		20	108
Vole species					7	1	1	9	8		1	9	18
House mouse									1			1	1
Wood Mouse		1	1		4			4	5			5	10
Mouse Species									2			2	2
Vole/ mouse	9	3	12	2	18	14		32	12			12	58
Totals	9	4	13	3	101	30	1	132	34	14	1	49	197

Table 6.37: Summary of small mammals by recovery method

6.9 *Measurements*

Measurements were recorded following von den Driesch (1976), with supplemental measurements from Harland *et al.* (2003). Because measurements were only recorded for adult fully fused elements, the quantity of measurements recorded was unfortunately low. No statistical differences were observed between phases for any element (Student's T-tests applied). There were insufficient quantities to examine breed or sex differences.

Withers heights were calculated for three cattle measurements and five caprine measurements (von den Driesch and Boessneck 1974). Cattle ranged from 99cm to 111cm, and caprines from 46cm to 56cm. These will be discussed in more detail in Chapter Nine, but are consistent with both ethnohistorical data and comparative material.

No standard for British cattle measurements has been published, but sheep can be compared using Davis' standard set of measurements (1996). Variations in time could not be studied because of the small quantity recorded, but several measurements could be pooled because they were shown to be highly correlated (Davis 1996, Tab. 7), thus creating more meaningful sample sizes. Figure 6.33 uses log ratios to compare the Quoygrew measurements to Davis' standard, shown here as the '0' value. Each measurement or group of measurements is compared using a histogram of log ratio values (calculated as $\log_{10}$(Quoygrew measurement / Davis' standard)). The Quoygrew sheep are generally smaller than or equivalent to the standard, which was determined using a modern but unimproved Shetland ewe flock. This is unsurprising given that the Quoygrew sheep lived in similar environmental conditions to the unimproved Shetland ewes, so both would be adapted to the conditions of the Northern Isles (Davis 1996, 610). The positive outliers in the metapodial BFp-BFd-BD category may indicate some variety or some larger rams, but this is difficult to explore.

Element	Phase	Bd	Dl	GLl	GLm
Astragalus	ii	36.79	32.91	55.52	50.62
	ii	35.7	30	55.2	50.6
	ii				52.52
	ii	36.73	33.07	57.95	53.63
	iii		31.77		51.82
	iii	34.56	31.84	55.66	50.33
	iii	39.43	34.4	59.39	53.41
	iii	37.08	33.05	59.24	54.24

Element	Phase	C	C+D	DS	GL
Calcaneum	ii	21.56	43.5	40.54	125.21
	iii	22.9	42.24	34.21	113.46
	iii	23.04	46.08	37.81	124.62

Element	Phase	BT	HTC	HT
Humerus	iii	64.85	29.49	36.75

Element	Phase	C LM3	C BM3
Mandible	ii		10.95
	ii	35.61	12.04
	ii	27.07	10.61
	ii	34.67	14.11

Element	Phase	BFp	DFp	BFd	Dd	Dem	Dvm	Dim	SD	GL	Bd
Metacarpal	ii					21.48	28.94	27.84			53.37
	ii					20.15	27.41	24.71			47.65
	iii				30.64	24.45	31.09	27.8	31.64	181.6	58.61
	iii	45.53	27.37		17.5	20.34	27.55	24.06	24.33	163	47.66
	iii					20.58	27.42	24.73			
	iii	51.66				23.41	31.32	27.36	30.52	162	59.87
	iii/v.ii			49.61							

Element	Phase	Dem	Dvm	Dim
Metapodial	ii	20.69	27.26	24.46
	ii	18.1		24.11

Element	Phase	BFp	BFd	Dem	Dvm	Dim
Metatarsal	ii	42.31	36.73			
	iii		46.12	18.9		23.46
	iii	47.11				
	iii		34.95	18.1	24.78	23.4

Element	Phase	GL	SD	Bp	Dp	Bd	BFd	Glpe
Phalanx1	ii	62.64	25.5	33.55	34.45	29.75	29.42	61.33
	ii		22.86	24.74		25.33		50.34
	ii		22.67		28.56	24.6		
	ii		19.36	23.26		24.82		50.38
	ii		18.81	24.82		21.79		43.04
	iii	45.31	19.48	25.84		24.14		
	iii		22.53	29.59		25.84		53.58
	iii	55.46	19.96	24.32		23.1		49.35
	iii	52.16	17.87	21.21		19.97		47.08
	iii	54.66	20.34	26		23.68		50.76
	iii	49.41	18.99	24.21		21.46		44.79
	iii	56.53	20.13	23.17		22.52		52.94
	iii		20.58	22.36		23.25		52.33
	iii		19.46	23.11		22.76		
	iii		20.22	25.47		23.49		46.24
	iii		19.89			23.05		
	iii		20.9	23.81		24		47.62
	iii		20.55	24.55		23.41		51.42
	iii		20.93	24.51		25.52		47.45
	iii		20.64	24.32		24.17		51.96
	iii		20.74	25.87		24.39		45.94
	iii		22.11			24.09		
	iii		20.56	23.22		25.09		51.53
	iii		21.61	24.67		24.64		
	iii		21.23	24.23		26.04		48.97
	iii		20.4	22.2		21.56		51.18
	iii		19.88	23.03		22.68		48.85
	iii		23.72	25.99		27.72		54.96

Element	Phase	Bp	BFp
Radius	iii	68.12	62.07

Element	Phase	GLP	SLC	GL
Scapula	iii	60.33	46.88	51.5
	iii	55.82	47.72	48.37
	iii	56.55		47.71
	iii	60.74	47.24	50.4

Element	Phase	Bd	Dd
Tibia	ii	51.54	37.99
	ii	52.65	
	iii	54.37	

Element	Phase	DPA
Ulna	iii	52.9

Table 6.38: Cattle measurements

Element	Phase	Bd	Dl	GLl	GLm
Astragalus	ii		13.57		
	ii	18.36	15.95	28.42	26.74
	ii	17.49	14.57	26.38	24.99
	ii		14.26	25.66	25.74
	ii	16.91		26.06	24.65
	ii	18.11	14.7	26.73	24.66

's' refers to a definite sheep identification (but as only one goat fragment was found, all are likely to be sheep)

s	iii	17.11	14.59	26.67	25.95
s	iii	16.85	13.84	25.66	24.34
s	iii	16.81	14.58	26.59	25.12
s	iii	17.24	14.46	25.54	24.98
s	iii	16.78	13.68	24.57	23.83
s	iii	16.77	14.92	26.89	25.6
s	iii	17.51	14.44	25.61	23.85
s	iii	17.78	15.12	26.68	25.64
s	iii	19.7	15.6	28.46	27.54
s	iii	18.72	15.68	28.02	26.26
s	iii	16.38	13.56	25.18	25.53
	iii	17.32	14.93	26.19	25.26
	iii	16.74	14.32	26.08	24.22

Element	Phase	C	C+D	DS	GL
Calcaneum	ii	9.26	18.86	18.4	53.49
	ii	9.1	18.67	15.89	
	iii	10.52	19.73	17.98	54.47
	iii	9.29	17.43	4.99	45.24
	iii	9.39	18.76	15.6	49.01

Element	Phase	BT	HTC	HT
Humerus	i	27.24		
	ii	27.62		
	ii	27.22	13.48	16.45
	ii	26.25	12.48	16.12
	iii	24.7	12.53	16.3
	iii	27.79	14.32	18.41
	iii	25.11	13.56	16.17
	iii	26.81	13.66	18.17
	iii/v.ii	29.31	12.82	19.06

Element	Phase	S_LM3	S_BM3
Mandible	ii	19.69	7.74

Element	Phase	BFp	DFp	Dd	Dem	Dvm	Dim	SD	Bd
Metacarpal	ii							17.25	
	ii				10.27	14.67	12.9		22.85
	ii				10.4	14.66	13.62		25.57
	iii	19.51	14.75						
	iii			15.49	10.25	15.31	13.55		22.89
	iii				10.2	15.26	12.91		
	iii				9.68	14.12	12.26		23.93
	iii				9.82	14.83	12.81		22.66

Element	Phase	Bd	Dem	Dvm	Dim
Metapodial	ii	22.14	9.77	15.3	13
	ii		9.52	14.95	13.32
	ii	22.99	10.49		12.93

Element	Phase	SD	BFp	DFp	BFd	Dem	Dvm	Dim
Metatarsal	ii	13.59						
	ii					19.3	27.4	25.3
	ii		20.59	21.61				
	iii		18.25					
	iii					9.97		13.29
	iii				21.96	9.77	15.77	13.22

Element	Phase	GL	SD	Bp	Dp	Bd	BFd	Glpe
Phalanx1	ii		9.05	11.31		10.45		34.92
	ii		8.28	9.73		8.94		29.75
	ii		9.47	10.55		12.07		33.24
	ii		8.95	11.42		10.08		34.39
	ii	37.15	9.08	11.73	13.72	9.89	35.96	
	ii	32.94	9.06	11.43	13.47	10.39		32.96
	ii	35.62	8.84	10.8	12.9	9.5		32.88
	ii	36.19	10.99	12.35	14.76	11.55		34.05
	ii	34.4	9.33	10.74	12.94	9.97		32.63
	ii	31.2	9.27	10.98	12.61			30.61
	ii			13.94	15.22			
	ii					10.2		
	ii		9.29	10.54		11.46		33.71
	ii		8.91	11.47		10.67		31.04
s	iii		9.83	11.8		10.96		30.78
s	iii		10.77	12.26		11.74		33.43
s	iii		8.23	9.78		10.29		30.68
s	iii		8.14	9.54		10.78		32.94
s	iii		8.4	10.04		9.97		32.05
s	iii		8.51	10.33		10.23		30.89
	iii	36.5	10.77	12.06		11.88		35.49
	iii	34.84	9.83	11.9		11.49		33.56
	iii	35.44	9.44	11.95		11.24		34.57
	iii	34.99	9.48	11.52		10.66		33.67
	iii		8.43	10.23				
	iii			11.24				
	iii		9.05	10.99		10.5		34.17
	iii		9.02	11.05		10.17		32.56
	iii		7.86	9.44				
	iii		9.1	10.5		11.07		32.75

Element	Phase	Bp	BFp	GL	SD	Bd	BFd
Radius	ii					26.81	
	ii	25.71					
	iii	28.93	26.79				
	iii					27.82	
	iii	27.05	24.66	138.17	14.65	25.64	21.08

Element	Phase	GLP	SLC	GL
Scapula	ii	28.85	16.77	
	ii		18.57	
	ii	29.85	16.98	
	iii	30.43	16.28	
	iii	32.96	21.06	25.48
	iii	27.13	18.1	23.99
	iii	28.2	18.03	22.03
	iii	31.22		
	iii	29.57	17.3	

Element	Phase	Bd
Tibia	ii	21.01
	ii	24.31
	ii	22.96
	ii	23.51
	iii	25.29
	iii	21.65
	iii/v.ii	22.98

Table 6.39: Caprine measurements

Element	Phase	P 6	P 7	P L
Mandible	ii	14.03	13.45	32.2

Element	Phase	SD	Bp	Bd	Glpe
Phalanx1	iii	11.81	14.86	14.01	30.93
	iii	12.29	14.03	15.77	

Table 6.40: Pig measurements

Element	Phase	BFd	GB	GH	LmT
Astragalus	ii	45.11	55.2	54.12	52.59

Element	Phase	Bd	Dd
Tibia	ii	64.54	40

Table 6.41: Horse measurements

Element	Phase	GL	SD	Bd
Tibia	ii	103.71	6.15	13.79

Table 6.42: Cat measurements

Element	Phase	Bd
Tibia	ii	9.05

Table 6.43: Red deer measurements

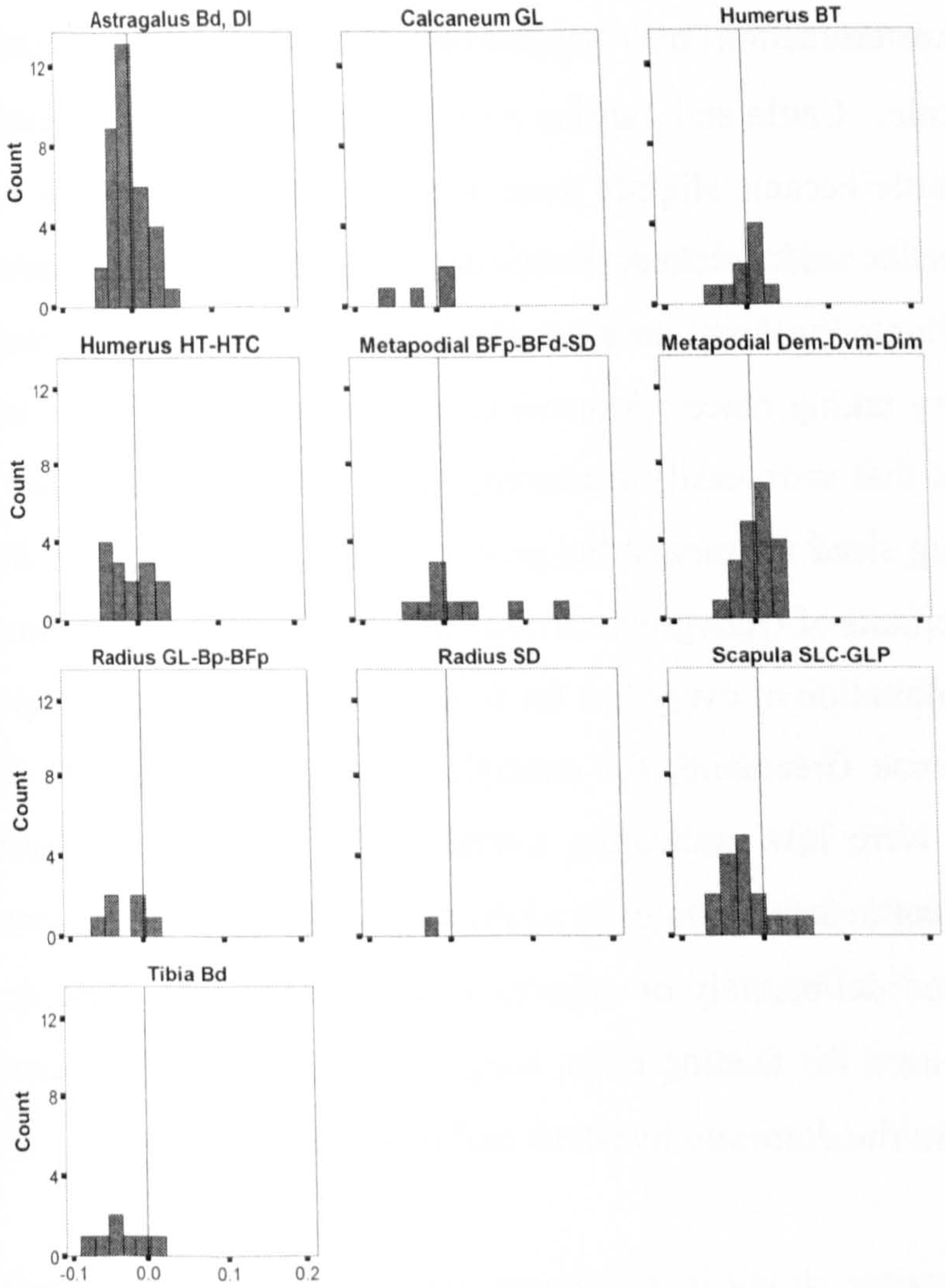


Figure 6.33: Caprine log ratio measurements showing difference from Davis' mean

6.10 Summary

The mammal bone from area G was from the same spatially defined midden deposit, thus only chronological differences could be analysed from this area. Phase i, probably dating to the early Viking Age (some point before a date spanning the 9-11th centuries), contained little bone so could only be included in overall discussions, while phases ii and iii contained substantial quantities of bone permitting a detailed chronological analysis comparing the 9-11th centuries (phase ii) with the early 11th to mid 13th centuries (phase iii). The fish midden contained few mammal bones and therefore contributed little meaningful data, but quantities of caprines from phase 2 were sufficient to include during general analysis. The identified assemblage was almost entirely domestic cattle, caprines (almost all sheep, as only one goat was identified), pigs, and to a lesser extent, horses. Other species recovered included seals, cats, cetaceans, dogs, small mammals including

Orkney voles, rabbits (intrusive but in very small quantities) and red deer. Horse butchery (or at least marrow extraction) may suggest opportunistic use of dead horses or hippophagy on a small scale. Cattle and caprine remains were found in approximately equal quantities, though cattle became slightly more dominant in phase iii than in earlier phases. Element frequencies and butchery marks suggest all parts of the domestic species were utilised at Quoygrew, with no extra elements arriving or leaving the site, and no specialised butchery taking place. Marrow extraction in all phases was carried out on long bone elements that were easily fractured, with an increase from phase ii to phase iii for caprine and pig sized mammals, but processing for grease probably did not occur, suggesting the inhabitants of Quoygrew carried out a successful economic strategy that did not require the exploitation of every last fat deposit from their domestic animals, in contrast to medieval Norse Greenland, for example (Outram 1999; Outram 2003). Incidences of pathologies were low, indicating overall good health of the livestock, although some evidence of cattle arthropathies in adults may imply work-related stresses. Sea mammals were exploited deliberately or opportunistically; meat from these species may have been principally used for feeding dogs, suggesting the human population had an adequate food supply from the domestic livestock and from fishing.

The majority of cattle were very young in all phases, with neonates found throughout, increasing in quantities from phase ii to phase iii. Less than a quarter of all cattle reached an adult age in phases ii and iii, with phase iii having slightly fewer elderly and adult individuals than phase ii. The cattle mortality profile is consistent with other sites of this period (see Chapter Eight), and is probably indicative of a mixed economy with an emphasis on dairying.

Neonates were found in the caprine population at a fairly constant rate of one fifth of the population, with slightly higher quantities in phase ii than in phases i or iii. The majority of caprines died between late in their first year and two years of age in all phases, with less than 10% reaching adulthood. Phase ii contained a few elderly individuals, but none were found in phase iii. The caprines were probably used for a combination of meat and wool, because one or two year's worth of wool could have been removed prior to consumption as prime meat. Given ethnohistoric evidence (discussed in Chapter Nine), caprines may have contributed to the dairying economy as well.

Pigs were low in quantity compared to cattle and caprines, but the age profiles suggest the use of pigs for meat, with the majority killed while young and a few individuals kept, probably as breeding stock.

The Quoygrew mammal bone will be discussed further when compared and contrasted with other mammal bone assemblages from the Northern Isles in Chapters Eight and Nine.

Chapter Seven: Quoygrew Bird Bone

This chapter assesses the small collection of bird bone from Quoygrew, focussing on a few particular aspects. In continuing the theme of the zooarchaeological analysis, any variations in time and space will be identified and explanations for these differences will be put forward. This will consist primarily of comparing and contrasting phases ii and iii within the farm mound, and between phases iii and 2 of the farm mound and the fish midden. Secondly, the contribution of the bird bone towards the economy of Quoygrew will be discussed throughout, particularly emphasising the different environmental habitats exploited by the inhabitants to capture the sea birds and other wild fowl. An assessment of the taphonomic variation will be made, though the small sample size of the bird bone makes this difficult. Any analyses of age profiles, butchery patterning and pathologies are similarly limited by the small sample size.

7.1 Identification and recovery

A total of 1983 bird bone fragments weighing 1488g were identified from the fish midden (areas A to E) and the farm mound*. Counts for each area, phase and recovery method are provided in Table 7.1. Bird bone from areas A and G are directly comparable to the fish and mammal identified by the author, but the bird bone from the other columns along the fish midden can be used to augment that from area A where the phasing is the same. Some bird bones from the upper layers and topsoil of the farm mound were identified but are without corresponding fish or mammal bone, while some of the phasing from area D post-dates the focus of the fish midden. This extra bone from phases 5 and 7 will not be discussed in any detail. Because of the small sample sizes involved, it makes sense to combine all bone at the phase level; there will be no further distinction between areas of the fish midden.

A full summary of recovery rates by quantification code and phase is provided in Table 7.2. Overall, about one third of all bird bones could be identified as a QC1 element, another third as a QC0 element, with the final third unidentifiable. This rate of identification varied by recovery method and phase, with hand collected bone having higher rates of identification than sampled bone. Phases 2, i, ii and iii, the main focus of

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* All bird bones were identified by Rebecca Briscoe under the supervision of Terry O'Connor and James Barrett; see Chapter Three

this study, all have similar rates of identification, consistent with the results from mammal and fish (Chapters Five and Six). It is curious to note that phase 5, the post-medieval midden, has a large quantity of bird bone yet has some of the lowest rates of identification – however, further interpretation of this phase is outside the scope of this study.

Fragments of eggshell were observed by the author at low levels throughout samples from several areas and phases at Quoygrew, but these have not (yet) been identified. Detailed analysis of the samples from area A of the fish midden indicates that small quantities of egg shell were found in about half of all samples, in the >4mm, 2-4mm and <2mm fractions (Andrews 2005). These indicate that eggs from domestic fowl, and/or seabirds, contributed to the diet of the inhabitants.

Area	Phase	>4mm	Hand collected	Total Count
A	1.2	15		15
	2	56		56
	7	2		2
B	1.2	1		1
	2	13		13
C	2	21		21
D	3/5		8	8
	4	21	59	80
	5	34	507	541
	6		45	45
	7		15	15
	8		1	1
E	1.2	13		13
	2	152	5	157
	7	8		8
G	i	4	3	7
	ii	32	82	114
	ii/iii		2	2
	iii	283	528	811
	iii/v.ii		16	16
	v.ii		8	8
	v.iii	3	45	48
	vii	1		1
Total		659	1324	1983

Table 7.1: Bird bone counts by area, phase and recovery method

Phase	Recovery	QC1		QC 0		Unidentified		TNB
1.2	>4mm	6	21%	7	24%	16	55%	29
2	>4mm	68	28%	95	39%	79	33%	242
	Hc	3	60%	2	40%		0%	5
	Total	71	29%	97	39%	79	32%	247
3/5	Hc	5	63%	1	13%	2	25%	8
4	>4mm	4	19%	2	10%	15	71%	21
	Hc	16	27%	23	39%	20	34%	59
	Total	20	25%	25	31%	35	44%	80
5	>4mm	5	15%	6	18%	23	68%	34
	Hc	87	17%	195	38%	225	44%	507
	Total	92	17%	201	37%	248	46%	541
6	Hc	6	13%	30	67%	9	20%	45
7	>4mm	5	50%	0	0%	5	50%	10
	Hc	1	7%	10	67%	4	27%	15
	Total	6	24%	10	40%	9	36%	25
8	Hc	1	100%	0	0%		0%	1
i	>4mm	1	25%	1	25%	2	50%	4
	Hc	3	100%		0%		0%	3
	Total	4	57%	1	14%	2	29%	7
ii	>4mm	8	25%	8	25%	16	50%	32
	Hc	48	59%	24	29%	10	12%	82
	Total	56	49%	32	28%	26	23%	114
ii/iii	Hc	1	50%	1	50%		0%	2
iii	>4mm	58	20%	107	38%	118	42%	283
	Hc	280	53%	174	33%	74	14%	528
	Total	338	42%	281	35%	192	24%	811
iii/v.ii	Hc	6	38%	6	38%	4	25%	16
v.ii	Hc	5	63%	2	25%	1	13%	8
v.iii	>4mm	1	33%	2	67%		0%	3
	Hc	21	47%	9	20%	15	33%	45
	Total	22	46%	11	23%	15	31%	48
vii	>4mm	0	0%	1	100%		0%	1
Total		639	32%	706	36%	638	32%	1983

Table 7.2: Identification by recovery method and quantification code (percentages show proportion of TNB for each phase and recovery method)

7.2 Taphonomy

The small size of the bird assemblage makes any detailed examination of taphonomic patterning impossible, but the observations from the mammal and fish (Chapters Five and Six) can be applied to the bird bone with caution. Phases 2 and iii are likely to contain larger and more complete bird bones than phases ii and i. Texture scores were much better for birds than they were for fish or mammals, which could either reflect the nature of bird bone preservation, the greater predominance of adult material in the bird assemblage, or inter-analyst variability. Phases 2 and iii have better textures than the earlier phases i and ii from the farm mound, which confirms the general pattern observed using the fish and mammal assemblage. Percent completeness scores for bird QC1 elements are displayed in Table 7.3, but are difficult to interpret given the small quantities involved.

Recovery variation is likely to affect the smaller specimens (be they from smaller species or younger birds), but it cannot be statistically investigated because of the small size of the assemblage. Small passerines are more likely to be recovered from the >4mm sample fraction than from the hand collected bone. The different recovery fractions will be quantified separately below, during the discussion on species variation, in order to illuminate these potential biases.

Other taphonomic alterations include gnawing by rodents and carnivores, both present at a low level in most phases, and root etching, again present at a very low level throughout most phases (Table 7.5). Burnt bird bone ranged from 3 to 7% in the phases of interest (Table 7.6). The quantities of burnt bird are comparable to fish, but are substantially smaller than the quantities of burnt mammal. This may be indicative of differing economic exploitation, or different refuse disposal methods, although it is possible some small and unidentifiable fragments of charred or calcined bone were misidentified as mammal.

Most of the bird remains are probably the result of human activity (see section 7.6), but the influence of other species on the formation of the assemblage cannot be ruled out. Cats are well known predators of small birds like the passerine species, though it is not unknown for elderly or ill large birds to be captured by cats. Even a great black-backed gull, the largest of the Orcadian gull species (Snow and Perrins 1997, 754), can be caught and brought home by a cat (D Jaques, pers. comm. 2005), and if this were to have occurred in the past, the remains would presumably be disposed of in the middens. Various bird species would be attracted by the middens in any case, and would likely scavenge material from them, including rock doves, eagles, ravens and the black-headed gull (O'Connor 1993, 157-60; Serjeantson 1998, 31), all of which were identified at Quoygrew. Low describes the great black-backed gull as "sitt[ing] down contentedly to a piece of dead horse if it can get it" (1813, 116). Great black-backed gulls are known to prey on Manx shearwaters, leaving a distinctive pattern on the bones from the attack and subsequent consumption (Serjeantson *et al.* 1993, 193), but this pattern was not observed at Quoygrew.

Recovery	Phase	0-20%	21-40%	41-60%	61-80%	81-100%	Total
>4mm	1.2		4	1		1	6
	2	9	16	7	8	28	68
	ii	1	2	2	2	1	8
	iii	3	12	6	12	25	58
	Subtotal	13	34	16	22	55	140
Hand collection	2					3	3
	ii		17	9	4	18	48
	iii	9	80	49	30	112	280
	Subtotal	9	97	58	34	133	331
Total		22	131	74	56	188	471

Table 7.3: QC1 bird percent completeness

Phase	1	2	3	4	Total
2	58 (82%)	9 (13%)	4 (6%)		71
i	1 (25%)	1 (25%)	2 (50%)		4
ii	18 (32%)	23 (41%)	11 (20%)	4 (7%)	56
iii	191 (57%)	111 (33%)	34 (10%)	2 (1%)	338
Total	268 (57%)	144 (31%)	51 (11%)	6 (1%)	469

Table 7.4: QC1 bird textures

Phase	Carnivore gnawing	Rodent & carnivore gnawed	Rodent gnawing	Root etching	Total
2	1		1	1	3
4			1		1
5	2		1	1	4
6			1		1
ii	1			1	2
iii	3	1	1	6	11
iii/v.ii				1	1
v.ii				1	1
v.iii				1	1
Total	7	1	5	12	25

Table 7.5: Summary of gnawing and root etching

Phase	Charred	White	% of burnt bird bone per phase
1.2	1	1	6.9%
2	13	3	6.5%
5	1		0.2%
ii	5	3	7.0%
iii	25	5	3.7%
v.iii	1		2.1%
Total	46	12	

Table 7.6: Summary of burnt bird bone

7.3 Species

Thirty two species or species groupings were identified in total from all phases. Table 7.7 summaries the 28 species or species groupings from the most relevant phases, namely phase 2 from the fish midden and phases i through iii from the farm mound; these are the same phases used for the mammal and fish analysis. Table 7.8 summarises the species found in all other phases. Three species were only found in the sieved material: snipes, blackbird and waders (all from phase 2). All other species were found both by hand collection and by sieving, although in varying proportions. Phase iii showed the greatest differences between the sieved and hand collected assemblages, particularly for the passerines.

Domestic fowl were found in both the fish midden and farm mound, though in small quantities compared to wild species; ignoring the later small phases of the farm mound, the highest quantity of fowl remains were found in phase iii, when 14 were recovered representing 4% of all identified bird remains for that phase. Goose bones were only found in the farm mound, and although some of these may have been domestic, no attempt was made to identify them precisely. No measurements were taken thus a biometrical analysis could not be applied; nor was ancient DNA analysis possible at this time (following Macdonald *et al.* 1993; Barnes *et al.* 2000). The assemblage is otherwise dominated by the wild species found around Orkney and still common today, including shags, cormorants, various members of the gull family, razorbills and guillemots, and puffins, to list the more common species. Noup Head, approximately five kilometres southwest of Quoygrew, is now a RSPB reserve with breeding colonies of guillemots, black guillemots, razorbills, kittiwakes, puffins and fulmars (Anon. 2005; Booth *et al.* 1984, xxi). Some of those species have also been noted along the sea cliffs just to the north of Quoygrew. About 6km to the north-east from Quoygrew is a further rich and diverse RSPB bird reserve on Papa Westray (Booth *et al.* 1984, xix). A small puffin colony is also located on the south-east side of Westray. The nearest modern gannet colony is located at Sule Stack, about 86km to the southwest of Quoygrew, and although there is some suggestion that gannets may have nested at cliff colonies in Orkney in the past, these had probably fallen into disuse by the time Quoygrew was occupied (Serjeantson 2001, 44, 48). A few pairs of gannets have nested at Noup Head in the last couple of years, but all evidence points towards this being a recent phenomenon (Meek

2004). Small passerines, deliberately not identified to species during recording by Briscoe, represented about 20% of the identified species in most phases, and a number of moorland and other species were recorded.

No great auk remains were identified, though this is unsurprising given the low or absent recovery of this species from other sites in the Northern Isles in the Norse and medieval period (Serjeantson 2001). The last remaining great auk in Britain was killed on Papa Westray in 1813 (Groundwater 1974, 169).

The two recorded fulmar elements may be intrusive, as it was not recorded in Orkney until the late 19th century, although its presence from several other Orcadian archaeological sites may indicate it used to be local (Serjeantson 1998, 31). However, its tendency to nest in rabbit burrows and in archaeological sites points towards the fulmar remains from Quoygrew being intrusive (Barrett and Oltmann 2000, 13; Edwards and Ralston 2003, 90). One fulmar bone was recorded from the fill of a kelp burning pit in the upper layers of area D, so can be ignored, leaving only one as possibly intrusive.

At least two species of plover were found, with several instances of *Pluvialis* sp. recorded in phase iii. These were likely to be the golden plover, as it is the most common of the *Pluvialis* sp. found in Orkney. Along with the grouse, snipes and the waders, they prefer moorland and hill lands, rather than the coastal cliff edges of the sea birds (Groundwater 1974, 123-24).

Two elements in phase iii from a large eagle digit were most likely white-tailed eagle, as confirmed by TP O'Connor (pers. comm. 2005). No other elements from this species were recorded, so this foot may have had additional meaning beyond that of a foodstuff. Both white-tailed and golden eagles bred successfully in Orkney in the past, with the white-tailed being somewhat more common than the golden (Berry 2000, 156; Buckley and Harvie-Brown 1891, 147). All species of eagle were targeted in recent centuries "on account of the havoc they made amongst the native sheep, which were of a very small breed, and therefore easily carried away" (Buckley and Harvie-Brown 1891, 149); rewards were given for dead birds of prey in recent centuries (Fenton 1978, 510).

Common name	Phase 2			Phase i			Phase ii			Phase iii			Grand Total
	>4	Hc	Sum	>4	Hc	Sum	>4	Hc	Sum	>4	Hc	Sum	
Fowl (Domestic)	1 2%		1 1%					1 2%	1 2%	1 2%	13 5%	14 4%	16 4%
Fulmar	1 2%		1 1%										1 0%
Manx Shearwater	1 2%		1 1%					1 2%	1 2%		4 1%	4 1%	6 1%
Gannet	14 21%		14 20%					1 2%	1 2%	1 2%	14 5%	15 5%	30 7%
Cormorant	1 2%		1 1%		3	3		1 2%	1 2%	1 2%	17 6%	18 6%	23 5%
Shag	2 3%		2 3%					8 20%	8 17%	3 6%	43 16%	46 14%	56 13%
Cormorant/ Shag											4 1%	4 1%	4 1%
Duck								1 2%	1 2%		3 1%	3 1%	4 1%
Goose (Anser/ Branta)								1 2%	1 2%		3 1%	3 1%	4 1%
White-tailed Eagle?											2 1%	2 1%	2 0%
Grouse Family											1 0%	1 0%	1 0%
Plovers (Pluvialis)										3 6%	13 5%	16 5%	16 4%
Snipes	3 5%		3 4%										3 1%
Black-headed Gull								1 2%	1 2%	1 2%		1 0%	2 0%
Common Gull								3 7%	3 6%		1 0%	1 0%	4 1%
Common Gull/ Kittiwake								1 2%	1 2%		1 0%	1 0%	2 0%
Great Black-backed Gull	2 3%		2 3%					3 7%	3 6%	6 11%	22 8%	28 9%	33 7%
Herring Gull								2 5%	2 4%		2 1%	2 1%	4 1%
Herring/ Lesser Black-back Gull	3 5%	5	8 11%				1	2 5%	3 6%	4 8%	36 13%	40 12%	51 11%
Kittiwake	3 5%		3 4%				2		2 4%	6 11%	6 2%	12 4%	17 4%
Gull Family	1 2%		1 1%				1	1 2%	2 4%		17 6%	17 5%	20 4%
Puffin	5 8%		5 7%				1	4 10%	5 10%	2 4%	25 9%	27 8%	37 8%
Puffin?	2 3%		2 3%										2 0%
Little Auk?	1 2%		1 1%										1 0%
Razorbill/ Guillemot	9 14%		9 13%					4 10%	4 8%	5 9%	33 12%	38 12%	51 11%
Blackbird	1 2%		1 1%										1 0%
Raven										3 6%	4 1%	7 2%	7 2%
Wader (Haematopodidae/ Charadriidae/ Scolopacidae/ Phalaropodidae)	2 3%		2 3%										2 0%
Passerines	14 21%		14 20%	1		1	2	6 15%	8 17%	17 32%	8 3%	25 8%	48 11%
Total Identified	66	5	71	1	3	4	7	41	48	53	272	325	448

	100%		100%					100%	100%	100%	100%	100%	100%
Unidentified Bird	176	0	176	3	0	3	25	41	66	230	256	486	731
Total Bird	242	5	247	4	3	7	32	82	114	283	528	811	1179

Table 7.7: Bird species and NISP for major phases, based on QC1 and QC0 elements

Common name	1.2 >4	3/5 Hc	4 >4	4 Hc	5 >4	5 Hc	6 Hc	7 >4	7 Hc	8 Hc	ii/iii Hc	iii/v.ii Hc	v.ii Hc	v.iii >4	v.iii Hc	vii >4	Grand Total
Fowl (Domestic)													1		2		3
Fulmar							1										1
Manx Shearwater															1		1
Gannet						5	4		1						2		12
Cormorant	1					16	1						1				19
Shag				2		24									3		29
Cormorant/ Shag		1			3	11											15
Duck															1		1
Plovers (Charadriidae)		1				1											2
Great Black-backed Gull						1		1							1		3
Herring/ Lesser Black-back Gull	1			1		4		1				1					8
Kittiwake				1		2											3
Gull Family			1			1									1		3
Puffin	2	1			1	1									4		9
Little Auk							2										2
Little Auk?			2			1											3
Razorbill/ Guillemot						11	2	1			1	2	1		2		20
Rock Dove						1											1
Passerines	1		2	11		4		2		1		1	1				23
Total Identified	5	3	5	15	4	83	10	5	1	1	1	4	4	0	17	0	158
Unidentified Bird	24	5	16	44	30	424	35	5	14		1	12	4	3	28	1	646
Total Bird	29	8	21	59	34	507	45	10	15	1	2	16	8	3	45	1	804

Table 7.8: Bird species and NISP for minor phases, based on QC1 and QC0 elements

7.3.1 Spatial and temporal patterns

The small size of the bird assemblage makes it difficult to identify changes in either time or space. However, using a subset of the most commonly occurring species (detailed below), it is possible to statistically compare the phases that are most relevant: phases ii and iii can distinguish changes through time within the farm mound, while the contemporary phases iii and 2 can be tested for spatial variation (as listed in Table 7.9).

Using both sieved and hand collected material, the only statistical difference was observed between phases 2 and iii (Chi-Square value 49.803, 10 degrees of freedom, p=0.000, but five cells with expected values of <5.0). Phases ii and iii were not statistically different (16.916, 10, p=0.076, eight cells with expected counts <5.0), and phases ii and 2 had insufficient quantifies to test. However, these values may be influenced by differing proportions of hand collection and sieving, particularly for the smaller species like the passerines. Phase 2 had very little hand collected bone, so could not be included, but the hand collected bone from phases ii and iii was compared (data summarised in Table 7.10). These phases were statistically different (21.276, nine, p=0.011, but eight cells with expected counts <5.0). The counts from bone derived from >4mm sieving were also tested, though again the sample size was small (data summarised in Table 7.11). This again indicated a statistical difference between phases 2 and iii (17.277, six, p=0.008, but six cells with expected counts <5.0). Phase ii could not be included because its sample size was too small.

To summarise, statistical differences were observed:

- Through time:
    - Phases ii and iii, hand collection only, subset of 9 taxa
- Across space:
    - Phases 2 and iii, all data, subset of 11 taxa
    - Phases 2 and iii, >4mm only, subset of 7 taxa

Therefore, some variation in both space and time has been statistically observed, particularly between phases 2 and iii. For the combined hand collected and sieved dataset, this difference is likely to result from the higher proportions of gannets and passerines observed in phase 2 compared to phase iii. When only the sieved subset is examined, the difference in passerine proportions decreases: the main difference between phases 2 and iii is the high quantities of gannet in the coastal fish midden and the much lower proportions in the farm mound. This is explored in greater detail below. The variation between phases ii and iii was only observed with the hand collected dataset, so is overall less likely to be meaningful than the major differences between phases 2 and iii. Varying proportions of the gulls and the passerines account for this difference, so could indicate a real pattern, although hand collection of small passerine remains could be subjective and dependent on excavator experience and weather conditions. It does appear, however, that gannets increase from phase ii to phase iii, which probably indicates a growing reliance on marine products through time.

Common name	Phase 2		Phase ii		Phase iii	
Gannet	14	22%	1	2%	15	5%
Cormorant/ Shag	3	5%	9	20%	68	22%
Fowl (Domestic)	1	2%	1	2%	14	5%
Plovers (Pluvialis)	0	0%	0	0%	16	5%
Herring/ Lesser Black-back Gull	8	13%	3	7%	40	13%
Great Black-backed Gull	2	3%	3	7%	28	9%
Other gulls	1	2%	9	20%	22	7%
Kittiwake	3	5%	2	4%	12	4%
Puffin	7	11%	5	11%	27	9%
Razorbill/ Guillemot	9	14%	4	9%	38	12%
Passerines	15	24%	8	18%	25	8%

Table 7.9: Species and counts (combined hand collected and >4mm) tested for spatial and temporal variation

Common name	Phase ii		Phase iii	
Gannet	1	3%	14	6%
Cormorant/ Shag	9	24%	64	26%
Fowl (Domestic)	1	3%	13	5%
Plovers (Pluvialis)			13	5%
Herring/ Lesser Black-back Gull	2	5%	36	14%
Great Black-backed Gull	3	8%	22	9%
Other Gulls	8	21%	21	8%
Puffin	4	11%	25	10%
Razorbill/ Guillemot	4	11%	33	13%
Passerines	6	16%	8	3%

Table 7.10: Species and counts (hand collected only) tested for temporal variation

Common name	Phase 2		Phase ii		Phase iii	
Gannet	14	25%			1	2%
Cormorant/Shag	3	5%			4	9%
Gull family	6	11%	2	29%	11	24%
Kittiwake	3	5%	2	29%	6	13%
Puffin	7	13%	1	14%	2	4%
Razorbill/ Guillemot	9	16%			5	11%
Passerines	14	25%	2	29%	17	37%

Table 7.11: Species and counts (>4mm only) tested for spatial and temporal variation

7.3.2 Seasonality and environmental exploitation

Some of the wild species found at Quoygrew are only found in Orkney during the breeding season, including the guillemot and razorbill (March to July), puffin (March-April to August), Manx shearwater (spring to autumn), the lesser black-backed gull (never found in winter) (Anon. 2005; Berry 2000, 167; Booth and Booth 1998, 17; Buckley and Harvie-Brown 1891, 259; Serjeantson 1988, 212). Other species – like the black guillemot, gannet, shag, cormorant and fulmar – are probably found year round, though at different densities depending on the breeding season and whether or not an individual is breeding. Shags and cormorants were both recorded historically as winter food in the Northern Isles, and grouse were more likely to be eaten at this time of year (Serjeantson 1998, 26). The little auk, a tentative identification from phase 2, is conversely only found in Orkney during the winter months (Buckley and Harvie-Brown 1891, 259; Booth *et al.* 1984, 147). Some bird species are vulnerable in late summer and early autumn because they moult and cannot easily escape predators; these include geese and ducks, both found in the farm mound (Serjeantson 1998, 25). Table 7.12 summarises the environments preferred by each species, as well as the seasons in which they are found in Orkney.

Further evidence for seasonality could come from the presence or absence of medullary bone, the thickened layer of bone laid down in the long bones of females in the days leading up to the nesting season, in order to have sufficient calcium to produce eggs (Serjeantson 1998, 27). It is rarely observed in sea birds (Serjeantson 1998, 27), so the occurrence of only three samples from Quoygrew is not unusual. One humerus from phase iii had medullary bone, but was unfortunately not identified to species, while two other humeri were from phase 2; one was from a shag and the other a great black-backed gull. The evidence from the shag would indicate capture in the spring, thus (in this case) contradicting the ethnohistorical evidence that suggested shags were winter food but were best in September (Fenton 1978, 521; Serjeantson 1998, 26).

Some of the wild species do not live in cliff environments, but could still be found close to Quoygrew. These include the snipes (only found in phase 2), species that breed in wetlands and moors or pastures with shallow pools, and the plover species (only found in the farm mound), all of which prefer moorland, grassland or recently ploughed fields for breeding purposes (Groundwater 1974, 122-125; Snow and Perrins 1997; Berry 2000, 161). The golden plover is the most common plover species in Orkney, so is likely to be present in phase iii, and although it is found throughout the year, they may be more common in the winter months than the summer (Buckley and Harvie-Brown 1891, 201; Groundwater 1974, 123; Low 1813, 88). Common snipes are found throughout the year, and as the name suggests, are abundant, but the jack snipe is only found during the autumn and winter months (Buckley and Harvie-Brown 1891, 213-14). Low describes both the common snipe and the plovers as "very good eating" (1813, 81, 89). Some sea birds prefer not to nest in cliff edge environments, including the herring gull, the lesser black-backed gull, the common gull and the black-headed gull, all of which nest in wetlands and moors and are found throughout the year (Berry 2000, 167-68; Booth *et al.* 1984, 124-28; Snow and Perrins 1997).

Wild geese species often migrate through Orkney in the autumn, with many over-wintering on Orkney, along with wild ducks (Berry 2000, 174; Booth *et al.* 1984, 29-33; Buckley and Harvie-Brown 1891, 164-68). Geese and ducks were only found in the farm mound, and if wild, may indicate winter exploitation of a convenient resource. Wild ducks used to be found during the winter at the Holm of Aikerness, a habitat that would also suit wild geese, towards the north end of Westray and not far from Quoygrew (Buckley and Harvie-Brown 1891, 19).

The single grouse identification from phase iii was likely to be a red grouse, as they were the most commonly occurring of the grouse species on the islands. They also prefer a moorland environment, and are found throughout the year. There are no records of any nesting or living on Westray, they were known to occasionally fly over from their breeding grounds on Rousay (Buckley and Harvie-Brown 1891, 194).

The rock dove is the precursor to the domesticated pigeon, and is naturally found on Orkney in large numbers (Buckley and Harvie-Brown 1891, 187). They nest in cliff environments, in caves, and in disused buildings, and are found throughout the year (Baldwin 1974, 74; Berry 2000, 169; Booth and Booth 1998, 35). None were found in the major phases.

The nearest gannet breeding ground to Orkney is Sule Stack, in addition to several places throughout Shetland and St. Kilda, though historical references indicate they used to breed on Copinsay (Groundwater 1974, 56-57; Booth *et al.* 1984, 13). Suitable habitats could be found on other places in Orkney – and a small new colony is being established on Noup Head – which may suggest they used to breed more freely throughout the isles. However, the evidence suggests these possible breeding colonies were abandoned during the first millennium AD (Serjeantson 2001, 44, 48). Opinions differ on gannet seasonal variation; they either were found on Orkney throughout most of the year but not during the nesting season (Buckley and Harvie-Brown 1891, 160), or they are seen fishing in Orkney waters between March and November but not seen through the winter (Groundwater 1974, 57). Modern data suggests they live at the breeding grounds between February and September, although Orkney waters could be within reach when the birds were fishing for food (Serjeantson 2001, 51). If they were captured from breeding grounds, sufficient boat technology would have been required to make the difficult journey to the remote sea stacks, but as suggested by Serjeantson, their exploitation could coincide with the advances in boating and fishing technology around the end of the first millennium AD (2001, 48). Ethnohistorical sources suggest gannet chicks taste better and are fatter than the adults (Serjeantson 1998, 29), which would suggest that exploitation of the breeding colonies would be preferable over capture of adults. The smaller proportion of gannets in phase ii may suggest that the journey to Sule Stack was more difficult in the earlier phases, if we assume no gannet colonies were present on Orkney at that time (following Low 1813, 148; Serjeantson 2001, 44, 48 and contra Booth *et al.* 1984, 13 and Groundwater 1974, 56-7). Alternatively, gannets may have been caught at sea while fishing (Groundwater 1974, 57). The higher proportion of gannets recovered from the fish midden is further evidence that they were a marine-based resource, thus correlating with the differences in the fish assemblage observed between the farm mound and the fish midden (see Chapter Five).

	Habitats				Seasonality				
Common name	Coastal cliff edge	Other coastal	Moor-lands, wetlands	Notes	Late autumn - winter	Spring - summer	Autumn	Breeds on Orkney?	Notes
Fowl (Domestic)				near house	•	•	•	•	
Fulmar	•	•		probably recent intro.; nests in archaeological sites	•	•	•	•	
Manx Shearwater	•	•		burrowing		•	•	•	
Gannet	•			Sule Stack	?	•	•		
Shag	•	•			•	•	•	•	
Cormorant/ Shag	•	•			• / few	•	•	•	
Cormorant	•	•			few	•	•	•	
Duck			•		•		•		
Goose (Anser/ Branta)			•		•		•		
White-tailed Eagle/Golden Eagle			?	scavenger	•	•	•	•	
Grouse Family			•		•	•	•	•	
Plovers (Pluvialis sp.)			•		•	•	•	•	
Plover (Charadriidae sp.)			•		•	•	•	•	
Snipes			•		•	•	•	•	
Arctic Skua		•	•		•	•	•	•	
Great Skua		•	•	recent introduction	•	•	•	•	
Gull Family	•	•			•	•	•	•	
Herring Gull	•	•	•		•	•	•	•	
Herring/ Lesser Black-back Gull	•	•	•		• / rare	•	• / rare	•	Lesser black-back rare in winter
Common Gull		•	•		•	•	•	•	
Common Gull/ Kittiwake	?	•	?		• / few	•	• / few	•	Kittiwake uncommon in winter
Great Black-backed Gull		•		scavenger	•	•	•	•	
Black-headed Gull		•	•	scavenger	•	•	•	•	
Kittiwake	•					•		•	
Puffin	•	•		burrowing		•		•	
Razorbill/ Guillemot	•				• / few	•	• / few	•	Razorbill uncommon in winter
Little Auk	•				•				
Rock Dove	•	•		scavenger, also in buildings	•	•	•	•	
Raven	•	•		scavenger	•	•	•	•	

Sources include: Buckley and Harvie-Brown 1891; Groundwater 1974; Fenton 1978; Booth *et al.* 1984; Serjeantson 1988; Booth and Booth 1998; Serjeantson 1998; Berry 2000; Serjeantson 2001; Anon. 2005; for specific page numbers, see text

Table 7.12: Summary of environmental niche and seasonal occupation for birds at Quoygrew

7.4 Elements

Element summaries for the three largest and most important phases, 2, ii and iii, are provided below (Table 7.13, Table 7.14, Table 7.15). These indicate that all parts of the body were found, suggesting entire exploitation of the carcass. This is confirmed by the range of QC0 bird elements that were also identified, but not quantified.

Phase 2: Species	Carpometacarpus	Coracoid	Femur	Humerus	Tarsometatarsus	Tibiotarsus	Ulna	Total
Fowl (Domestic)	1							1
Fulmar				1				1
Manx Shearwater				1				1
Gannet					1			1
Shag				1				1
Cormorant			1					1
Snipes				1			1	2
Gull Family						1		1
Herring/ Lesser Black-back Gull	1					2	2	5
Great Black-backed Gull				2				2
Kittiwake					2	1		3
Puffin			3	1		3		7
Razorbill/ Guillemot	3		3	1		1	1	9
Little Auk?						1		1
Blackbird		1						1
Wader	2							2
Passerines	4	1		3	4		2	14
Total	11	2	7	11	7	9	6	53

Table 7.13: Phase 2 QC1 element summary

Phase ii Species	Carpometacarpus	Coracoid	Femur	Humerus	Scapula	Tarsometatarsus	Tibiotarsus	Ulna	Total
Fowl (Domestic)		1							1
Manx Shearwater								1	1
Shag		3	1	1	1	1	1		8
Cormorant								1	1
Duck				1					1
Gull Family		1							1
Herring Gull						1	1		2
Herring/ Lesser Black-back Gull	1			1				1	3
Common Gull				2				1	3
Common Gull/ Kittiwake		1							1
Great Black-backed Gull				1		1	1		3
Black-headed Gull						1			1
Kittiwake	1								1
Puffin			1	2		1		1	5
Razorbill/ Guillemot	1					1		1	3
Passerines	1	1		2		1	1	2	8
Total	4	7	2	10	1	7	4	8	43

Table 7.14: Phase ii QC1 element summary

Phase iii Species	Carpometacarpus	Coracoid	Femur	Humerus	Scapula	Tarsometatarsus	Tibiotarsus	Ulna	Total
Fowl (Domestic)	1	1	2	1		3	2	2	12
Manx Shearwater	1			2		1			4
Gannet	1	3		2	1	1	2	2	12
Shag		7	6	6	10	2	8	4	43
Cormorant/ Shag			2		2				4
Cormorant	2	4		2	1	1	4	2	16
Duck	1					1		1	3
Goose (Anser/ Branta)				1			1	1	3
Grouse Family				1					1
Plovers (Pluvialis)			1	3	1	3	3	5	16
Gull Family	2	1		1		2	3	1	10
Herring Gull		1						1	2
Herring/ Lesser Black-back Gull	5	7	4	4		6	8	5	39
Common Gull								1	1
Common Gull/ Kittiwake						1			1
Great Black-backed Gull		9	1	5	5	2	2	2	26
Black-headed Gull						1			1
Kittiwake	2				1	2	3	4	12
Puffin	6	1	1	2		3	2	7	22
Razorbill/ Guillemot	5	5	3	3	3	1	5	5	30
Raven	2					2		2	6
Passerines	7			4	1	2	4	7	25
Total	35	39	20	37	25	34	47	52	289

Table 7.15: Phase iii QC1 element summary

7.5 Age and sex

A small quantity of young, unfused long bones were recorded, but only one definite juvenile was recorded to species, a shag from phase v.iii. Research by Serjeantson would suggest that bones may appear fully fused in juvenile birds that have not yet fledged (Serjeantson 1998, 30), which probably indicates that juvenile bone is present in larger quantities than was recorded.

Three domestic fowl tarsometatarsi were recorded from phase iii, all with zone 2 present, the zone containing the spur that can be used to determine sex. No spurs were recorded, indicating all three birds were female. As the presence of eggshell was already noted above, this provides further evidence that domestic fowl contributed both eggs and meat to the local economy.

7.6 Butchery

A total of 20 butchery marks were recorded from a variety of phases (Table 7.16). Most were not identifiable to species, but those that were indicate that Manx shearwaters, shags, cormorants, ducks, gulls and domestic fowl were being butchered, presumably for consumption by humans. All of the species with butchery marks have a recognisable food value.

Phase	Species	Element	Butchery	Notes
1.2	Unidentified	Rib	cut	
2	Manx Shearwater	Humerus	cut	3 cut marks on distal epiphysis
5	Unidentified	Humerus	cut	across distal epiphysis
5	Shag	Coracoid	chop?	
5	Unidentified	Furcula	cut	cut marks on lateral side
5	Unidentified	Rib	cut	
5	Cormorant	Radius	cut	two marks below [proximal?] epiphysis
5	Unidentified	Vertebra	cut	
6	Cormorant	Pelvis	cut	
6	Unidentified	Pelvis	cut?	
iii	Cormorant	Sternum	cut?	
iii	Duck	Carpometacarpus	chop	
iii	Unidentified	Tibiotarsus	cut	
iii	Herring/ Lesser Black-back Gull	Humerus	chop?	on posterior facets of distal epiphysis
iii	Unidentified	Humerus	>1 knife marks	series of diagonal shallow cut marks on proximal joint surface
iii	Unidentified	Vertebra	cut	
iii	Unidentified	Humerus	cut	
v.ii	Fowl (Domestic)	Femur	chops	
v.iii	Unidentified	Humerus	chop?	on shaft and across distal epiphysis
v.iii	Unidentified	Tibiotarsus	cut?	

Table 7.16: Bird butchery summary

7.7 Discussion

The small quantity of bird bone recovered from Quoygrew was mostly in excellent condition, indicating that the general absence of bird bone was a real phenomenon, and not a product of differential preservation. Birds appear to only have been used at a low level or sporadically, without the importance placed on mammal or fish (see Chapter Three for a comparison with the proportions of mammal and fish through time and space). Different seasons of exploitation are represented by the wide range of species, indicating year-round use of birds and habitats throughout the occupation of Quoygrew.

A wide range of wild species were exploited, with only a small proportion of bone derived from domestic fowl. A number of different habitats were used, no doubt including the nearby cliffs at Noup Head, still known as a rich and diverse bird colony for sea birds today. Moorland environments from towards the north end of the island were probably exploited, as were the sheltered bays. Birds from the moorland and wetland environments tended to be deposited in the farm mound more frequently than in the fish midden.

Adult birds were probably the primary target of exploitation, but although a small number of unfused juvenile bone was found, birds that often appear skeletally mature have yet to fledge; thus the proportion of juvenile bone may have been higher than recorded. There is some suggestion that females were present, particularly for the domestic fowl, but quantities were very low.

Gannets may have been captured from Sule Stack, 86km away from Quoygrew. Differing proportions of gannet exploitation was one of the main differences between phases: not only did they became more exploited in the later phases 2 and iii, but they were also statistically more common in the fish midden than they were in the farm mound. This would suggest that gannets were seen as a marine resource, possibly captured during deep water fishing excursions. Their greater presence in the fish midden compared to the farm mound corroborates to the overall pattern of marine and terrestrial resource divisions and usage.

Chapter Eight: Discussion and exploration of intra- and inter-site zooarchaeological patterning

8.1 Introduction

This chapter will present a summary of the zooarchaeology of the Northern Isles, drawing together the evidence from the mammals, fish and birds. Primary data discussed in Chapters Four to Seven will be included, and information relating to the mammal and bird assemblages from Earl's Bu, as identified by Ingrid Mainland, will be included where relevant. The main aim of this summary will be to identify and describe the patterns observed in the zooarchaeological assemblages, without putting forward explanatory hypotheses; that will take place in the following chapter.

The comparative zooarchaeological assemblages were first introduced in Chapter One, with more detail provided in Appendix One. Rather than discussing all aspects of zooarchaeological data, this chapter will focus on those that can illuminate the spatial and temporal themes introduced in Chapter One. Thresholds requiring minimum numbers of identified bones will be set for each aspect of the zooarchaeological data, thus eliminating the phase groups with small sample sizes that contribute little towards an understanding of patterning. This chapter will present, explore and describe major patterns as they appear throughout the Northern Isles zooarchaeological dataset, applying statistical tests where relevant. Where possible, the following factors will be discussed at the intra- and inter-site level:

- Interclass comparisons using count and weight data
- Interclass midden densities, using counts or weights per litre of sediment
- Variation in major gadid fish species, using NISP counts
- Variation in minor fish species, grouped at the family or higher level if necessary, using NISP counts
- Variation in fish total length estimates, determined using both general size categories and biometrical regression formulae
- Evidence for fish butchery strategies, using element distributions and butchery marks
- Variation in major domestic mammals, using NISP counts
- Variation in minor mammal species, using NISP counts

- Evidence for domestic mammal ageing, using tooth wear, epiphyseal fusion and general ageing categories
- Evidence for mammal element distributions and exchange of meat between sites, using NISP counts and summary data provided in the reports
- Any biometrical evidence for temporal or spatial variation
- Variation in all bird species, using NISP counts

Chapter Nine will then attempt to provide explanations for the patterns identified and defined in this chapter, and the variations within these patterns over the Northern Isles, using ethnohistoric and contextual information. In so doing, the temporal and spatial themes introduced in Chapter One will be revisited.

The comparative evidence could be presented in a number of ways, and both intra-site and inter-site patterning need to be examined. A chronological approach that separated each site could not be applied, because important intra-site variation could be lost. Any ordering by site type or status was also difficult, given the mixing and/or absence of data for some sites. A geographic presentation was chosen as the easiest way to discuss the comparative sites, starting with Sandwick North, Sandwick and Scalloway from Shetland; St. Boniface, Quoygrew, Tuquoy and Pool from Orkney's smaller islands to the north; the group from the Birsay Bay area that included Rescue Excavations and Room 5 from the Brough itself, Buckquoy, Brough Road, Burnside and Studio sites, and Saevar Howe; the sites from the Deerness peninsula including the Brough of Deerness, Skaill and Newark Bay; Earl's Bu as a separate site on Mainland (befitting its status); and finally, Robert's Haven and Freswick in Caithness. This approach had several advantages over others, as will become clear, not least of all because the group of sites around the Birsay Bay area form a group of closely inter-linked and contemporary assemblages. Fishing habitats from contemporary sites located near to each other may be assumed to be similar, yet the records from fishbone reports may be substantially different.

Each comparative site will be assessed for any evidence of recovery and taphonomic biases. The final zooarchaeological datasets in published reports are a product of a range of processes, not least of which are the recovery methods applied and the analytical methods used to quantify and discuss the data. Each of these processes ideally needs to be clearly articulated and examined prior to any economic reconstructions taking place. Analytical methods and inter-analyst variability may also make groups of sites appear more similar than they actually are, so attempts will be made to identify and clarify any such variation. Having considered these factors, it may then be possible to examine the variation related to date, feature type, site status and function – thus approaching the structured deposition within each site and finding "real" patterning.

8.2 Inter-class comparisons

Inter-class comparisons of the material were possible using weight and count data from the primary sites (with minor problems), but it is more difficult to extend this method of comparison across all sites in the Northern Isles. Recovery issues are likely to influence ratios of fish and mammal bone at a number of sites, and sometimes one class has been differently quantified from others, making comparison difficult. However, where possible, interclass comparisons using count data will be explored. Additionally, deposit densities measured as weights or counts of bone per litre of sediment could be calculated for a small number of sites, including Sandwick North, Sandwick, Quoygrew, St. Boniface, Beachview Studio, Robert's Haven and Freswick.

8.2.1 Count and weight comparisons

Basic NISP and TNB data were provided for each of the three classes for most sites. These data are summarised in Appendix Table 6.1, for fully sieved sites (St. Boniface, Saevar Howe and Robert's Haven), Appendix Table 6.2, for sites with both sieving and hand collection that were quantified separately (Sandwick North, Quoygrew, Beachview, Beachview Studio, Earl's Bu and Freswick), Appendix Table 6.3, for sites with both sieving and hand collection but that were quantified together in the reports (Sandwick, Scalloway, Pool, Brough Road and Brough of Deerness) and Appendix Table 6.4, for sites where bone was only collected by hand (Brough of Birsay Rescue Excavations and Brough of Birsay Room 5). A number of sites are not included in this list because they do not have sufficient data for inter-class comparisons or because they are not fully quantified. These include Jarlshof (not quantified), Tuquoy (mammal not yet quantified), Buckquoy (fish not quantified), Newark Bay (mammal, bird and fish phased differently and very small sample sizes) and Skaill (fish phased differently to mammal).

The inter-class count data have been separated into three categories by recovery method: hand collected, sieved and mixed recovery. Because TNB data were not always available (and when present, tended to be similar to NISP data), this analysis has focussed solely on NISP results. These data are displayed in two ways, firstly by basic counts, and secondly by percentages. The former allows the overall size of each assemblage to be compared to every other one, while still showing the representation of each class, while the latter permits an easier comparison between the classes. Not all phase groups have been included, because small phase groups are likely to skew and complicate the results while contributing little to overall patterning. Minimum requirements for each category were therefore established and are made explicit on each figure. For example, sieving recovers many more bone fragments than hand collection, and consequently the threshold for sieved phase groups was set at a minimum of 600 fragments, but for hand collection, this was set at 300 fragments. The results are displayed in Figure 8.1 to Figure 8.6.

Very few sites extend across all of the figures, which makes finding overall trends difficult. That said, Earl's Bu is one of these few sites, and these phase groups form a distinctive pattern: Earl's Bu consistently has higher proportions (and higher absolute quantities) of mammal than most other sites, regardless of quantification method. Other sites, like Brough of Birsay Rescue Excavations and Room 5, also have large proportions of mammal bone, but these are likely biased by recovery methods as only hand collection was applied. Beachview Studio Midden phase 1D/E Y has a higher proportion of mammal than all other phase groups at Beachview Studio (when contrasting the mixed recovery proportions), but this reflects the higher than usual portion of hand collected bone in this phase group compared to all others (see Appendix Five for data). As can be seen by comparing the hand collected figures with those derived from sieved material, hand collection biases increase the proportion of mammal bone recovered and identified.

Little inter-class comparative data was available for Freswick, but there appears to be an unusually high concentration of mammal bone in the SCA areas dating to the late Iron Age to the Viking Age. This may reflect the second trend running through these data, namely an increase in the proportion of fish through time, particularly after about 1000. Again, Earl's Bu displays this trend throughout all figures. Other sites with sufficient chronological data and that show this pattern include Quoygrew and Pool (Nicholson 1998). Deposits at Brough Road probably show this, but are very broadly dated;

however there was an increase in the proportion of fish from area 1 and the earlier deposits of area 2 to the later deposits of area 2. This trend can also be observed within the hand collected material at Brough of Birsay Room 5 (contrast the earlier phase groups with phase 4), which indicates an increase in at least the larger and more readily found fish bones through time. Despite the lack of quantification at Buckquoy, intensification in fishing can be argued by the increase in identifications made in the 'Norse' phases compared to the preceding 'Pictish' phases (Wheeler 1976-77; Barrett *et al.* 2001, 145).

Several sites have higher proportions of fish bone than others. These include Robert's Haven phase 1 area A, St. Boniface and Quoygrew, which were identified as fish middens during excavation, as well as select deposits including Sandwick middle phase area 2 (comprised almost entirely of fish), Freswick inland area 3, most of Beachview Studio site and Sandwick North. Most of these date from 1000 onwards (or are from a date range that includes this), the exception being the late Iron Age phase 7 from St. Boniface. This issue will be examined in greater detail below, when analysing midden densities (section 8.2.2), and when examining spatial and temporal patterning within the fish assemblages (section 8.3).

Bird bone is very much in the minority throughout all sites in the Northern Isles, but a few sites have slightly higher levels than others. These include the fish midden at Quoygrew, area 1 Y from Beachview Studio, midden area 2 X from Beachview, phases 2 and 3 from Sandwick North and phase 1, area B, phase 2, area B and area E from Robert's Haven. With the exception of Sandwick North, these patterns were found in sieved material, making them unlikely to be related to recovery biases. The two Beachview phase groups and the two Sandwick North phase groups are all associated with higher than usual proportions of fish, possibly indicating a correlation between fish and seabirds similar to those found in the fish midden at Quoygrew, but this pattern does not apply to Robert's Haven.

Finally, two assemblages that date towards the end of the medieval period have an increase in mammal bone. This was observed at Robert's Haven, when comparing the 11th – 13th century phase 1 area A and the 14th – 16th century area E (sieved recovery), and at Sandwick North, between the 11th – 12th century phase 2 and the 12th – 13th century phase 3 (mixed recovery). However, both of these trends could also be explained by spatial differences within each site, given that area E at Robert's Haven was associated with a structure and was further inland than area A, and phase 3 at Sandwick North was also associated with a structure while phase 2 was not.

The density of deposition will now be investigated in detail, using counts and weights of bone per litre of sediment. These allow changes in the intensity of deposition to be identified across time and space. Unfortunately, only the sites excavated more recently with good sampling strategies have the required data: Sandwick North, Sandwick, Quoygrew, St. Boniface, Beachview Studio, Robert's Haven and Freswick.

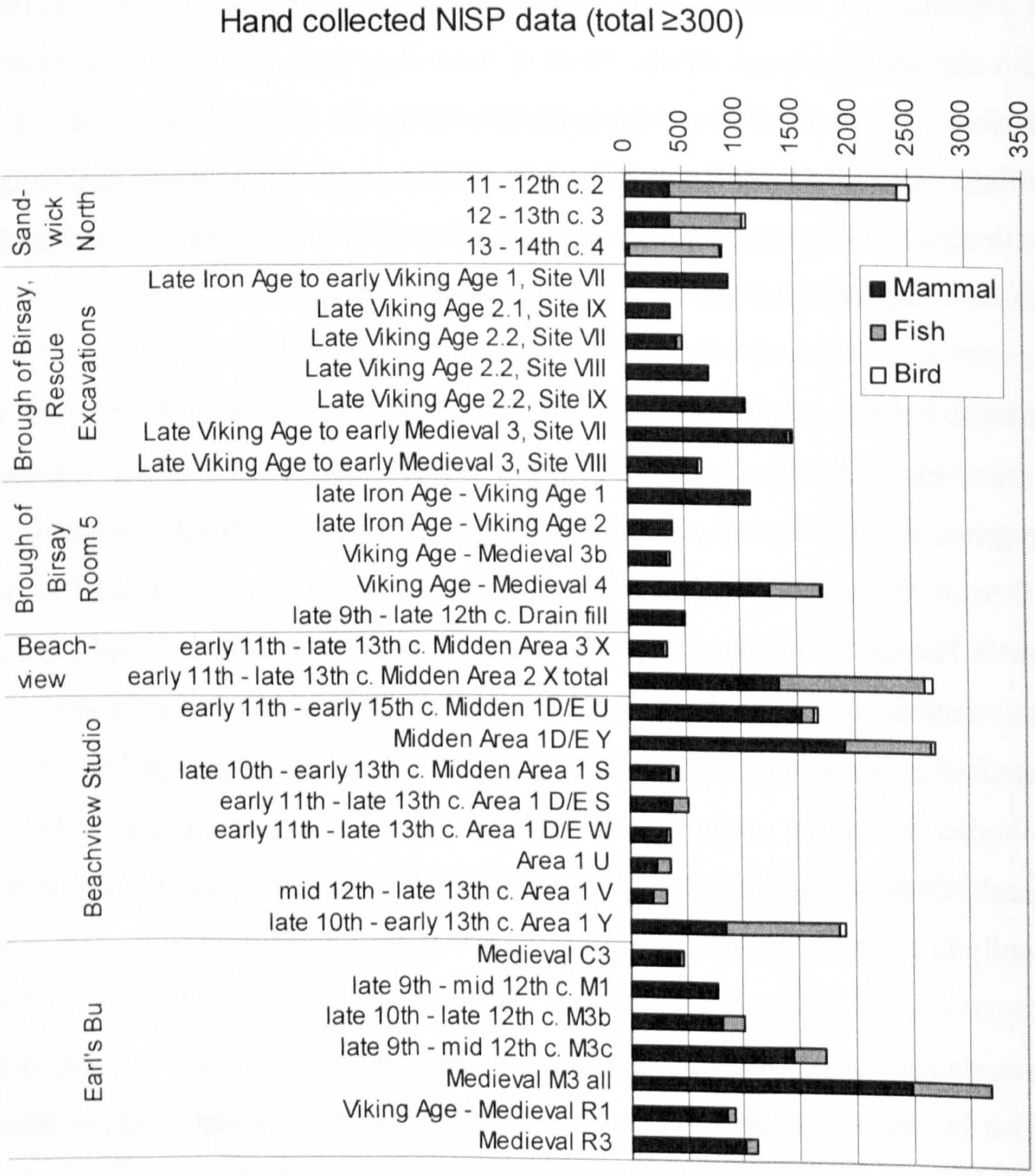


Figure 8.1: NISP for sites with hand collected bone, with ≥300 fragments

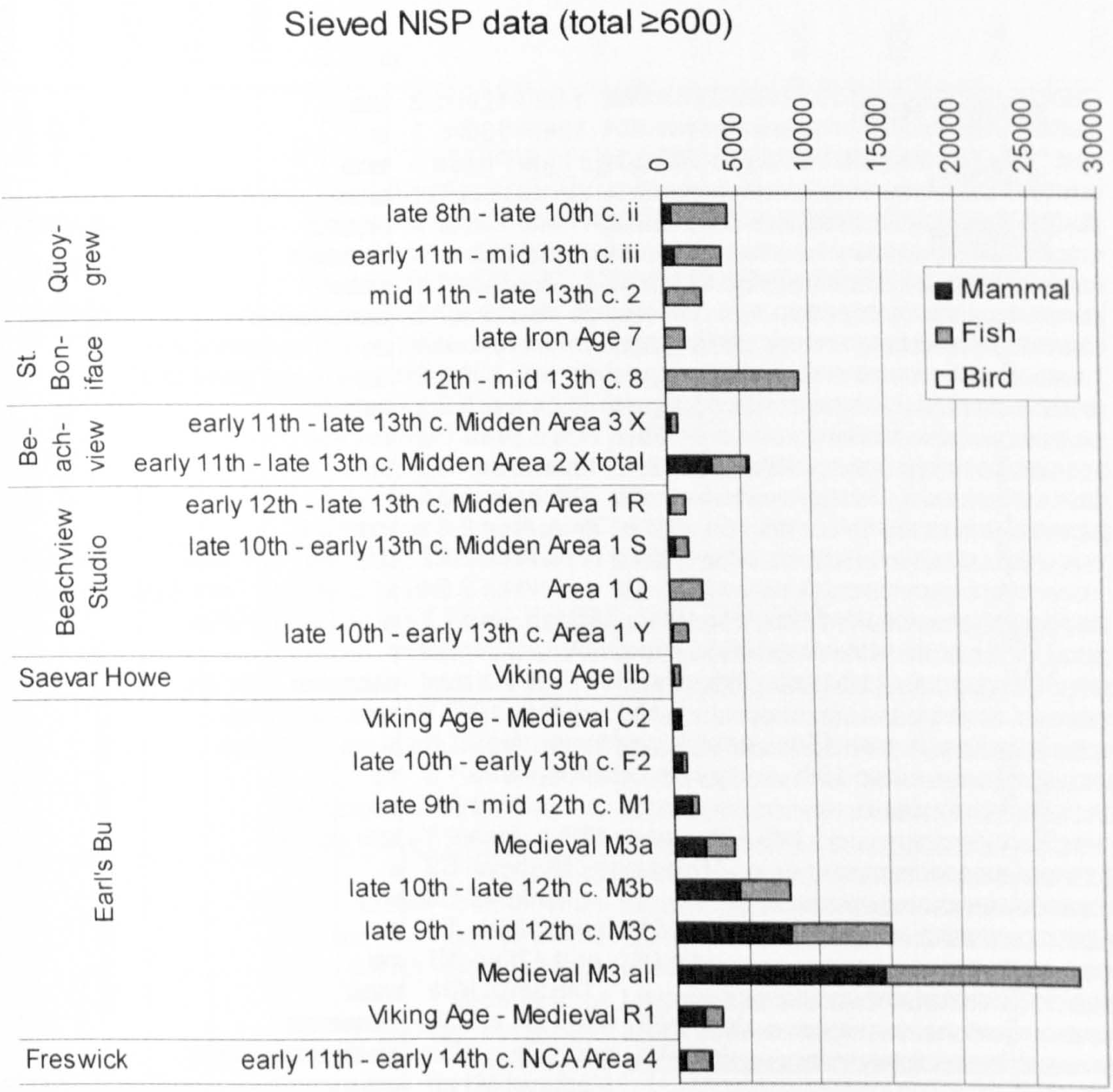


Figure 8.2: NISP for sites with sieved bone, with ≥600 fragments

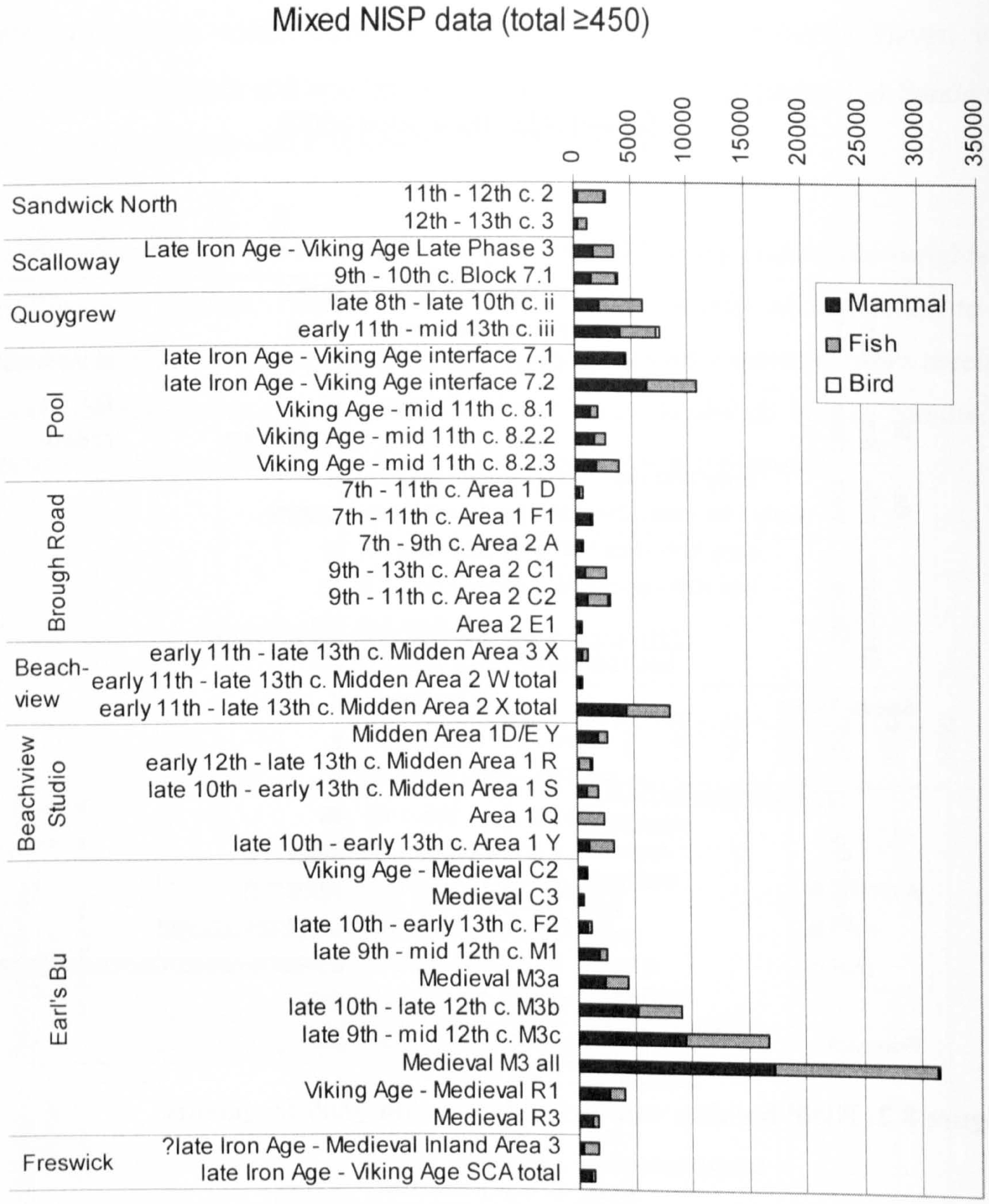


Figure 8.3: NISP for sites with mixed recovery, with ≥450 fragments

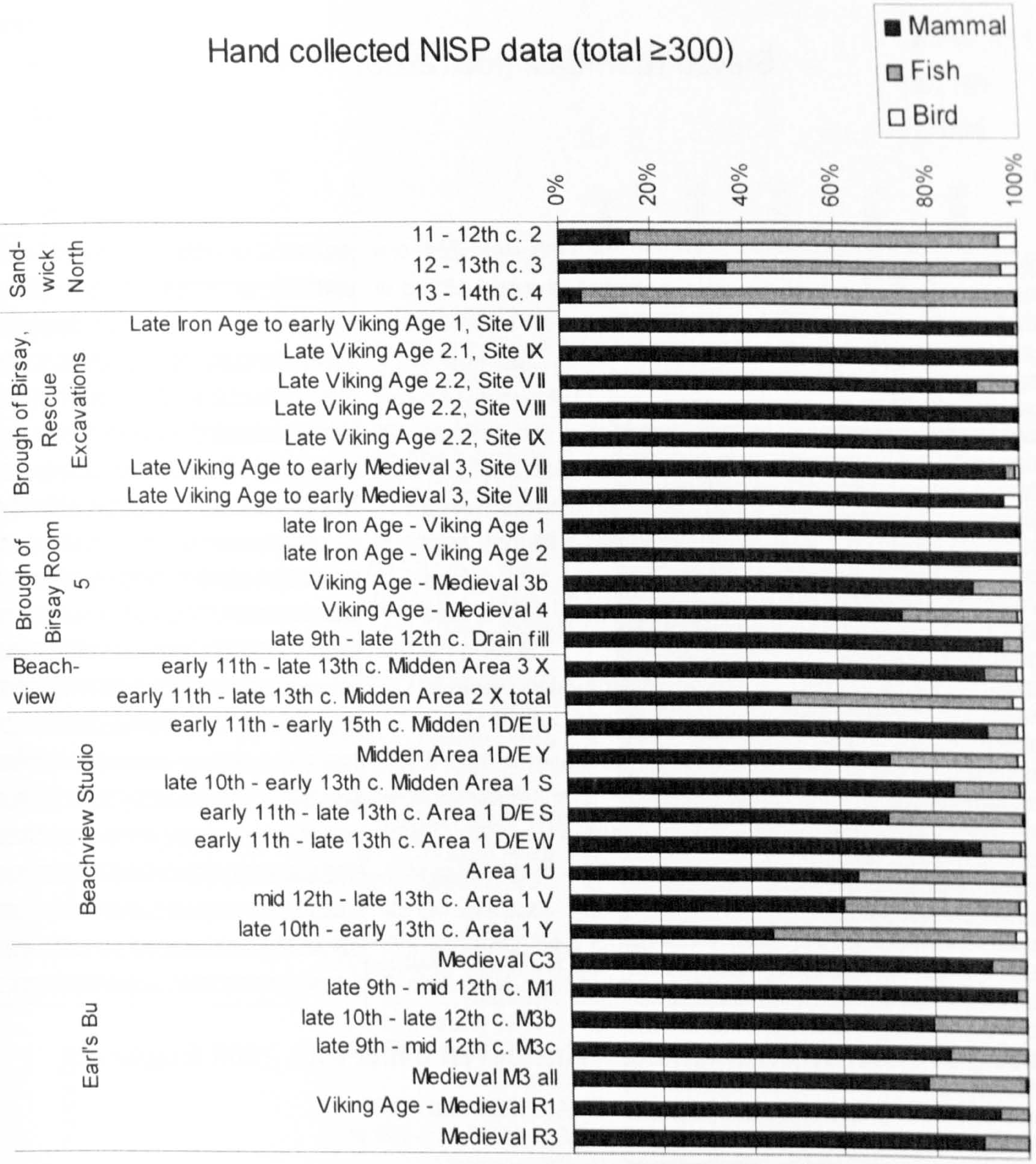


Figure 8.4: Percent NISP for sites with hand collected bone, with ≥300 fragments

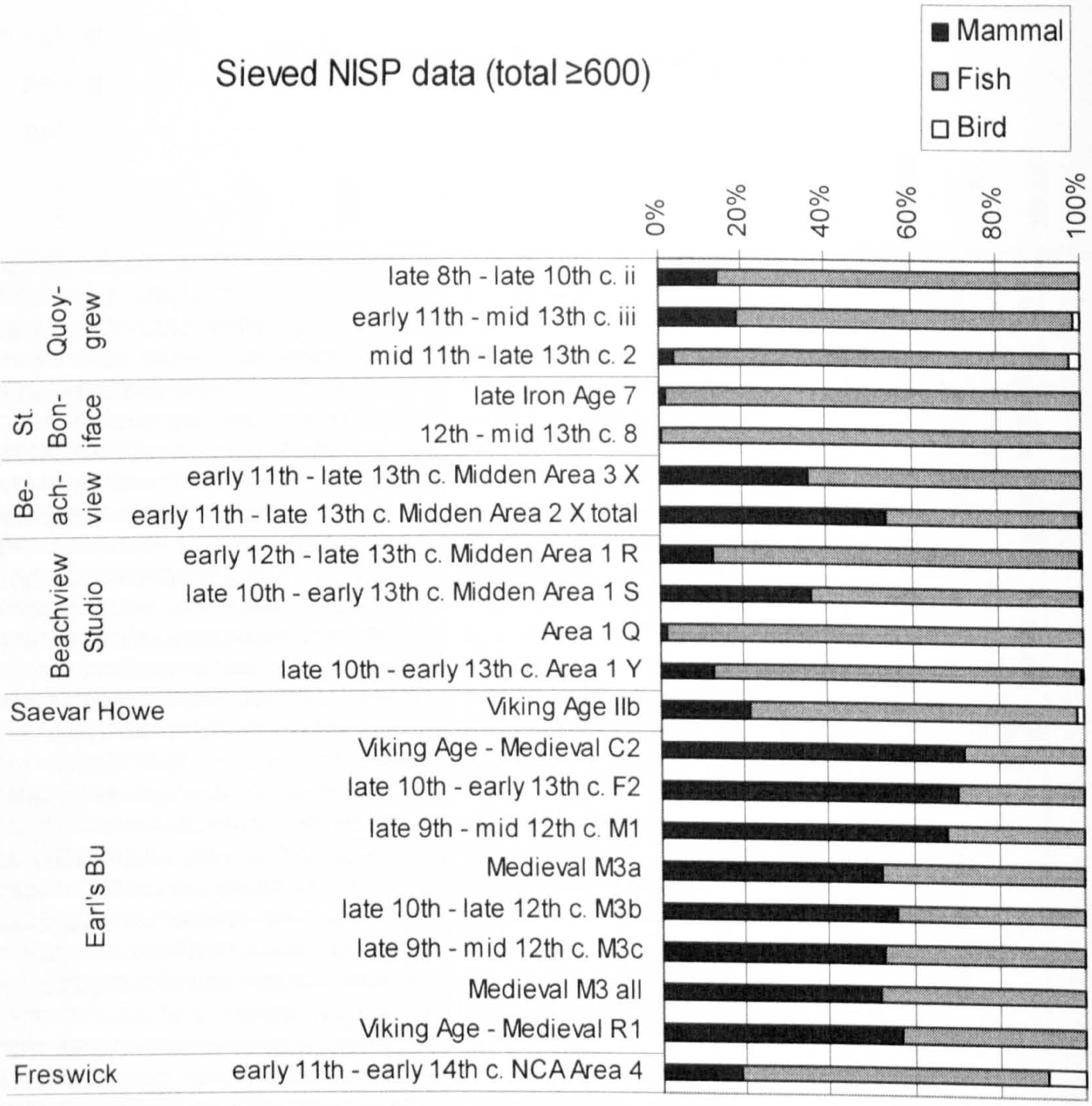


Figure 8.5: Percent NISP for sites with sieved bone, with ≥600 fragments

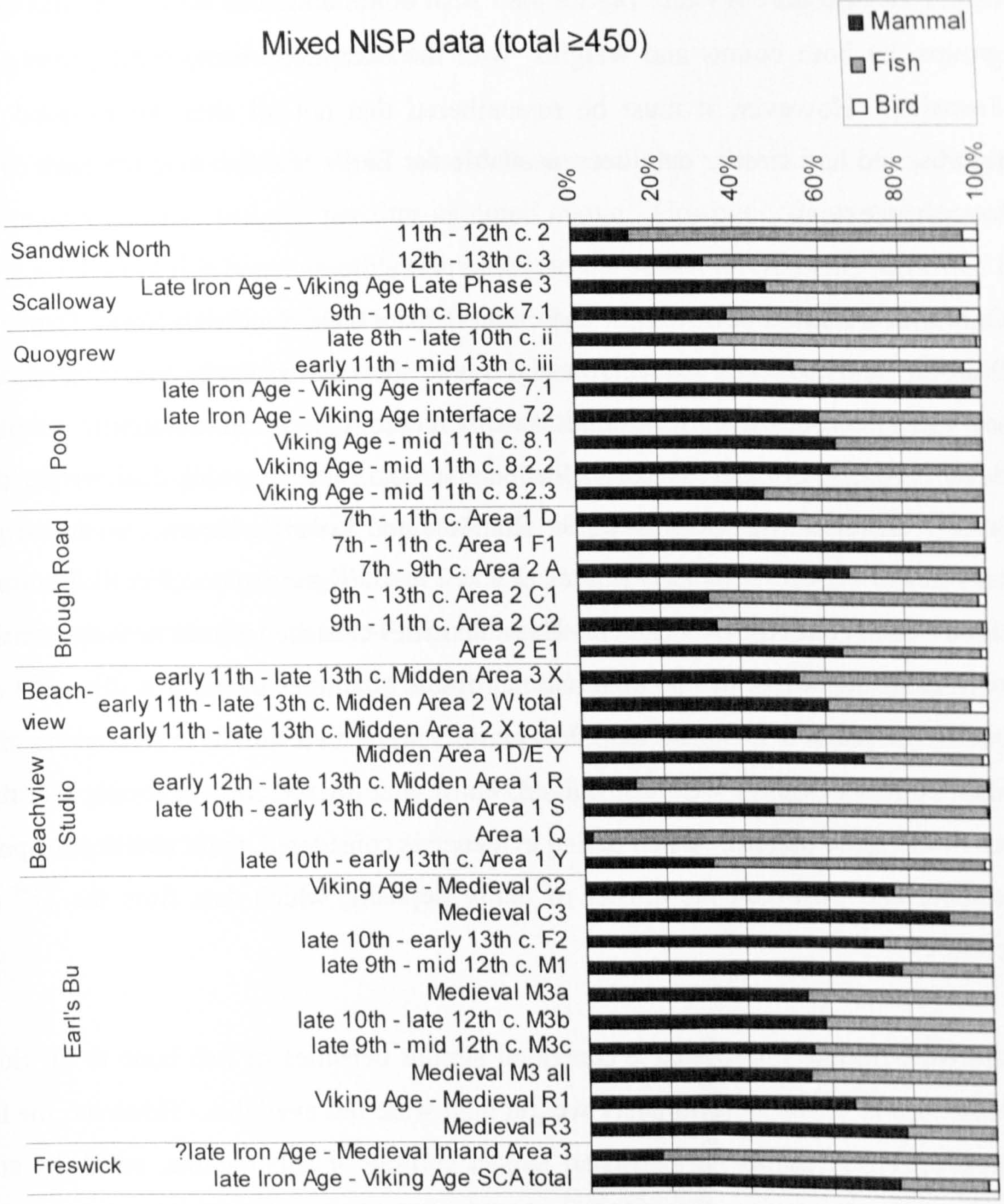


Figure 8.6: Percent NISP for sites with mixed recovery, with ≥450 fragments

8.2.2 Midden densities

Within the seven sites with density information provided, material was quantified by either a count of bones per litre of sediment (TNB/L), or by a weight of bones per litre (g/L). All of these deposits had been classed as midden or deflated midden when excavated. In the case of Freswick, the weight per kilo of sediment was originally provided (g/kg), but based on data recorded from Quoygrew and summarised in Table 8.1, this was approximately equal to the weight per litre of sediment and could therefore be compared with other sites. The results are provided in Table 8.1, and are graphically displayed in Figure 8.7 and Figure 8.8. Fish bones dominate almost all sites and phase groups, by both counts and weights, with the exceptions being some phase groups at Freswick. However, it must be remembered that not all sites are included in these figures, and had similar data been available for Earl's Bu, fish may not have dominated to such an extent.

Only four sites had both weight and count density data: Sandwick North, Quoygrew, St. Boniface and Robert's Haven (these are also the most recently excavated sites in the survey, reflecting the current trend towards recording more information). Additionally, Beachview Studio and Sandwick had count data, and Freswick had weight data for density calculations. Quoygrew, St. Boniface and Robert's Haven contain the greatest densities of bone, particularly phases iii and 2 at Quoygrew, phase 8 at St. Boniface, and phase 1 area A at Robert's Haven. These densities consisted almost entirely of fish bone, with small quantities of mammal and negligible quantities of bird (as discussed above). Quoygrew phase 1.2 and St. Boniface phase 9 were both similar to these dense deposits when counts of bones were considered, but less so by weight, suggesting that they did not fit the same pattern. When dating evidence is considered, these two sites respectively pre-date and post-date the cluster of dense deposits, which date from the 11th to 13th centuries.

Sandwick middle phase area 2 contained similar densities of fish bone to St. Boniface phases 8 and 9, but unfortunately weight data were not available. However, the middle phase area 2 at Sandwick consisted almost entirely of small saithe, which by analogy with St. Boniface phase 9, would have had a relatively low density by weight. These two assemblages are probably similar. These densities appear quite low compared to other sites, suggesting a less intensive depositional process. Similar conclusions can be drawn for the few phase groups at Birsay with density data. Phases Y and R from Beachview Studio site date from the late 10th century to late 13th, and phase Q is approximately medieval in date. The material from area E at Robert's Haven post-dates most other deposits considered and represents quite a low density of material compared to all others, but is similar to phase 7 from Quoygrew. This phase group likely post-dates many others as well, suggesting broad similarities between these deposits. Area B at Robert's Haven represents a broad range of dates within the Viking Age and medieval periods, and both phase groups contain densities similar to area E at Robert's Haven – suggesting similar dates and/or similar depositional processes.

Density data from Freswick were provided as weights per kilo of sediment, approximately equal to weights per litre as noted above. However, these weights only included a subset of fish bone, possibly correlating to the subset of elements identified by Jones (Jones 1995, 155-56, Table 11, 12; Jones *et al.* 1995, 153). Later reanalysis of sample residues suggested the original fish weights were underestimated (Barrett 1995, 103, Figure 5.19). The densities found at Freswick are different from most other sites, particularly in the higher concentrations of mammal bone compared to fish, but this can be attributed to sampling biases because the original mammal weights remained unchanged following reanalysis (Barrett 1995, 103). Most of the midden material from Freswick was identified as 'deflated', including areas 4, 5 and 6, and all of the SCA areas. The CCA deposits were not deflated midden, but they were associated with industrial deposits, implying a difference in deposit type. Together, these explanations account for the very low densities of the Freswick middens compared to all others (Morris *et al.* 1995, 58).

	Densities by count (TNB/L)				Densities by weight (g/L)				
	Mam.	Fish	Bird	All	Mam.	Fish	Bird	All	Source and notes
Sandwick									Bigelow 1984, Tables 8, 12, 13, Page 121 Data from >1.5 to >3mm sieving and hand collection. Mammal and bird were fully quantified but fish only includes 6 cranial elements and vertebrae; other fish were not counted.
Early area 3	0.18	0.30	0.01	0.49					
Early area 4	0.16	0.33	0.01	0.50					
Middle area 2	0.09	23.07	0.00	23.16					
Middle area 3	0.21	0.56	0.01	0.78					
Middle area 4	0.30	0.44	0.02	0.77					
Late area 3	0.35	0.82	0.01	1.18					
Late area 4	2.70	8.23	0.15	11.07					
Sandwick North									Barrett and Oltmann 2000, Table 1 Data from >4mm sieving only.
Phase 2	3.50	6.95	0.09	10.54	1.35	1.13	0.04	2.52	
Phase 3	0.54	8.73	0.00	9.27	0.09	1.09	0.00	1.18	
Quoygrew									Data from >4mm sieving only. Weights are from the sample record. Not all fish have been examined.
Phase i	1.16		0.01		1.05	0.15	0.00	1.20	
Phase ii	5.02		0.02		2.29	1.02	0.02	3.33	
Phase iii	2.68		0.11		1.49	8.66	0.04	10.19	
Phase 1.2	1.54		0.18		0.61	4.26	0.04	4.91	
Phase 2	1.41		0.07		1.17	6.58	0.15	7.91	
Phase 7	1.50		0.05		0.26	0.12	0.04	0.42	
Phase i	1.16	1.31	0.01	2.49	1.04	0.15	0.00	1.20	Data from >2mm subset of fully identified samples; it is only this subset that has had all 2-4mm bone analysed as well as all >4mm.
Phase ii	5.08	8.13	0.02	13.23	2.24	1.03	0.01	3.28	
Phase iii	3.05	55.13	0.10	58.28	1.83	10.70	0.01	12.55	
Phase 1.2	4.15	45.44	0.48	50.07	0.89	6.37	0.05	7.30	
Phase 2	3.06	50.50	0.16	53.72	1.40	8.29	0.04	9.73	
Phase 7	0.83	5.00	0.00	5.83	0.28	0.24	0.00	0.52	
St. Boniface									Lowe 1998, Table 15, Table 16 Data from >1mm sieving. TNB for mammals not provided; this uses NISP. Bird bone TNB for all phases is 60; therefore negligible for these 3 phases.
Phase 7	c.0.03	3.54	c.0	3.56	2.5	0.5	c.0	3.00	
Phase 8	c.0.04	30.54	c.0	30.58	3.3	8.3	c.0	11.60	
Phase 9	c.0	33.04	c.0	33.04	4.4	2.9	c.0	7.30	
Beachview Studio									Rackham 1996, 147-48 Data from >2mm sieving. These sample volumes have been estimated.
Area 1, Y	0.25	15.37	0.01	15.54					
Area 1, S	0.51	7.46	0.01	7.95					
Area 1, R	0.34	22.86	0.02	23.21					
Area 1, Q	0.23	13.83	0.02	14.07					
Area 1, P	0.03	0.48	0.01	0.52					
Area 1, L	0.04	8.67	0.01	8.71					
Robert's Haven									Barrett 1995, Table 5.13, Appendix 7.1, Parks pers. comm., Mainland nd. Fish sieved to >4mm, but fish dentaries, premaxillae, otoliths and vertebrae sieved to >2mm. Mammal weights are based on sample record.
Phase 1, A	0.92	56.71	0.32	57.95	0.31	13.02	0.06	13.38	
Phase 1, B	1.08	10.73	0.34	12.15	0.51	0.74	0.10	1.36	
Area E	1.61	8.26	0.29	10.15	0.52	0.32	0.04	0.88	
Phase 2, B	0.72	3.46	0.15	4.33	0.26	0.21	0.01	0.48	

Freswick	Mammal and bird g/kg	Fish g/kg	Rackham 1995, Table 11 Approximate sample densities were provided in g/kg of sediment for all context types. Based on comparisons with Quoygrew, 1 L of sediment weighs about 1kg, +/- 10%.
Area 1 (Inland)	0.54	0	
Area 3 (Inland)	0.38	0.01	
Area 3 east (Inland)	0.27	0.49	
Area 4 (NCA)	0.62	2.44	
Area 5 (NCA)	0.1	2.11	
Area 6 (NCA)	0.12	0.48	
Area 7 (CC)	0.38	0.68	
Area 8 (CC)	0.46	0.59	
Area 9 (Inland)	0.07	0.08	
Area 10 (NCA)	0.04	0.04	
Area 11 (SCA)	0.09	0.24	
Area 12 (SCA)	0.26	0.01	
Area 13 (SCA)	0.19	0.01	
Area 14 (SCA)	0.16	0.02	

Table 8.1: Fish, mammal and bird deposit densities by count and weight

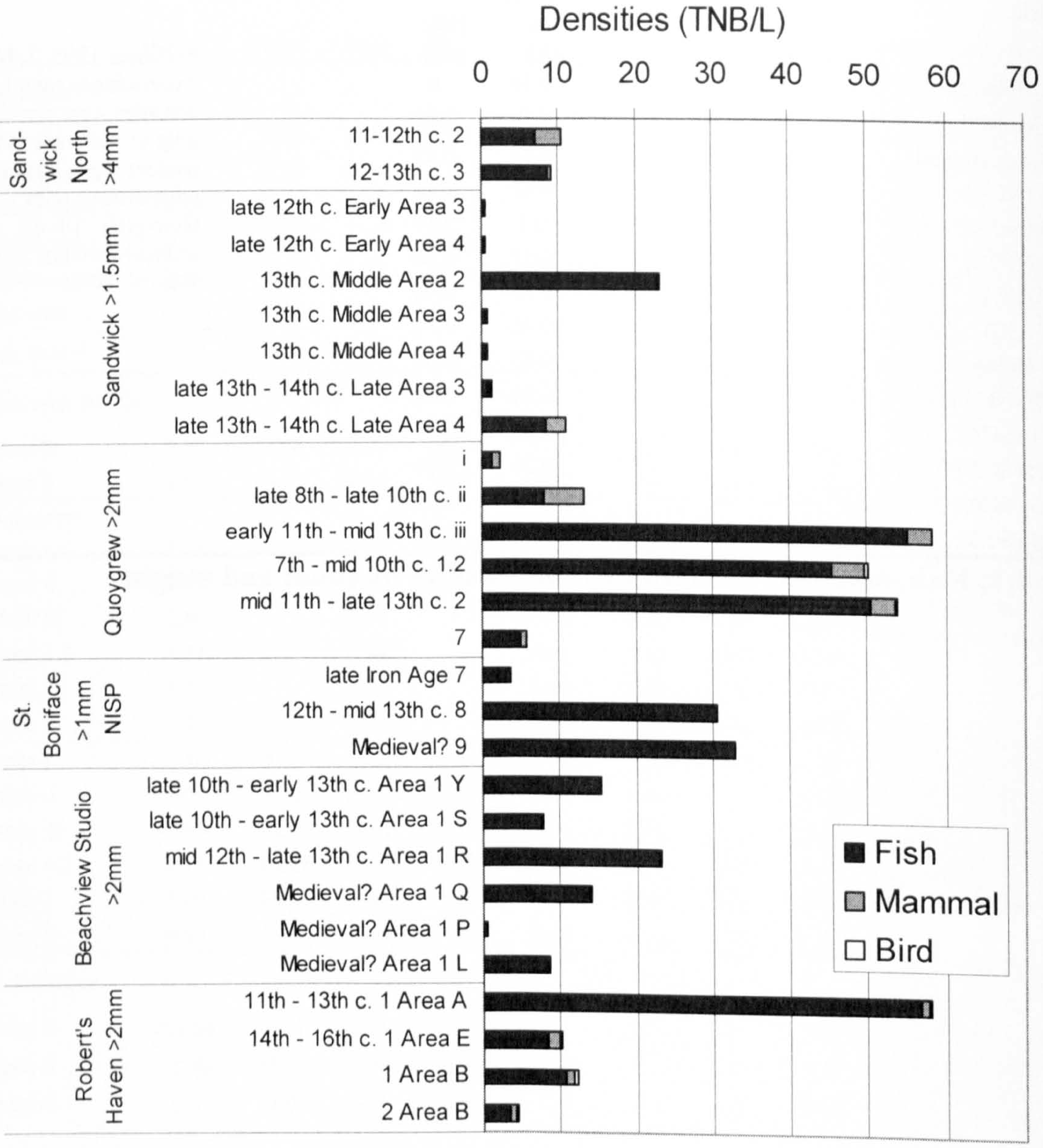


Figure 8.7: Densities of mammal, fish and bird in counts per litre of sediment

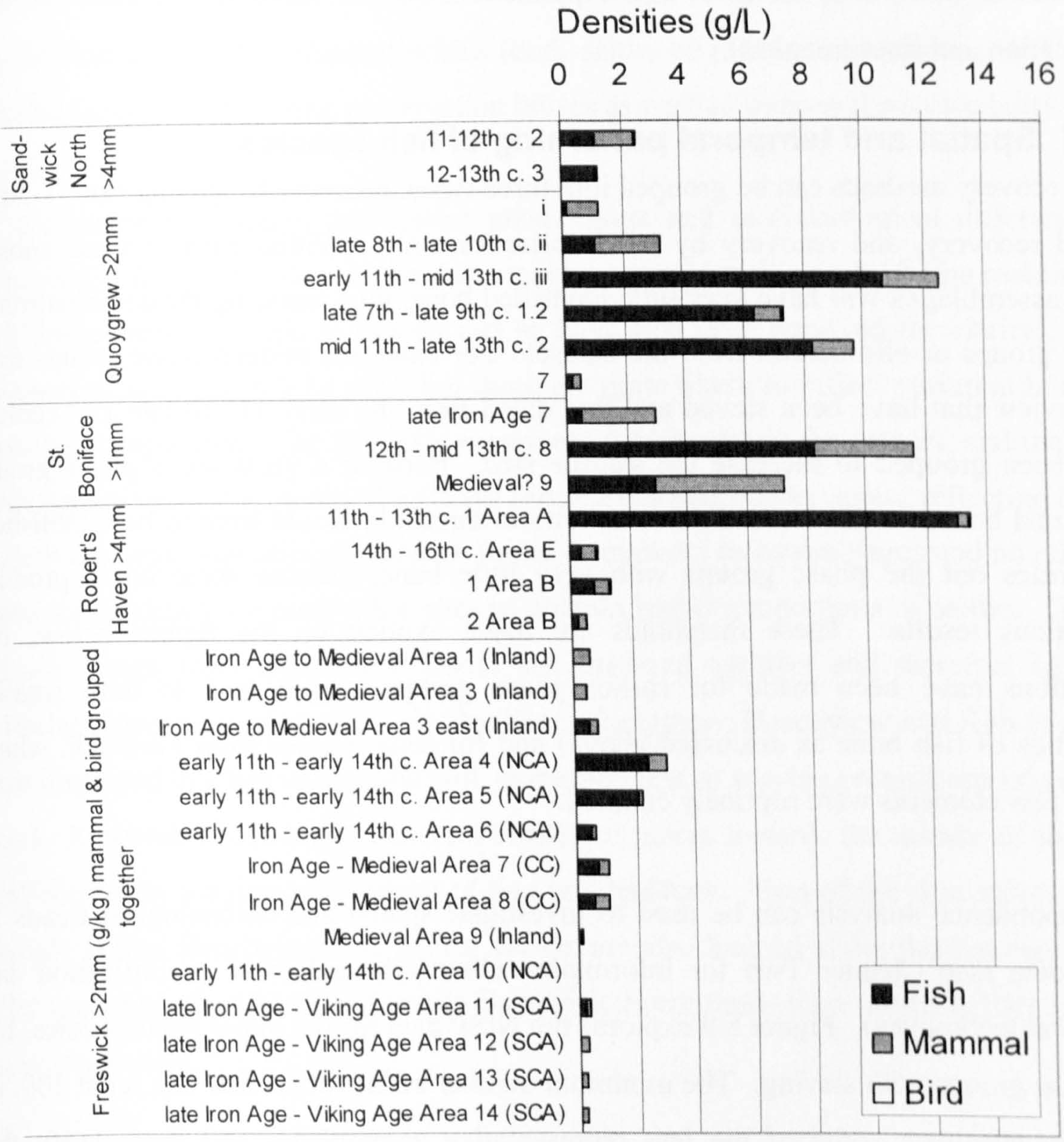


Figure 8.8: Densities of mammal, fish and bird in weights per litre of sediment

8.3 The fish

The comparative sites from the Northern Isles area are assessed below, in order to observe and define spatial and temporal patterning in the fishbone evidence. Both intra-site and inter-site variation are considered. The comparative sites were first introduced in Chapter One and Appendix One, and combined they comprise over 500,000 fish bones. From these, a dataset of about 144,000 identified bones has been compiled. The majority of these were from sieved sites, thus producing a large and comparable set of phase groups from which patterning may be interpreted. NISP evidence is explored below, using correspondence analysis (CA), and fish total length estimates ('sizes') are explored using histograms and summary figures. Evidence for butchery patterning and element distributions are discussed qualitatively. Statistical tests have been applied where appropriate (see Chapter Two and Appendix Two for more information on their application and interpretation).

8.3.1 Spatial and temporal patterning of fish species

Fish recovery methods can be grouped into three types: recovery by sieving from 1-5mm, mixed recovery, and recovery by hand collection only. Within each of these subsets some assemblages will have very little identified bone, thus requiring the combination of phase groups or elimination from the dataset. For example, midden phase groups from Beachview that have been sieved and that dated from the early 11th to late 13th century have been grouped to increase the sample size. Because a great many phase groups contained bone, it was decided that a minimum threshold would have to be established. This rules out the phase groups with very little bone, because these could produce anomalous results. These thresholds are made explicit on the figures below, but exceptions have been made for earlier phase groups (which tend to have smaller quantities of fish bone as discussed above) and for some phases from Freswick, where only a few elements were routinely counted.

Correspondence analysis can be used to investigate spatial and chronological trends in NISP data (see Chapter Two for information about this and other quantification and statistical techniques). Figure 8.9 explores the NISP data for the major gadid species, for all phase groups with sieving. The minimum number of identified fish was set at 300, in order to eliminate some of the less representative assemblages and thus clarify the patterning. Some of the phase groups from Freswick had fewer than this, but were included as noted above. With the exception of a few phase groups from Earl's Bu, all of these were classed as midden during excavation, therefore ruling out one potential source of variation. Almost all of the variation in the dataset is displayed in these plots because the first axis is responsible for 0.44 inertia, and the second axis 0.35 inertia. This pattern displays a grouping based primarily on separation by site, as displayed in the row plot: Earl's Bu forms a discrete cluster, as do Quoygrew, Beachview Studio and, to a lesser degree, St. Boniface. Only the deposits from Robert's Haven and Freswick are scattered. Patterns like these could result from identification methods or inter-analyst variability, but this is unlikely to be the only source of variability given that Quoygrew and Earl's Bu were recorded using essentially the same analysts and methods, as were Beachview

Studio and Beachview, yet these are found in distinct areas of the plot. Instead, this pattern was probably influenced by the relative usage of 'gadid' (which contributed 0.44 to the first axis) and *Gadus/pollachius* (cod, saithe or pollack, contributing 0.32 to the second axis), thus reflecting preservation biases as well as inter-analyst variability.

If the taxonomic groups that reflect preservation and methodological differences are removed, a different pattern in the data emerges, as seen in Figure 8.10 (the rocklings and whiting contributed little to this dataset so have also been removed for clarity). There, clusters of sites can still be seen, but these are more likely to reflect variation in original species composition. The first axis represents 0.46 inertia in the dataset, and the second axis represents 0.098 inertia. Earl's Bu forms a discrete cluster again, reflecting both the relatively large quantities of haddock found throughout its assemblages and no other, and also the tendency for most other sites to contain higher proportions of saithe. The three phase groups from Beachview Studio are clustered together and therefore have very similar proportions of species. St. Boniface, Quoygrew, Beachview and Robert's Haven are displayed in a line on the row plot, corresponding to varying proportions of saithe and cod. Freswick forms a less coherent cluster of points towards the middle of the graph, influenced by varying proportions of ling and haddock. Two of the sites represented by single points, Beachview and Saevar Howe, are also located along the line representing the spectrum of saithe to cod, while Sandwick North tends more towards Earl's Bu than any other point.

The row plot is reproduced in Figure 8.11 and coded by both site and phase group, thus allowing for intra-site variation to be examined. The variation within Earl's Bu is primarily chronological, with the earlier phase groups tending more towards cod and therefore more closely resembling the other sites in the Northern Isles. The later phase groups at Earl's Bu, with their intense deposition of haddock, are much more distinctive. The three points for Quoygrew are directly influenced by proportions of cod and saithe, with phase iii containing higher quantities of cod and phase ii higher quantities of saithe. The three St. Boniface phase groups are similarly influenced by varying proportions of saithe and pollack (highest in phase 9) compared to cod (highest in phase 8); this variation proved statistically significant between each pair of phase groups (Table 8.13). Robert's Haven area E had similarly high levels of saithe to St. Boniface phase 9, while Robert's Haven phase 1 area A contained rather higher proportions of cod – thus explaining the substantial and statistically different intra-site variation at Robert's Haven (Table 8.19). The five points representing Freswick are spaced more widely than those of any other site, probably reflecting the diversity of deposits there. These differences were statistically significant (Table 8.20). The high quantities of ling in area 9, and to a lesser degree area 4 'early' (early 11th – late 14th century), account for the more central and 'average' position of these two points, while area 3 is almost entirely comprised of cod. The SCA deposits and area 4 'late' (12th – early 14th century) contain comparable quantities of cod and saithe to other sites. The four Beachview and Studio phase groups form a discrete cluster associated with relatively high proportions of saithe, while the geographically close assemblage from Saevar Howe is found at the opposite extreme of the saithe to cod line of points, representing an assemblage consisting almost entirely of cod. Recovery at Saevar Howe used a 5mm sieve size, slightly larger than was used on all other sieved sites (Colley 1983a, 112). This could explain the bias away from the saithe at this site – if one assumes that the saithe were smaller than cod (see fish sizes, section 8.3.2). However, substantial quantities of small saithe were recovered in the earlier phase groups at Saevar Howe with this recovery method (these produced small quantities of fish bones and are therefore not included here); this pattern could therefore reflect both taphonomic biases and an increased preference for cod. Temporal patterning could explain this variation, because phase IIb from Saevar Howe dates to the 8th to 10th century, while the four Beachview and Studio phases date from the medieval period. This variation between the spatially and chronologically similar deposits in the Birsay Bay area will be examined in greater detail below, when examining fish sizes (section 8.3.2) and when considering patterning within the mammal dataset (section 8.4).

The three points from Beachview Studio appeared closely related on the CA plots, but there was some significant variation present at the intra-site level, as summarised in Table 8.16. This likely resulted from spatial variation in the proportions of cod and saithe, given that these three phase groups are chronologically similar and that significant variation was not associated with different recovery methods or deposit types. Unfortunately only one phase group from Saevar Howe could be included in the CA plots, but the results of intra-site statistical testing are shown in Table 8.18. These indicate that phase I (Iron Age) is not statistically different from phase IIa, despite its 7th to 9th century date. The later phases IIb (shown in the CA plots), IIb/c and IIc are statistically different from the earlier phase groups, indicating a shift towards cod and away from saithe (and ling) over time, in this case, around the 9th century. This may be linked to the increasing intensification of deep sea fishing that occurred at the late Iron Age to Viking Age transitional period, focussing more on the larger cod and less on the inshore small saithe.

The same row plot as described above can then be recoded to demonstrate chronological patterning, as shown in Figure 8.12. Intra-site patterning was discussed above using the previous row plots, but this new figure has the potential to indicate inter-site chronological similarities. In particular, a cluster of earlier phase groups dating to the late Iron Age and early Viking Age is notable (circled in Figure 8.12); these comprise St. Boniface 7, Quoygrew ii and Freswick SCA, and are located in the middle of the cod to saithe spectrum. A further point representing the 8th to 10th century phase IIb at Saevar Howe is located at some distance, representing an assemblage comprised almost entirely of cod. Sites of medieval date were located on either side of the cluster of earlier phase groups, indicating some contained very high proportions of saithe, including Beachview and Beachview Studio and area E from Robert's Haven. Other phase groups from the medieval period indicated a tendency towards cod, including those from Quoygrew, several from Freswick, Robert's Haven phase 1 area A and St. Boniface phase 8. This latter cluster contains all of the distinctive fish middens, characterised by the dense deposition of bone as discussed in section 8.2.2, and these accord with the general pattern of increasing proportions of cod after c. 1000, compared to an earlier reliance on smaller saithe (Barrett *et al.* 2001, Tab. 2). The former cluster does not fit this established pattern, nor does the outlying phase IIb from Saevar Howe. The group of medieval deposits with high quantities of saithe include the very late area E at Robert's Haven, the late medieval phase 9 at St. Boniface, and a number of phases from the Birsay Bay area loosely dated to the medieval period; these may collectively post date the period of intense deep sea fishing, or factors of site status may have influenced these taxa. As mentioned above, the 8th to 10th century phase IIb at Saevar Howe is comprised almost entirely of cod. The late Iron Age phase groups at this site contain high quantities of saithe, and these conform to the established chronological pattern, suggesting that phase IIb is either incorrectly dated, or is an unusual outlier.

A greater range of taxa was also explored using correspondence analysis, by combining them into 11 categories by family or order. This procedure permitted variation in the less frequently occurring species and families to be analysed. Belonidae were excluded because although a few hundred of them were recovered, they were almost entirely found at Quoygrew and therefore caused an outlier which masked other patterning. Phase group C2 from Earl's Bu was also excluded because of the large quantities of ray teeth found. The resulting CA plots are illustrated in Figure 8.13, with phase groups coded by site. These plots accounted for very little of the variation in the dataset (0.040 inertia on axis one, 0.012 on axis two), because the differences within the Gadiformes (gadids and hake) constitute most of the variability in these datasets. Phase groups were loosely clustered by site for Earl's Bu and St. Boniface, while several of the points representing phase groups from Freswick were outliers corresponding to Pleuronectiformes (flatfish) and Triglidae (gurnards). When the row plot was recoded for phase groups (Figure 8.14) and dates (Figure 8.15), very little patterning was found. The three outliers from Freswick, from SCA and area 4, only had a limited number of gadid elements identified, thus inadvertently over-estimating the proportions of non-gadid species, for which all elements were identified. Leaving aside Freswick, the slight tendency towards clustering by site rather than by time period suggests that the occurrence of these minor species probably is dependent on a combination of inter-analyst variability and the locations used for fishing. The latter possibility is confirmed by the slight tendency for eels and salmonids to correspond with Earl's Bu and the Beachview middens, reflecting access to fresh water and/or a preference for fresh water species. The stream associated with the mill race at Earl's Bu and the eponymous burn at Beachview "Burnside" indicate both sites had easy access to fresh water streams. There has been some suggestion eels were rarely eaten in the early modern period in Orkney, but their skins were useful and valuable products (Low 1813, 14, 186; Fenton 1978, 586).

The four sites which had mixed recovery methods and at least 200 identified specimens were also analysed using CA. Figure 8.16 shows the results for most phase groups at Sandwick, Tuquoy, Pool and Brough Road, using all gadid species. At Sandwick, all saithe and tentative pollack identification were grouped together by the analyst as *Pollachius sp.*, despite only a very small quantity of positively identified pollack elements (Bigelow 1984, 121). In order to compare with other sites, these have been assumed to be saithe. These plots only show six of the phase groups at Tuquoy, all of which were classed as solely midden. There was little point in including the others because they were of mixed or non-midden context type and none have yet been securely dated. All but one of the phase groups represented in the plot are now classed as midden (the exception being Brough Road area 2 phase A, which was classed as 'sand' but which obviously contained a quantity of bone). The variation within this dataset is still considerable (axis one inertia is 0.28, axis two 0.16). Pool and Sandwick form discrete groups, but the Tuquoy and Brough Road deposits show considerable overlap. Because axis two is highly influenced by the 'cod/saithe/pollack' category (contributing 0.70), this figure mostly shows methodological, preservation and inter-analyst patterning. The latter probably accounts for the similarity between the Tuquoy and Brough Road material, given that Colley identified the fish from both sites.

Figure 8.17 illustrates CA plots for the above dataset, but only for the main gadid species: cod, haddock, saithe, ling and pollack, thus eliminating some of the variation that resulted from methodological and taphonomic patterning (axis one inertia 0.27, axis two 0.065). The three Sandwick phase groups still form a discrete cluster of points associated with saithe, but the Pool, Tuquoy and Brough Road points are intermixed. The same row plot has been recoded to display phase group data in Figure 8.18. Sandwick Middle phase area 2 corresponds more to the saithe point than any other phase group, reflecting the fact that this phase is comprised almost entirely of saithe, with small quantities of ling and cod. Sandwick Late phase area 4 has correspondingly less saithe than the Late phase area 3, but compared to Tuquoy, Pool and the Brough Road, all of the Sandwick North phase groups correspond much more towards saithe and away from cod and haddock. Tuquoy midden phase XIVa is an outlier that tends towards both saithe and haddock and away from cod. This phase group is very different from the others, and although it is of later medieval date, the contemporary phase XIIIa has a very different composition. Significant variation was present within the entire dataset from Tuquoy (Chi-Sq 2799.574, 15 degrees of freedom, p=0.000 but one cell with expected count <5.0), and between most phase groups, as summarised in Table 8.14. In the current absence of any further information about these phase groups, however, interpretation is difficult. Phase 8.2.2 from Pool has high quantities of ling compared to other phase groups, which explains its position on the edge of the cluster of points in the centre of the graph, while phase 8.1 is an outlier with relatively high quantities of cod, haddock and pollack, and very little saithe and ling (see also Table 8.15). Figure 8.19 displays the same data but recoded to reflect dating rather than phasing, but no chronological patterning was observed. Instead, the variation mostly reflects intra-site patterning and spatial variation.

The variation found within the three phase groups and three areas at Sandwick can be further examined for intra-site spatial and temporal patterning using Chi-Square tests. These were applied to the more commonly occurring species, and as indicated by the results in Table 8.12, not only is there significant variation within the entire dataset, but there is also significant variation when the abnormal fish-rich area 2 is ignored. There was also more variation through time than there was through space, because there was no significant variation between areas in each of the early and late phase groups. However, within the middle phase, there was a considerable variation, probably caused by the presence of the fish-rich, densely deposited area 2 that was located at some distance away from the house. As noted above, this unusual deposit was composed of large quantities of saithe.

Although the Brough Road deposits appeared to be relatively closely associated on the CA plots, statistical tests indicate there was some significant variation within the dataset. Recovery biases caused some of the variation, because although recovery for all phase groups was mixed, some phase groups were sieved to 1mm. These tended to contain high quantities of smaller fish, mostly saithe, thus implying they were underrepresented in the deposits that were only sieved to 1cm (Colley 1989, 248). However, as will be shown below, despite the 1mm sieving the Brough Road sites mostly lacked saithe of <400mm, in contrast to most other sites from the Northern Isles but similar to Earl's Bu. Statistically significant results are summarised in Table 8.17, showing both spatial and temporal variation, as well as recovery biases. Area 2, phases C1 and C2 both had similar recovery methods and both dated to approximately the same centuries (C1 dated from the 9th to the 13th centuries, C2 from the 9th to 11th centuries), yet phase C1 contained significantly more cod. In sum, spatial patterning accounted for the majority of the intra-site variation at the Brough Road sites.

Using the four sites with mixed recovery, patterning at the order and family level can be investigated, although not to the detail of the sieved assemblages. No herring family (Clupeidae) or sand eel family (Ammodytidae) fish were recovered so the dataset is restricted to nine orders and families. Very little inertia was accounted for by the resulting CA plots, shown in Figure 8.20 (axis one 0.052, axis two 0.009), but one phase group from Tuquoy was an outlier associated with the Pholidae family (butterfish). As shown in Figure 8.21, this was midden phase XIVa, which dated to the medieval period and which has already been discussed as an outlier when considering patterning within the gadid family, because it contained less cod than all other phase groups, and correspondingly more saithe and haddock. No other phase group has such a high concentration of these tiny fish that are often gut contents of larger fish; they may represent a discrete and unusual deposit that was sampled in its entirety, or preservation and recovery may have been better in this phase group than in others. Four of the five Brough Road phase groups are also outliers, and tend towards the Labridae (wrasse) family. These phase groups may represent deliberate, small-scale fisheries for these species, but wrasse can also be caught when fishing for small, inshore saithe (Barrett *et al.* 1999, 367). Area 1, phase D is unusual in that it does not contain these higher than usual quantities of labrids; given that this phase group is contemporary with others, this probably reflects intra-site variation within this very secondary fishery.

Having examined patterning within both the sieved and mixed recovery datasets, all that remains is to apply a similar procedure to the hand collected material. Figure 8.22 displays the CA plots for the phase groups from seven sites with at least 100 identified bones, using NISP data for gadid species. Although most of these were midden, a few of the phase groups from Beachview Studio included rubble, ashy deposits and sandy layers, and the one phase group from the Brough of Birsay Room 5 contained bone from floor layers. These represent less of the variation within the dataset than similar CA plots for the sieved and mixed material (axis one inertia 0.33, axis two 0.14). The phase groups from Earl's Bu form a discrete cluster corresponding to the greater quantities of haddock found there, but aside from Sandwick North, the phase groups from other sites are mostly intermixed. As illustrated by Figure 8.23, no chronological or spatial patterning was observed within the Earl's Bu cluster. Skaill's 'Norse' phase represents an outlier, corresponding to saithe/pollack and pollack, both of which were found in large quantities there. Variation in recording methods and preservation differences probably account for much of the patterning found here, particularly on axis one where 'gadid' contributes 0.45 to the inertia. Assemblages that are poorly preserved are more likely to use this category of identification than a species-specific attribution, but limited access to reference material or inexperience could also be linked to a greater use of the 'gadid' category.

Figure 8.24 illustrates the CA plots for all hand collected phase groups, but only using the main gadids identified to species, thus eliminating the variation caused by differential usage of the 'gadid' category. These plots describe a moderate amount of the variation in the dataset, certainly comparable to that found for sieved and mixed recovery (axis one inertia is 0.22, axis two 0.17). Most of the patterning can be explained primarily by varying proportions of haddock and cod, and secondly by varying proportions of cod and saithe. The Earl's Bu phase groups form a discrete cluster again, corresponding to their higher quantities of haddock, while most sites are found along a line corresponding to cod and saithe. Some deposits were influenced by higher than usual proportions of ling, including the three phase groups from Pool, while one of the Beachview Studio phase groups and one of the Sandwick North phase groups tended much more towards saithe and pollack than most others. These were investigated in greater detail in Figure 8.25, by recoding the row plot by phase group. Area 1, phase U from Beachview Studio is an outlier that appears to contain much higher quantities of saithe than any of the other Beachview sites, but upon closer examination of the data, no 'cod' identifications were made in this phase group but poor preservation led to 60% of the gadids being labelled as *Gadus/pollachius*. This outlier therefore reflects poor preservation rather than real patterning. The remainder of the phase groups from the Birsay Bay area show little variation. A chronological trend can be observed within Sandwick North, with saithe increasing significantly through time from phase 2 to phase 4. The phase 3 middens at Earl's Bu contain more haddock than the non-midden phase groups, thus illustrating a spatial trend, while the early phase 7.1 from Pool contains lower proportions of cod and higher proportions of ling than the two later phase groups. As shown in Figure 8.26, aside from the few intra-site chronological patterns mentioned above, there is very little inter-site chronological patterning present in the hand collected material. This result may be due in part to the bias against small saithe which created some of the chronological patterning discussed above.

Finally, variation within most of the orders and families found in the hand collected dataset is examined in Figure 8.27. Only eight groups could be included because few of the smaller fish, like the herring family (Clupeidae), were found in the hand collected material. As can be seen from the row plot, most phase group points cluster around the origin reflecting the near absence of non-gadid species in the hand collected material, a fact also apparent in the low inertia of both axes (axis one inertia is 0.044, axis two is 0.015). Four phase groups were outliers, but interpretation of these is difficult. Identifications of the rarer species could be interpreted as real patterning, access to a comprehensive reference collection, or equally, good recovery and thorough hand collection. Phase 7.1 from Pool has higher proportions of eels (Anguilliformes) and flatfish (Pleuronectiformes) than most other phase groups, including those from Pool. Because the later phase groups have the same recovery and recording methods, this pattern is likely real and probably indicates that these two orders were deliberately fished in this Viking Age to Iron Age transitional phase group. The 'Norse' phase from Skaill contained higher quantities of gurnards (Triglidae) than most other sites, which accounts for its outlying status, but these are difficult to interpret given the problems surrounding the recovery, analysis and phasing of this site. Finally, two phase groups from Beachview Studio are slightly different from others. Area 1D/E phase S has slightly elevated levels of Salmonidae and very few other non-gadids, while area 1 phase U has slightly higher levels of wrasse (Labridae) and sea scorpion family (Cottidae) fish. Both the Salmonidae and the Labridae could represent important minor fisheries, but could equally represent differential preservation and recovery.

CA proved to be a useful method of exploring patterning at species, family and order levels within the data, once divided by recovery method to eliminate one potential source of patterning. The results from the three different recovery methods can be compared to examine overall trends within the Northern Isles fish assemblages, and actual count and percentage data can be incorporated to further illustrate the patterning observed using CA. (Appendix Table 5.1 and 5.2 summarise the fish species for each site and phase group, using percentage NISP data for gadid species.)

Almost all of the phase groups investigated were classed as midden during excavation, which eliminates another source of potential patterning, and the few non-midden phase groups have been explicitly discussed above. The hand collected assemblage from area 1, phase U from Beachview Studio was different from most other hand collected phase groups, both in preservation (worse than most others) and in the type of non-gadid species present. This phase group was also unlike all others in that it consisted of ash and clay that accumulated against the exterior of a structure. Area 1D/E phase S was another phase group from Beachview Studio with slightly different non-gadid species; this was classed as ash and sand layers during excavation. The intra-site patterning within the hand collected material at Beachview Studio can probably be explained by context-level variation, made difficult to interpret because of the small sample sizes. The three large, sieved midden deposits from Beachview Studio were very similar both to each other and to other sites.

Some variation was visible within the assemblages from the Birsay Bay area. Leaving aside the context-level variation discussed above, the sieved material from Saevar Howe phases IIb, IIb/c and IIc contrasted with that from Beachview and Beachview Studio. The former was comprised largely of cod, and dated to the 8th to 10th centuries, spanning the transitional period, while the latter assemblages contained similarly high proportions of saithe and all were approximately dated to the medieval period. Fish from Saevar Howe were recovered using a 5mm sieve, but because substantial quantities of small saithe were recovered from the Iron Age phase I deposits, there does not appear to be a recovery bias against smaller fish here. This was a chronological pattern, indicating small saithe were dominant in the late Iron Age, then cod became predominant in the very late Iron Age and Viking Age periods, before saithe again became common in the medieval period. This pattern is not restricted to the Birsay Bay area, as will be discussed further below.

The most distinctive pattern apparent in the sieved and hand collected material was the difference between Earl's Bu and all other sites. As discussed in Chapter Four, Earl's Bu contained large quantities of haddock (18% of identified gadids in the early midden phase groups and from 26 to 34% in the later midden phase groups) and very little saithe (7% in the early midden phase group and from 2 to 9% in the latter midden phase groups). Most other sites contained much higher proportions of saithe, and very little haddock. Sandwick North phase 2 (sieved) was an exception, as it contained 13% haddock and 7% saithe. A similar pattern was found at Pool phase 8.1 (mixed), where haddock represented 10% and saithe 7%. However, the correlation between high proportions of haddock and low proportions of saithe did not apply to the final medieval midden phase XIVa at Tuquoy (6% of the identified gadids were haddock but 83% were saithe) or at the medieval midden in area 9 at Freswick (where 14% were haddock but

29% were saithe). As discussed at length in Chapter Four, some haddock elements are very robust and are easily identified, even if badly preserved. Their absence from most sites cannot therefore be attributed to taphonomic biases, but their unusually high presence at a few sites could be ascribed to taphonomic patterning that over-emphasised their significance. If that were true, higher than usual proportions of gadids would be attributed to "cod/saithe/pollack", but this is clearly not the case for Sandwick North phase 2, Tuquoy phase XIVa, or Freswick area 9, where a negligible number of identifications were made in this category. At Pool phase 8.1, this category contained an average number of identifications, suggesting the high proportion of haddock here too could not be attributed to taphonomic biases. At Earl's Bu, the prevalence of haddock and absence of small saithe likely reflects the high status of this site. By analogy, other phase groups with similar patterning could also be high status, as will be discussed in Chapter Nine.

Aside from Earl's Bu, most of the variation in species composition consisted of varying proportions of cod and saithe. This can be clearly seen in all CA plots, where most phase groups corresponded to a line between the saithe and cod data points. Despite finding some intra-site chronological patterning, there was no overall trend towards one or other of these species. Saithe increased through time at Sandwick North, Sandwick, St. Boniface (but only between the later two phase groups, from 1100-1250 to the ?medieval period), Tuquoy (between the broadly dated Viking Age-medieval phases and the medieval phases), Brough Road (between the earlier phases dating to the 7-9th and 7-11th centuries, and the later phases dating to the 9-11th and 9-13th centuries), Robert's Haven (between the 11-13th centuries and the 14-16th centuries) and Freswick (between the earlier phase dating to the 11th to late 14th centuries, and the late phase dating to the 12th-early 14th centuries). Cod increased through time at St. Boniface (only between the earlier two phases, from the Iron Age to 1100-1250), Saevar Howe (between the Iron Age and c. 9th century phases) and within the farm mound at Quoygrew (between 782-995 and 1004-1262). It therefore appears that there were increases in cod at the late Iron Age to Viking Age transitional period – which is expected given that these phases all fall within the recognised intensification of fishing at the late Iron Age to Viking Age transition. This is characterised by an increase in deep sea species, particularly cod. Subsequently, the Fish Event Horizon of c. 1000 can be recognised by an intensification of deposition in middens of medieval date, including Quoygrew phases iii and 2, Sandwick middle phase area 2, St. Boniface phase 8 and Robert's Haven phase 1 area A. As noted in the previous section, these have the greatest density of bone, predominantly fish, they date from the early 11th century to the 13th and 14th centuries, and they contain large proportions of cod and saithe. The final cluster of phase groups included in this study indicate a later increase in saithe within the medieval period. The dates for this transition are difficult to ascertain with certainty because few phase groups have been precisely dated, but the pattern is likely to be real because it can be observed across so many sites. Some have not been included in this list, but only because there is inadequate chronological separation (e.g. Beachview) or there are insufficient identified bones (e.g. Brough of Birsay, Brough of Deerness).

The CA plots were able to illuminate patterning both within the gadid family, and between the more commonly occurring orders and families. However, they do not allow easy comparison of the actual proportions of gadid to non-gadid fish across all phase groups. Appendix Table 5.1 includes the percentage identified to the gadid family for each phase group, and for most, at least 90% of all identified bones were from the gadid family. Figure 8.28 illustrates the subset of phase groups with at least 300 identifications (if sieved), 200 identifications (if mixed), or 100 identifications (if hand collected). These thresholds were established to rule out the phase groups with small sample sizes that could unduly bias the results. While most phase groups contained at least 90% gadid, there were a few exceptions. Within the sieved material, area 3 phase X from Beachview contained only 84% gadid, while the contemporary phase from area 2 contained well over 90%. No one non-gadid species contributed to this difference, but slightly inflated levels of eels, salmonids, wrasses and butterfish were found in area 3. This appears to indicate a real, spatial distinction between these two early medieval midden areas – the differences cannot be explained by methodology or preservation. Phase C2 at Earl's Bu was exceptional, as mentioned above. The difference between phase groups at Freswick reflects methodological differences: only a few gadid elements were identified for the NCA area, and yet all non-gadids were identified, thus over-emphasising the latter. In area 3, all elements were identified.

Every phase group with mixed recovery methods contained at least 90% gadids. Within the hand collected material, only one phase group contained less than 90% gadid. This was the Iron Age to Viking Age transitional phase 7.1 at Pool, and given that no other hand collected phase group was from this time period, this probably reflects chronological patterning. An overall increase in the proportion of gadids through time was observed at several sites, including Quoygrew, Pool, Beachview Studio, Earl's Bu and Robert's Haven. In contrast, only a few sites showed a decrease in the proportion of gadids through time, including very slight decreases of 1 or 2% at Sandwick North, Sandwick, St. Boniface and Brough Road. Tuquoy was the only site with a substantial decrease of almost 10% in the proportion of gadids, and even that was only pronounced in one of the medieval midden phases, XIVa. This phase group has already been noted as an outlier, both in the identified gadid species and in the concentration of non-gadid species identified. The proportions of haddock and saithe have also been discussed as unusual. Until further information is known about Tuquoy, it is difficult to further interpret this midden phase group, other than to state that it is quite unique and possibly of a different date than most others. Therefore, the overall pattern in the proportions of gadids is an increase through time from the late Iron Age to the later medieval periods.

Overall, the spatial and temporal patterning at the taxonomic level can be summarised as follows:

- Earl's Bu has much more haddock than any other site, and proportions increase through time
- Higher proportions of haddock tend to correlate with much lower than average proportions of saithe
- Most sites and phase groups are largely composed of cod and saithe
- Cod increased while saithe decreased chronologically, between the late Iron Age and the Viking Age, and between the Viking Age and medieval period
- Saithe later increased while cod decreased chronologically, within the medieval period
- An overall chronological increase in the proportion of gadids was identified
- Some non-gadid species may represent deliberate but small fisheries, but others may be incidental by-catch and stomach contents; very little spatial or chronological patterning was observed for these trace taxa
- Within the Birsay Bay area, the late Iron Age –Viking Age phase at Saevar Howe had much higher proportions of cod than other sites, which tended to be of later date; this may be partially the result of recovery biases

- Methodological changes between phases and areas at Freswick account for most of the variation found there
- Tuquoy medieval midden phase XIVa is unusual and does not conform to other patterns

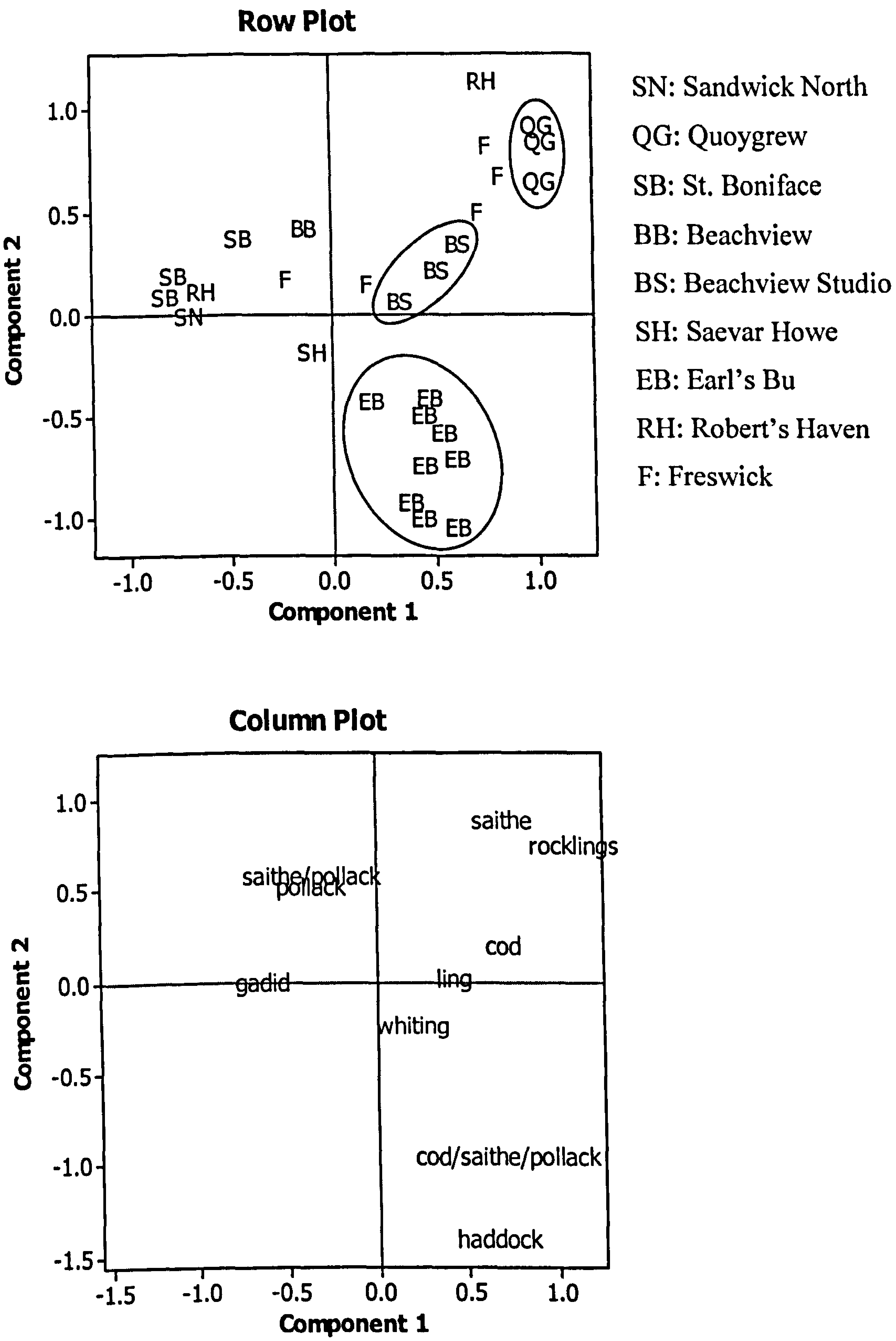
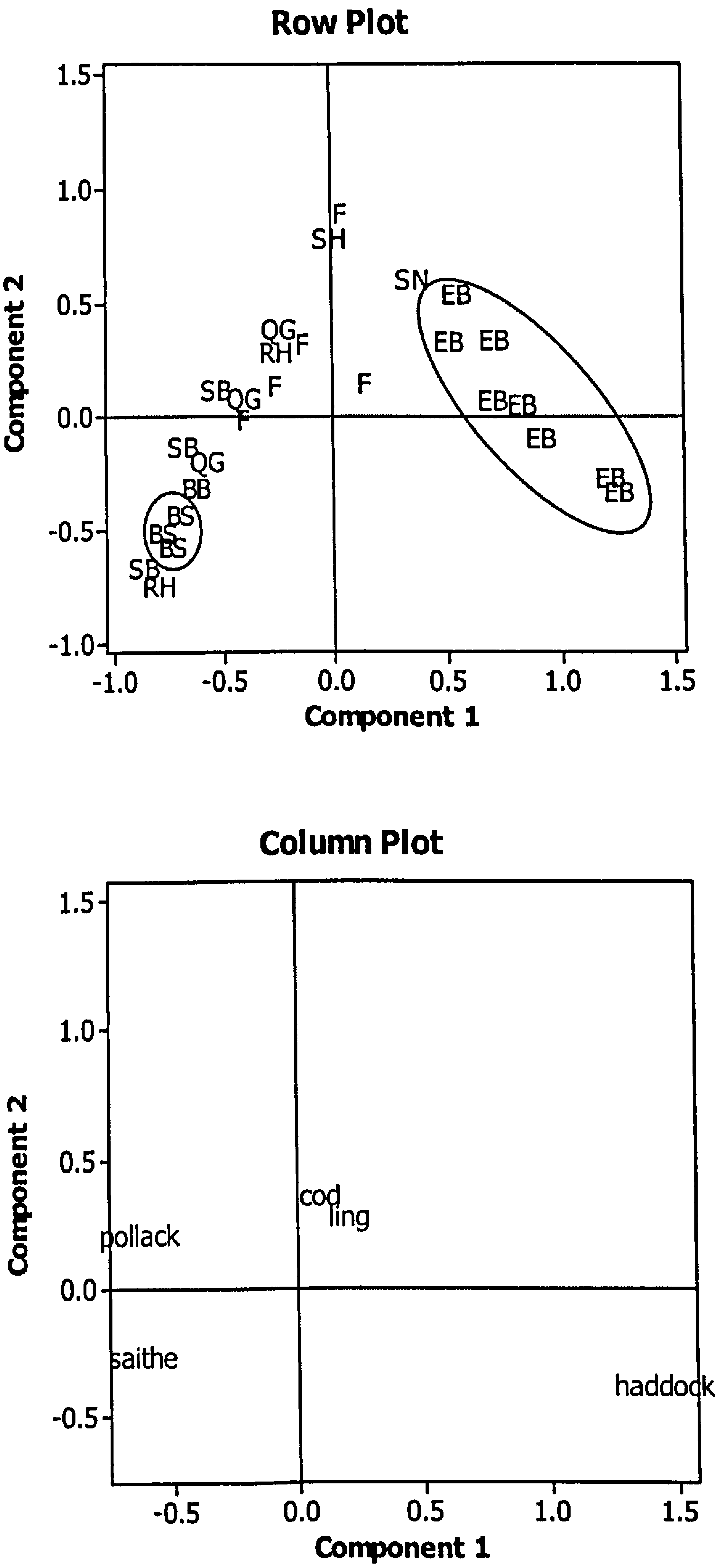


Figure 8.9: CA plots of gadid fish NISP for sites with sieving to 1-5mm and total NISP ≥300

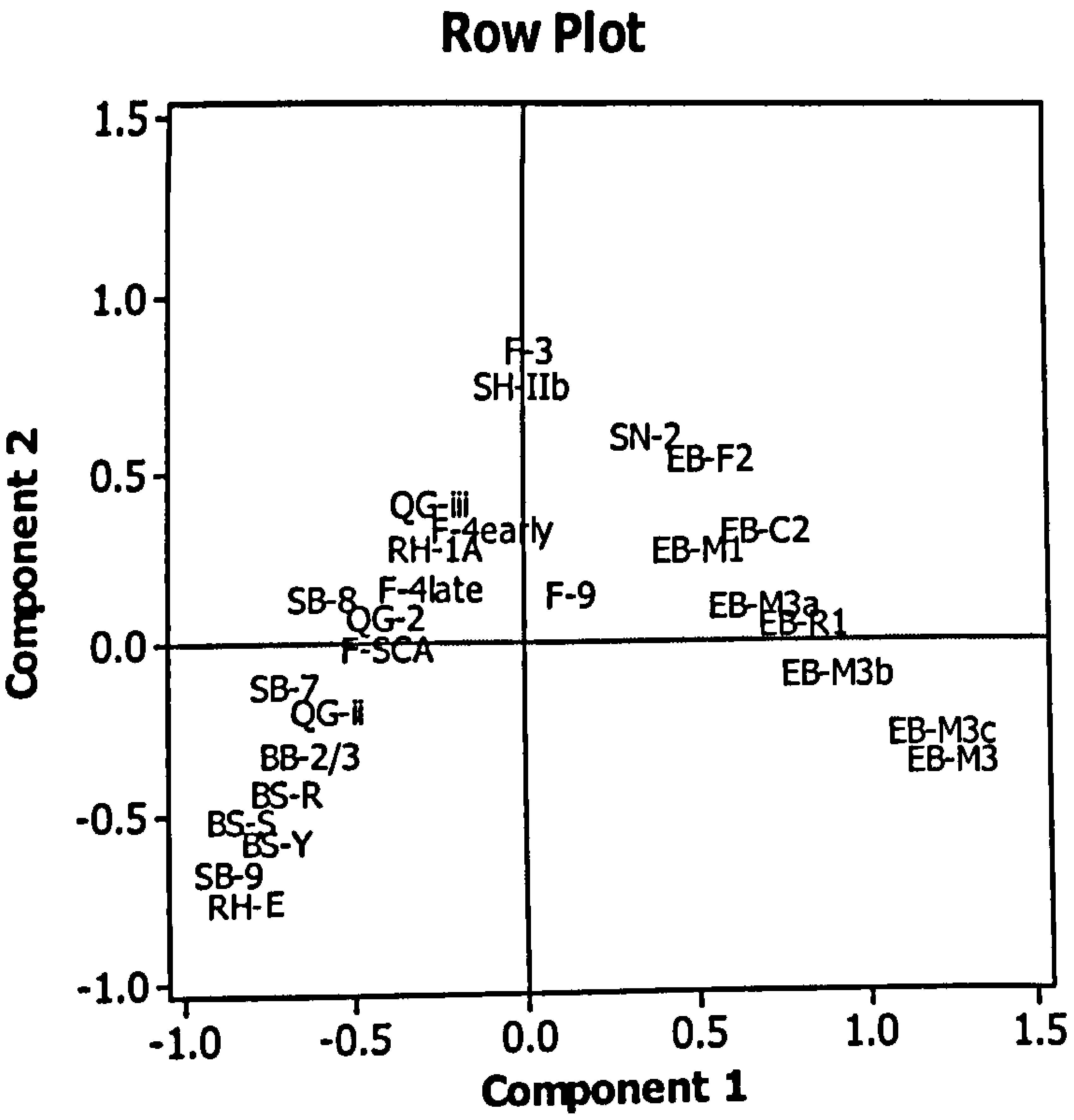
Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Gadid	0.999	0.517	0.229	-0.634	0.999	0.472	-0.001	0.000	0.000
Cod/saithe/ pollack	0.864	0.093	0.169	0.713	0.308	0.108	-0.958	0.556	0.268
Cod	0.669	0.159	0.140	0.705	0.620	0.180	0.199	0.049	0.020
Haddock	0.935	0.055	0.157	0.667	0.172	0.056	-1.405	0.763	0.342
Whiting	0.089	0.000	0.000	0.198	0.037	0.000	-0.236	0.052	0.000
Saithe/pollack	0.190	0.001	0.003	-0.355	0.057	0.000	0.541	0.133	0.001
Pollack	0.324	0.006	0.008	-0.359	0.107	0.002	0.511	0.216	0.005
Saithe	0.903	0.147	0.230	0.711	0.355	0.169	0.882	0.547	0.359
Rocklings	0.437	0.002	0.010	1.102	0.300	0.006	0.746	0.137	0.004
Ling	0.068	0.018	0.053	0.427	0.068	0.007	0.023	0.000	0.000

Table 8.2: Contributions for CA plot Figure 8.9



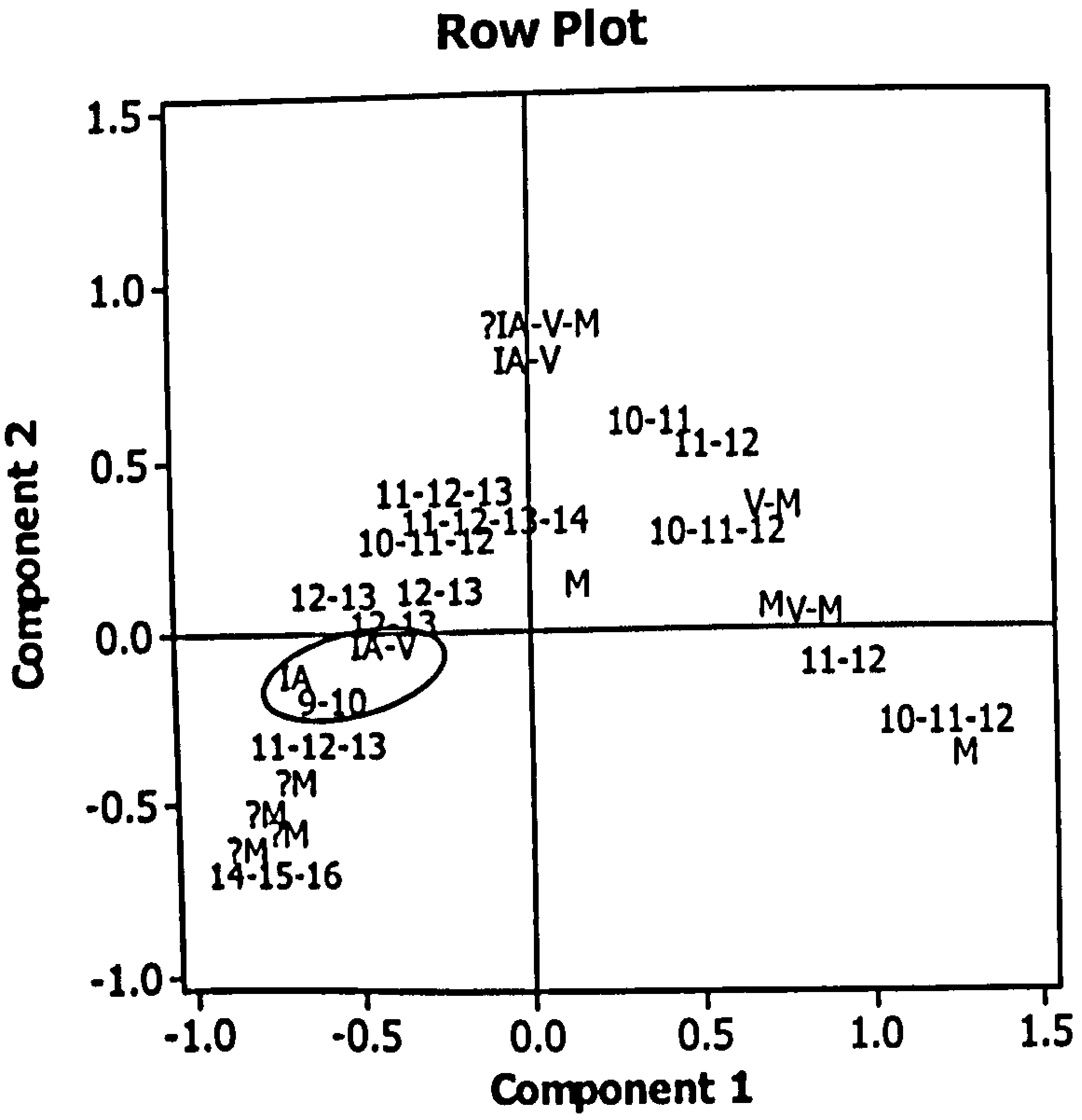
SN: Sandwick North
QG: Quoygrew
SB: St. Boniface
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

Figure 8.10: CA plots of cod, haddock, saithe, ling and pollack fish NISP for sites with sieving to 1-5mm and total NISP ≥300



SN: Sandwick North
QG: Quoygrew
SB: St. Boniface
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

Figure 8.11: Row plot coded for phase groups from previous figure



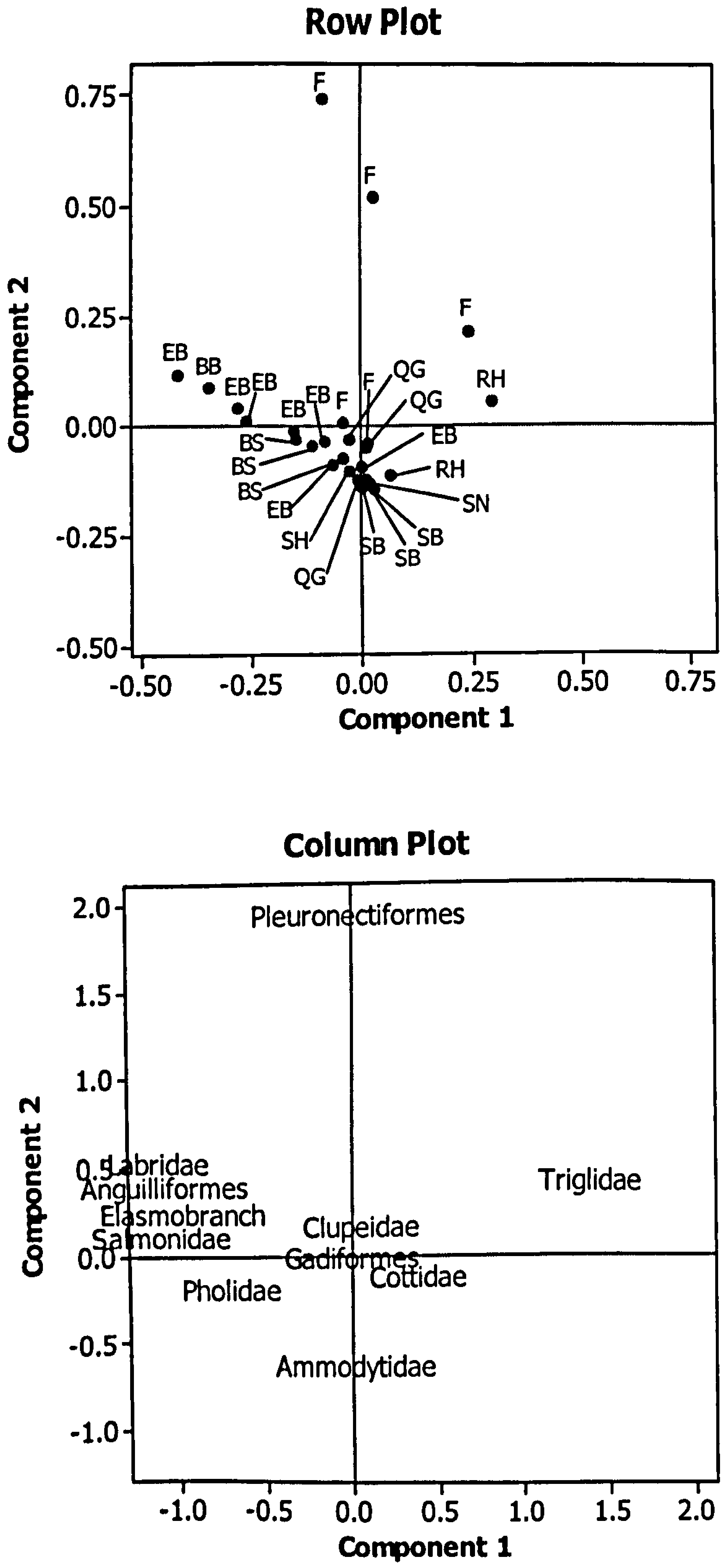
Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.12: Row plot coded for dates from previous figure

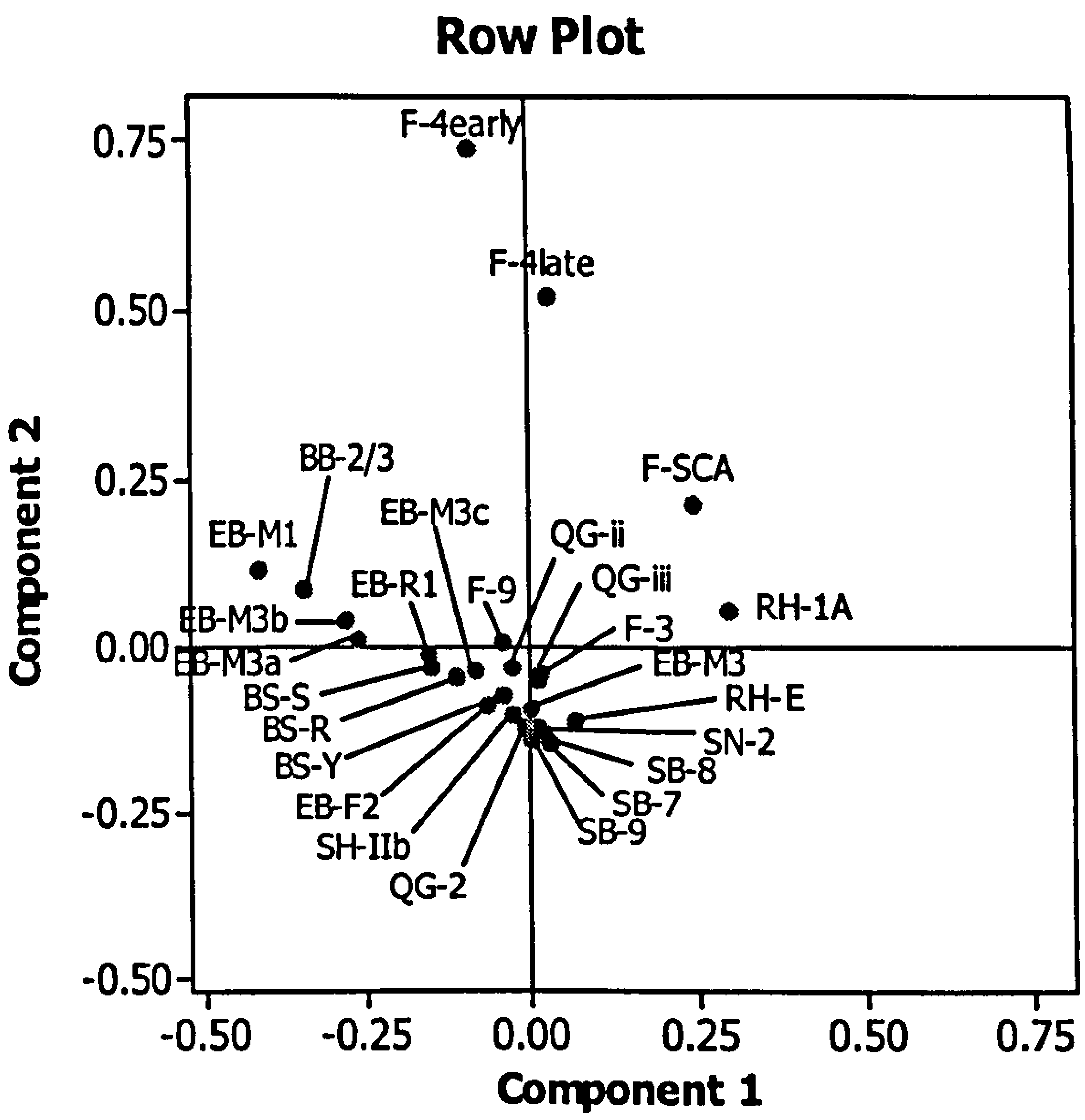
Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Cod	0.864	0.414	0.083	0.095	0.065	0.008	0.332	0.798	0.469
Haddock	0.998	0.140	0.454	1.449	0.933	0.641	-0.382	0.065	0.209
Pollack	0.103	0.016	0.104	-0.639	0.093	0.015	0.205	0.010	0.007
Saithe	0.996	0.384	0.259	-0.629	0.847	0.331	-0.264	0.149	0.273
Ling	0.088	0.046	0.100	0.210	0.029	0.004	0.298	0.059	0.042

Table 8.3: Contributions for CA plot Figure 8.10, Figure 8.11 and Figure 8.12



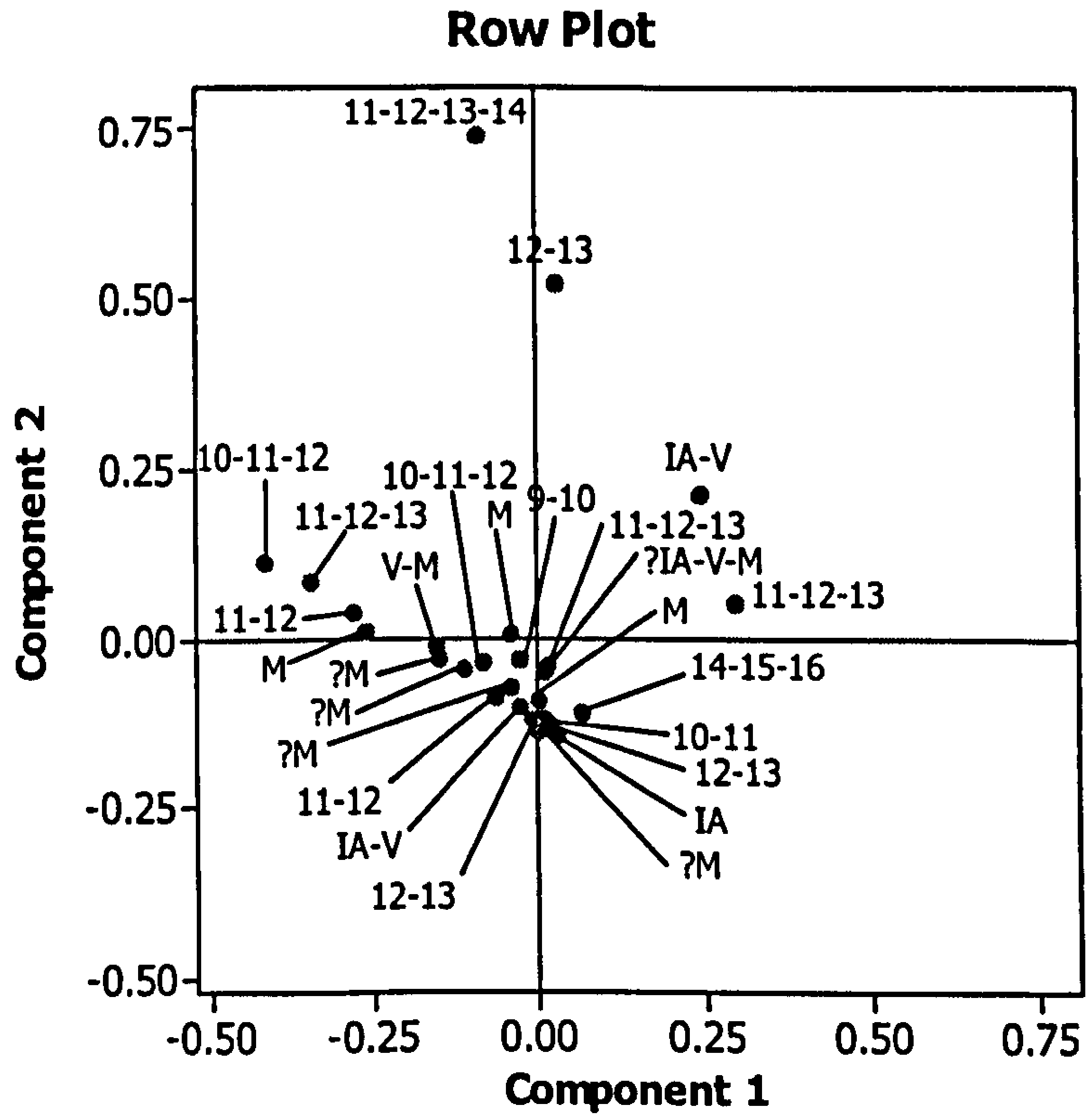
SN: Sandwick North
QG: Quoygrew
SB: St. Boniface
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

Figure 8.13: CA plots of major orders and family NISP for sites with sieving to 1-5mm and total NISP ≥300



SN: Sandwick North
QG: Quoygrew
SB: St. Boniface
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

Figure 8.14: Row plot coded for phase groups from previous figure



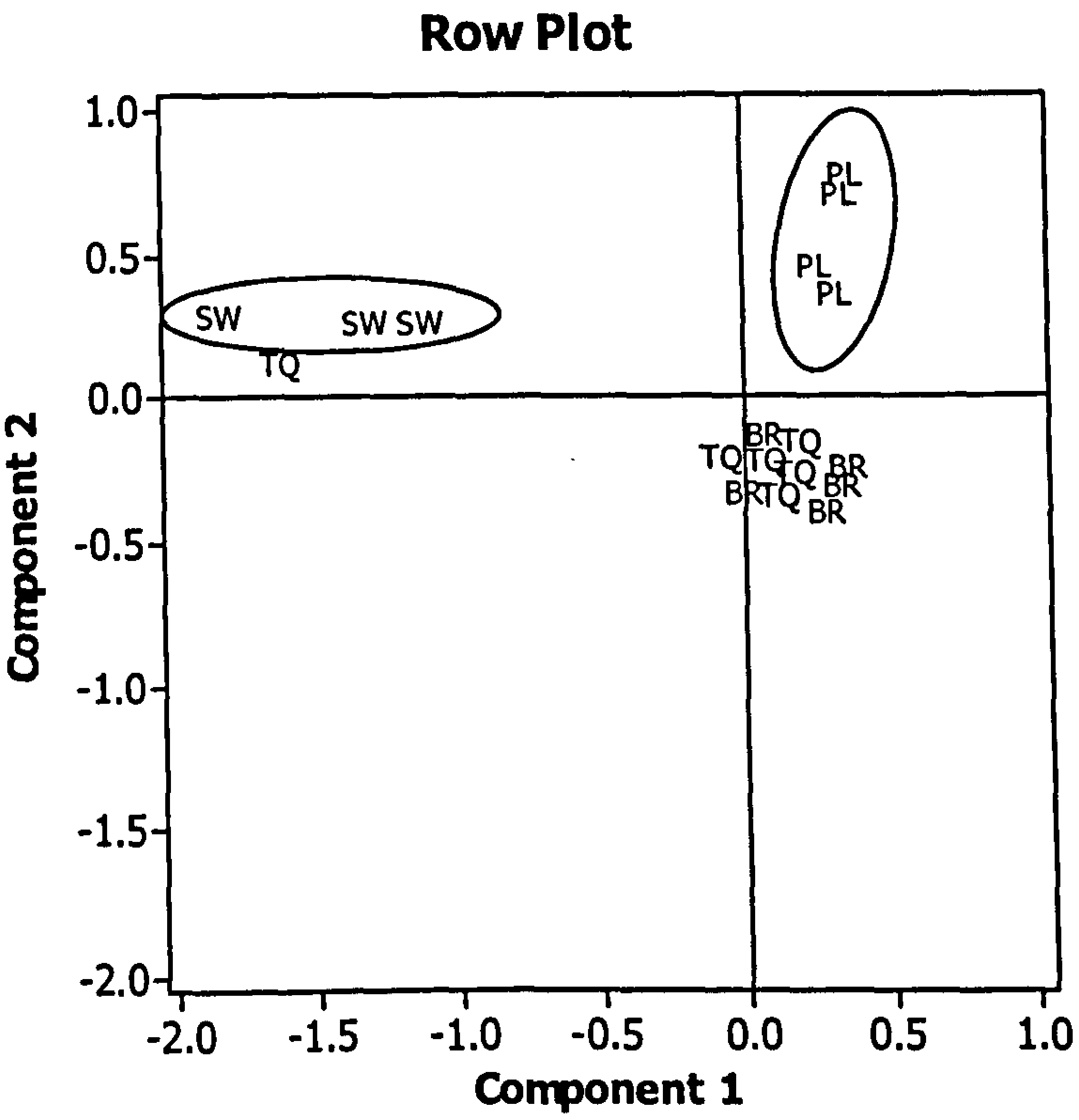
Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.15: Row plot coded for dates from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Elasmobranch	0.451	0.004	0.101	-0.978	0.427	0.101	0.233	0.024	0.012
Clupeidae	0.027	0.003	0.031	0.050	0.002	0.000	0.165	0.024	0.004
Salmonidae	0.413	0.002	0.064	-1.098	0.409	0.061	0.109	0.004	0.001
Anguilliformes	0.764	0.010	0.182	-1.079	0.653	0.279	0.445	0.111	0.101
Gadiformes	0.612	0.963	0.005	0.004	0.024	0.000	-0.018	0.588	0.016
Labridae	0.359	0.001	0.055	-1.108	0.294	0.038	0.522	0.065	0.018
Ammodytidae	0.118	0.001	0.036	0.014	0.000	0.000	-0.626	0.118	0.021
Pholidae	0.373	0.001	0.015	-0.705	0.348	0.012	-0.190	0.025	0.002
Triglidae	0.774	0.010	0.302	1.386	0.709	0.504	0.418	0.064	0.098
Cottidae	0.108	0.001	0.017	0.380	0.104	0.004	-0.077	0.004	0.000
Pleuronectidae	0.754	0.004	0.193	0.054	0.001	0.000	1.934	0.753	0.727

Table 8.4: Contributions for CA plot Figure 8.13, Figure 8.14 and Figure 8.15



SW: Sandwick

TQ: Tuquoy (showing only the 6 phases identified as midden)

PL: Pool

BR: Brough Road

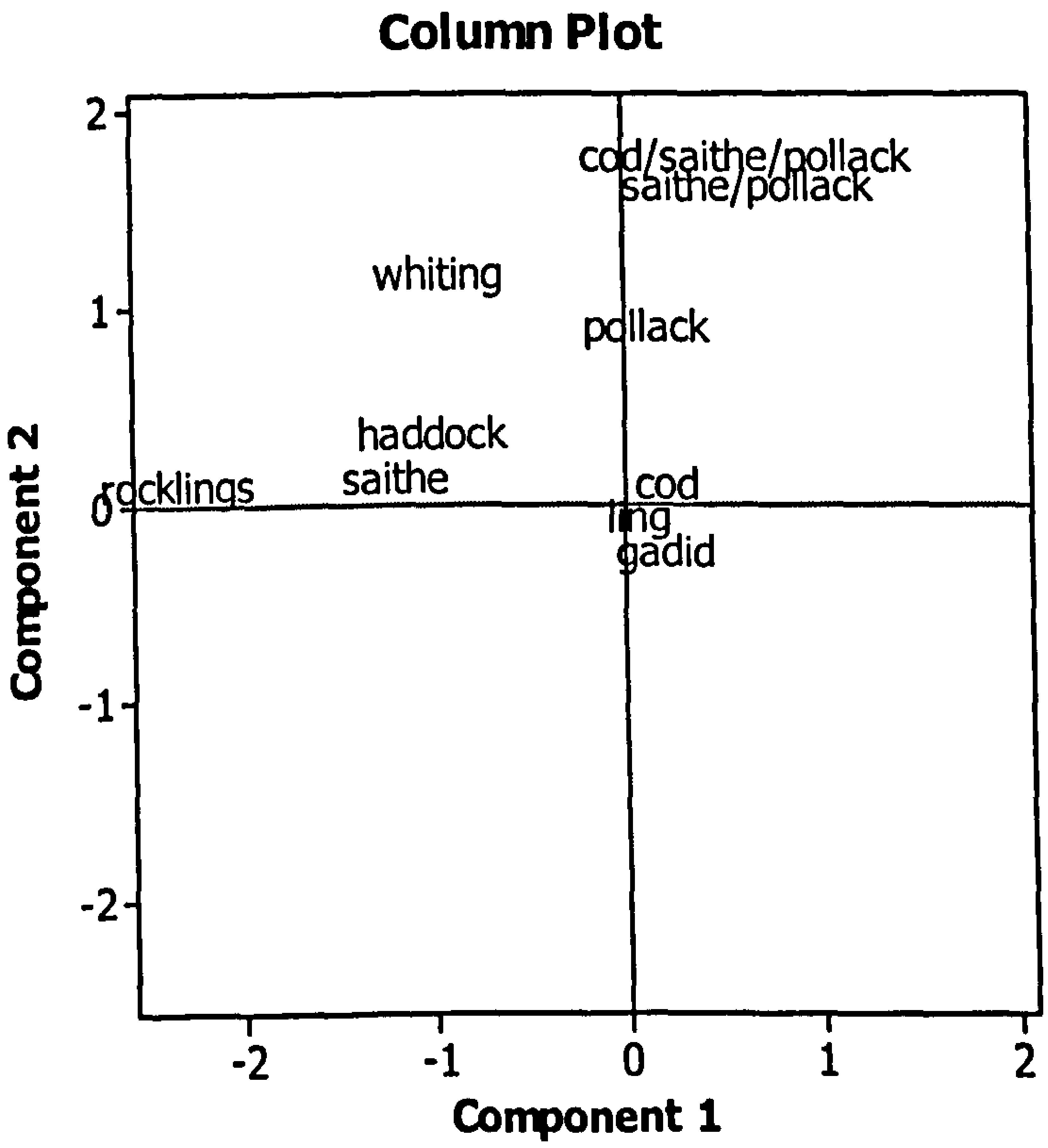


Figure 8.16: CA plots of gadid fish NISP for sites with mixed recovery and total NISP ≥200; Sandwick 'saithe/pollack' coded as saithe

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Gadid	0.871	0.469	0.108	0.214	0.363	0.076	-0.253	0.509	0.184
Cod/saithe/pollack	0.987	0.037	0.242	0.644	0.117	0.055	1.756	0.870	0.704
Cod	0.707	0.269	0.039	0.216	0.585	0.044	0.098	0.122	0.016
Haddock	0.220	0.005	0.048	-1.005	0.195	0.018	0.356	0.025	0.004
Whiting	0.469	0.000	0.001	-0.951	0.189	0.000	1.158	0.280	0.001
Saithe/pollack	0.904	0.004	0.023	0.633	0.113	0.005	1.671	0.790	0.061
Pollack	0.233	0.003	0.017	0.122	0.004	0.000	0.909	0.229	0.013
Saithe	0.987	0.148	0.393	-1.189	0.974	0.739	0.134	0.012	0.016
Rocklings	0.436	0.003	0.073	-2.338	0.435	0.062	0.100	0.001	0.000
Ling	0.018	0.061	0.055	0.069	0.010	0.001	-0.063	0.008	0.001

Table 8.5: Contributions for CA plot Figure 8.16

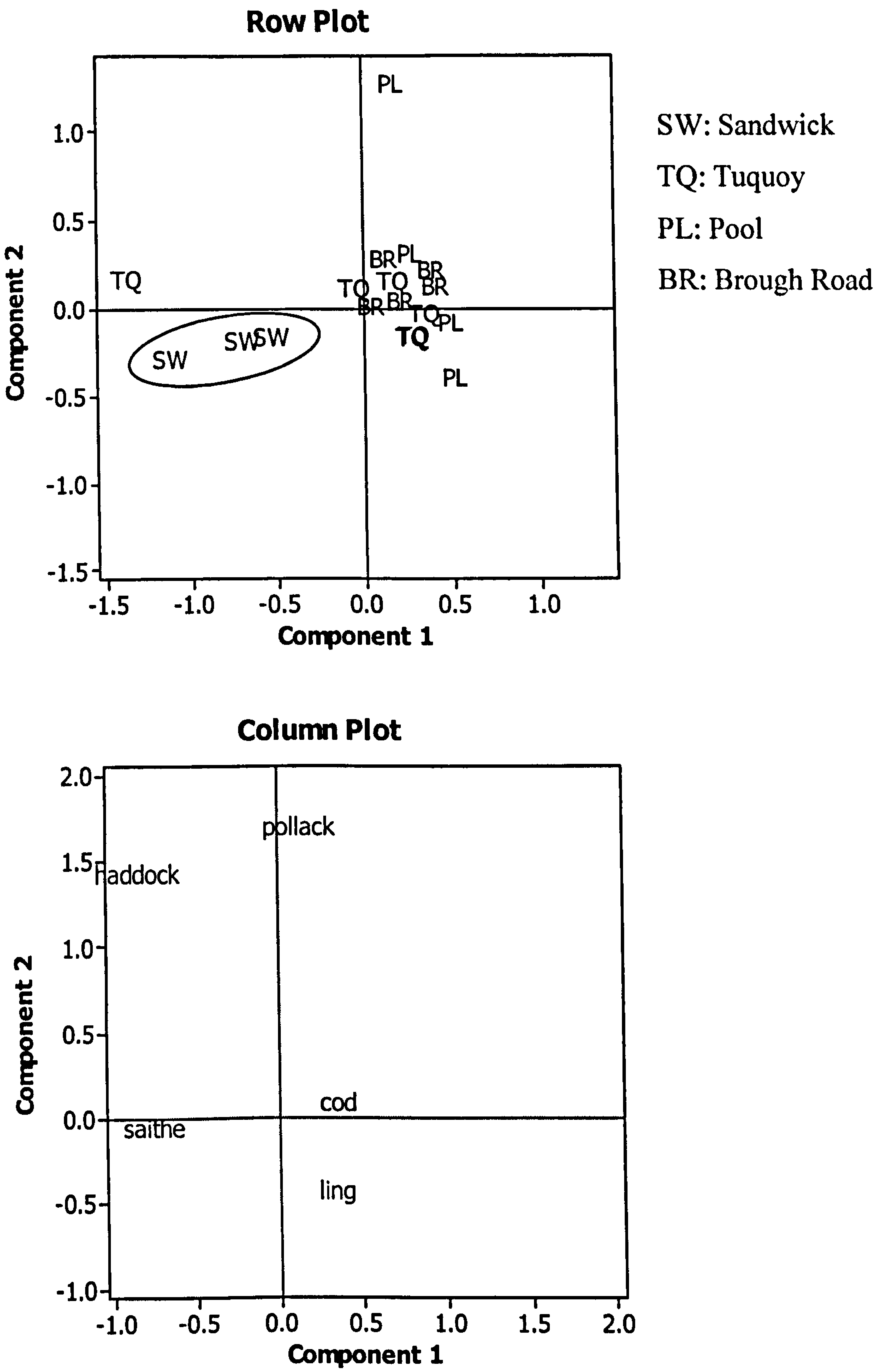
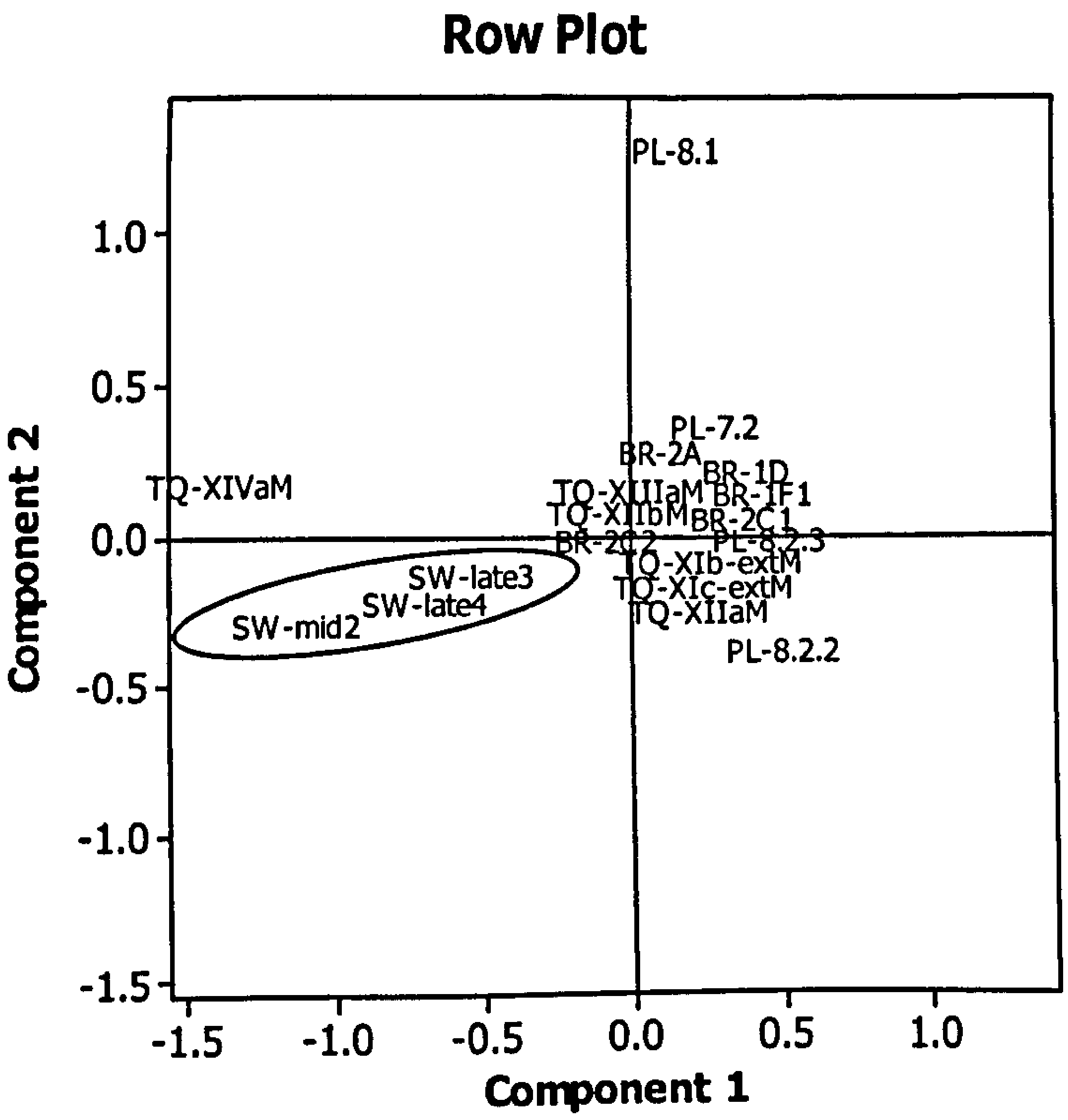


Figure 8.17: CA plots of cod, haddock, saithe, ling and pollack NISP for sites with mixed recovery and total NISP ≥200



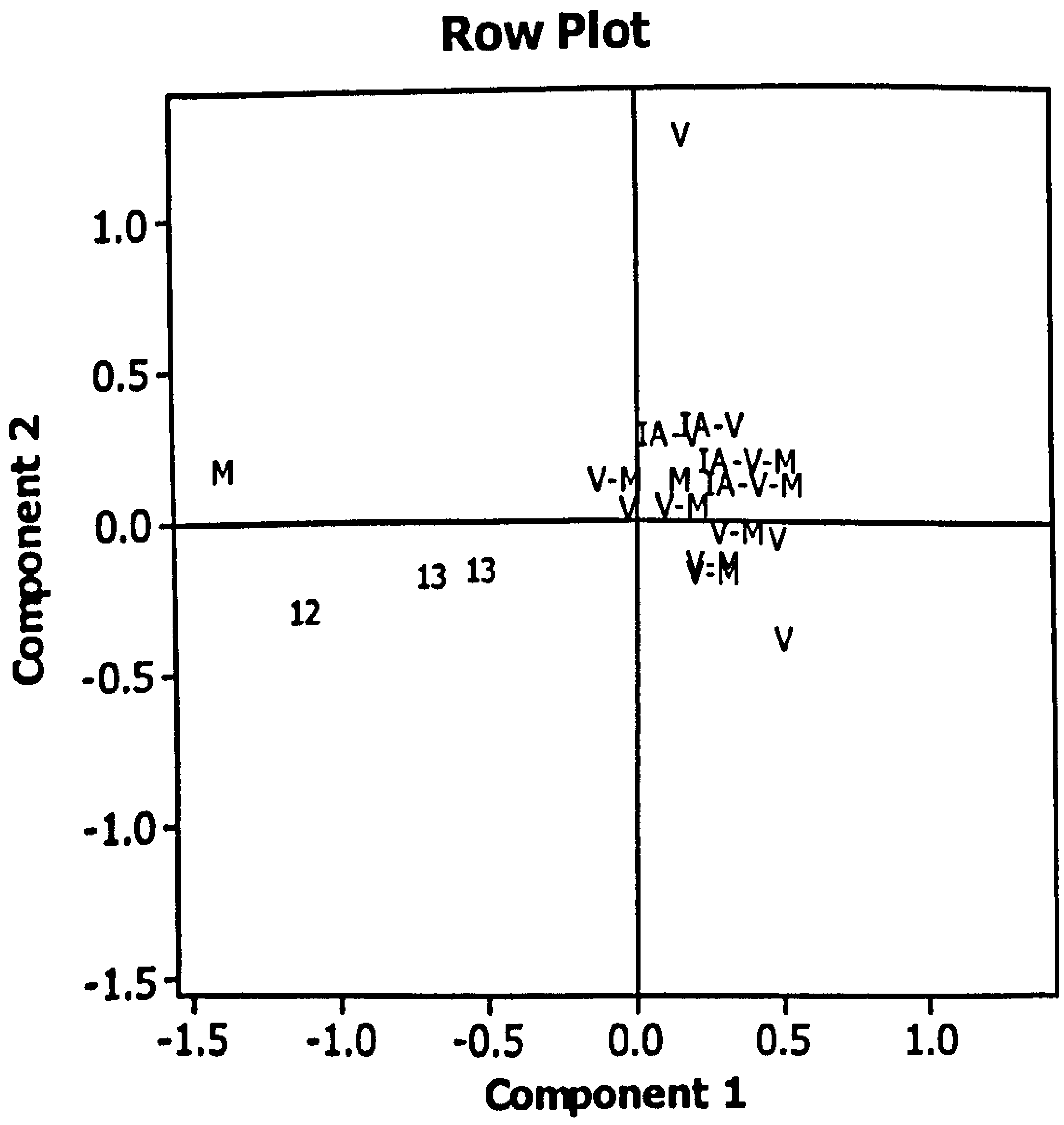
SW: Sandwick

TQ: Tuquoy

PL: Pool

BR: Brough Road

Figure 8.18: Row plot coded for phase groups from previous figure



Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.19: Row plot coded for dates from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Cod	0.957	0.553	0.207	0.357	0.904	0.261	0.087	0.053	0.064
Haddock	0.633	0.011	0.122	-0.854	0.168	0.028	1.422	0.466	0.328
Pollack	0.730	0.005	0.055	0.139	0.005	0.000	1.691	0.725	0.230
Saithe	0.996	0.305	0.475	-0.763	0.990	0.655	-0.057	0.005	0.015
Ling	0.728	0.126	0.140	0.344	0.282	0.055	-0.433	0.446	0.363

Table 8.6: Contributions for CA plot Figure 8.17, Figure 8.18 and Figure 8.19

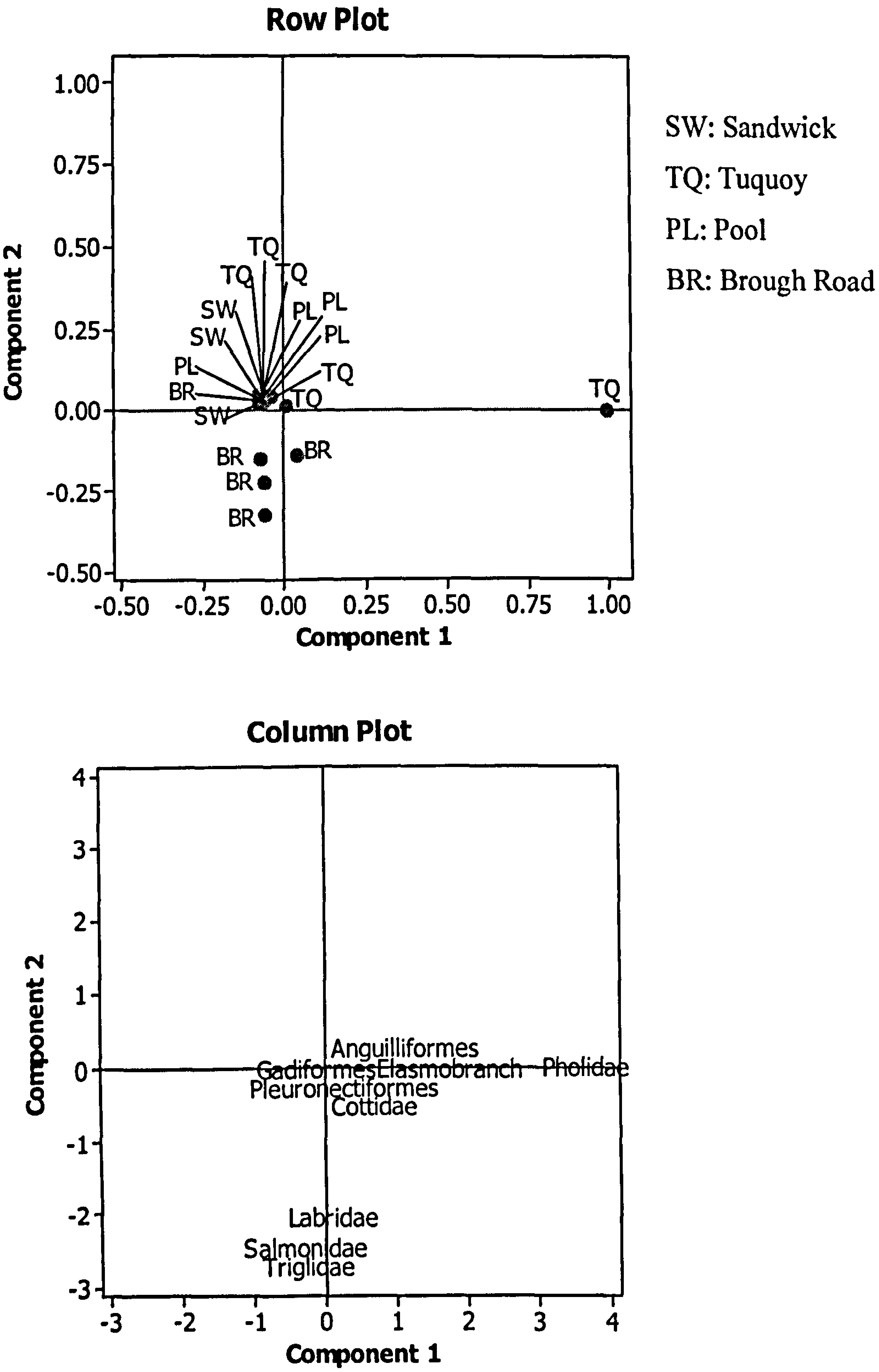
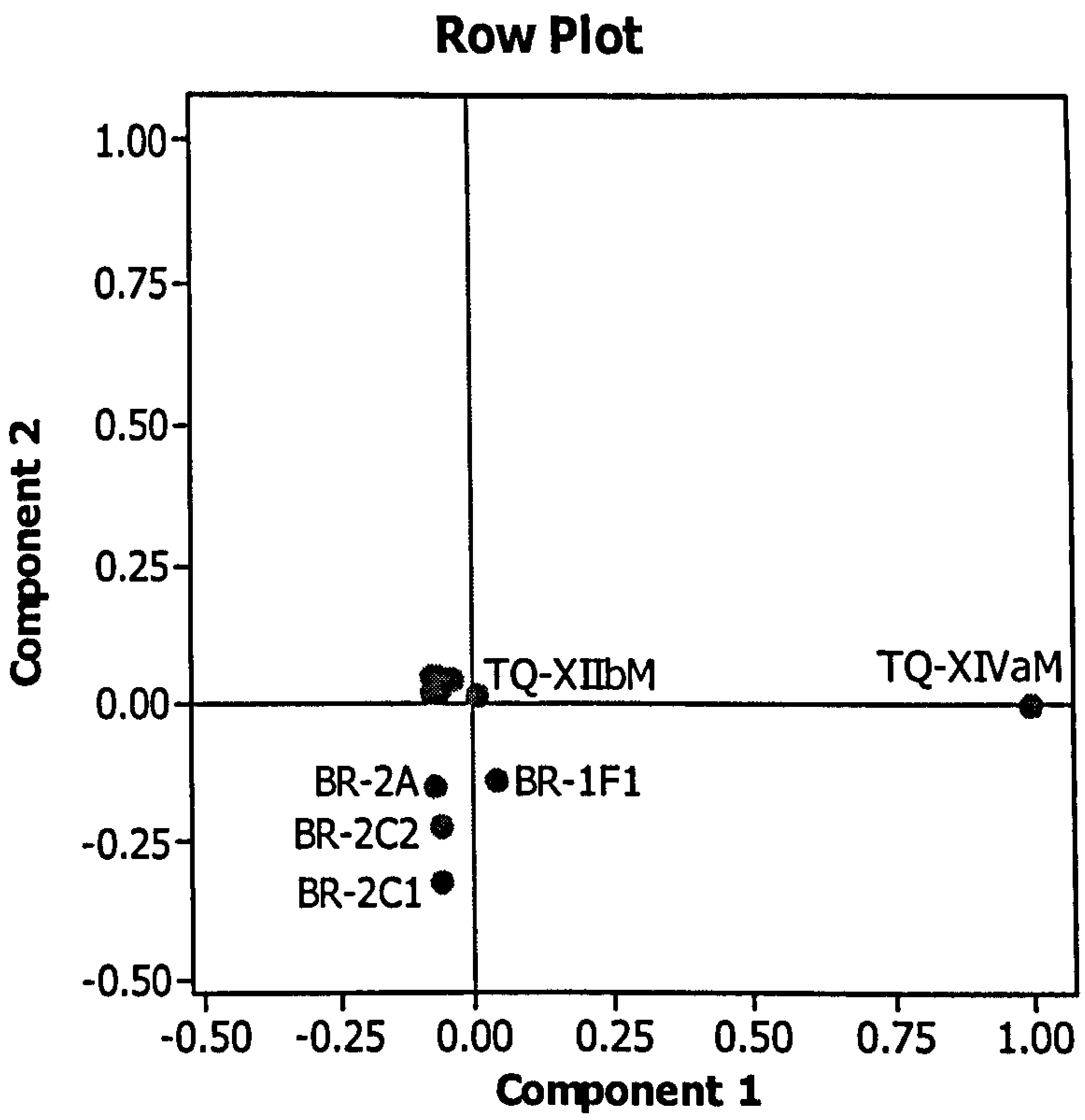


Figure 8.20: CA plots of major orders and family NISP for mixed recovery sites with total NISP ≥200



SW: Sandwick

TQ: Tuquoy

PL: Pool

BR: Brough Road

Only the outliers are labelled; the majority of points are located just to the left of the centre

Figure 8.21: Row plot coded for phase groups from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Elasmobranch	0.934	0.003	0.133	1.737	0.933	0.156	0.058	0.001	0.001
Salmonidae	0.619	0.000	0.018	-0.276	0.007	0.000	-2.566	0.612	0.077
Anguilliformes	0.661	0.001	0.023	1.112	0.647	0.018	0.164	0.014	0.002
Gadiformes	0.994	0.989	0.006	-0.018	0.934	0.006	0.005	0.060	0.002
Labridae	0.989	0.002	0.122	0.105	0.003	0.000	-2.057	0.986	0.833
Pholidae	0.996	0.003	0.643	3.660	0.996	0.806	0.025	0.000	0.000
Triglidae	0.746	0.000	0.012	-0.276	0.008	0.000	-2.650	0.738	0.062
Cottidae	0.400	0.001	0.027	0.688	0.328	0.011	-0.323	0.072	0.014
Pleuronectiformes	0.143	0.001	0.016	0.283	0.073	0.001	-0.277	0.070	0.008

Table 8.7: Contributions for CA plot Figure 8.20 and Figure 8.21

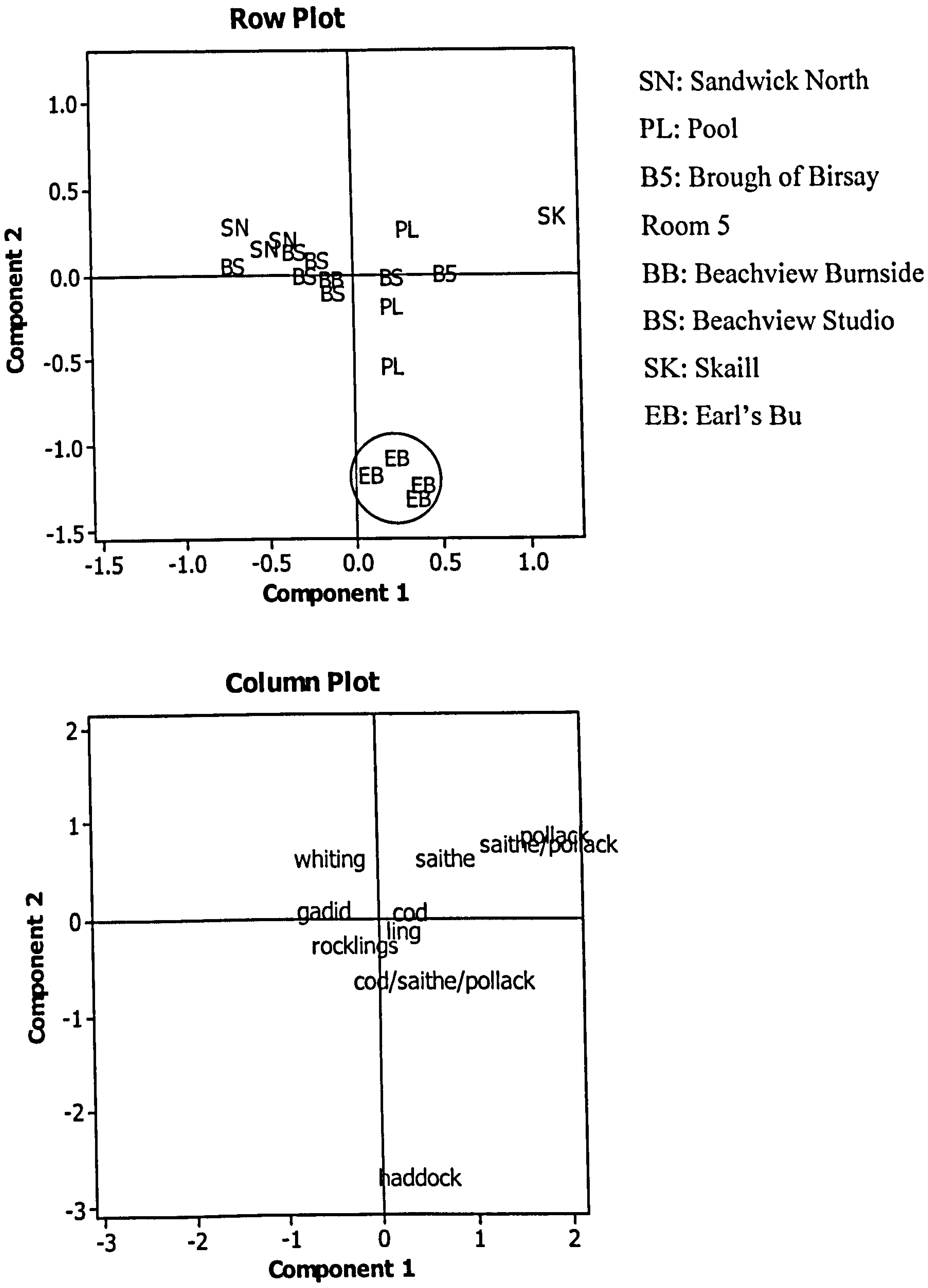
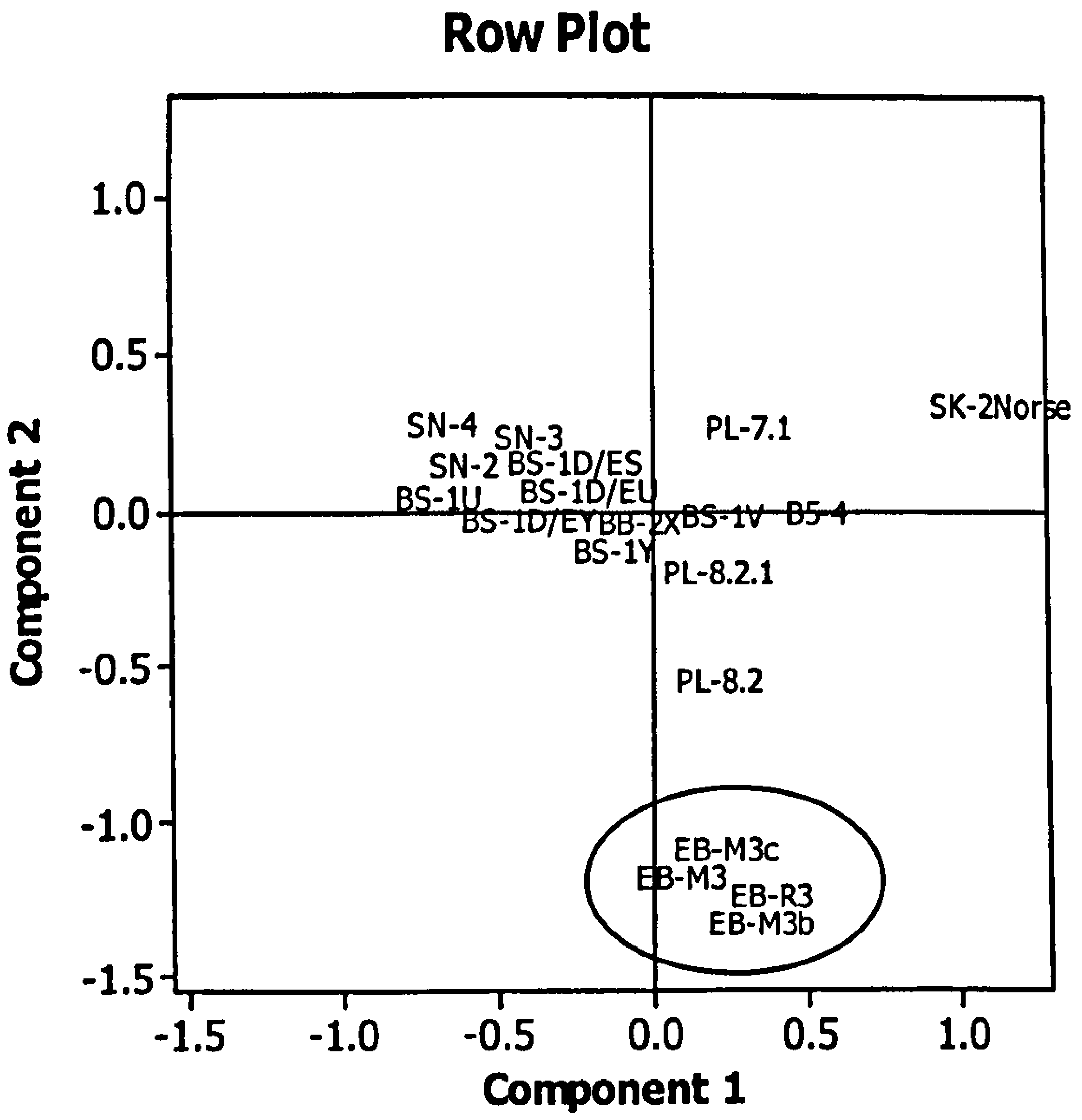


Figure 8.22: CA plots of gadid fish NISP for sites with hand collection and total NISP ≥100



SN: Sandwick North

PL: Pool

B5: Brough of Birsay Room 5

BB: Beachview Burnside

BS: Beachview Studio

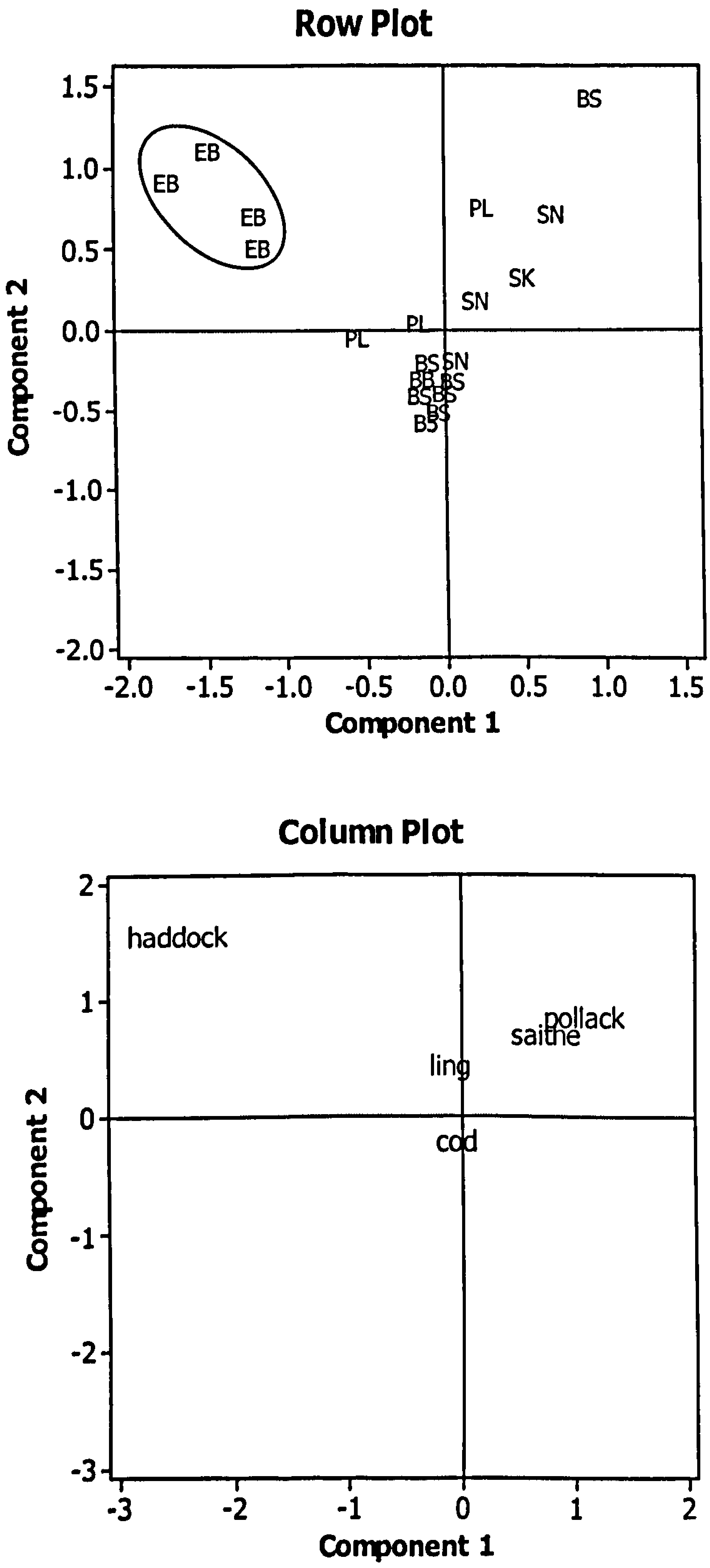
SK: Skaill

EB: Earl's Bu

Figure 8.23: Row plot coded for phase groups from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Gadid	0.952	0.436	0.241	-0.584	0.939	0.450	0.069	0.013	0.014
Cod/saithe/pollack	0.708	0.067	0.128	0.677	0.367	0.093	-0.653	0.341	0.201
Cod	0.363	0.368	0.146	0.308	0.363	0.105	-0.002	0.000	0.000
Haddock	0.846	0.010	0.140	0.375	0.016	0.004	-2.719	0.831	0.537
Whiting	0.055	0.000	0.005	-0.499	0.023	0.000	0.596	0.032	0.001
Saithe/pollack	0.841	0.009	0.064	1.814	0.695	0.089	0.829	0.145	0.043
Pollack	0.872	0.017	0.124	1.872	0.724	0.179	0.847	0.148	0.085
Saithe	0.641	0.046	0.094	0.717	0.378	0.071	0.598	0.263	0.114
Rocklings	0.009	0.000	0.001	-0.173	0.003	0.000	-0.230	0.006	0.000
Ling	0.101	0.046	0.058	0.257	0.080	0.009	-0.134	0.022	0.006

Table 8.8: Contributions for CA plot Figure 8.22 and Figure 8.23



SN: Sandwick North

PL: Pool

B5: Brough of Birsay Room 5

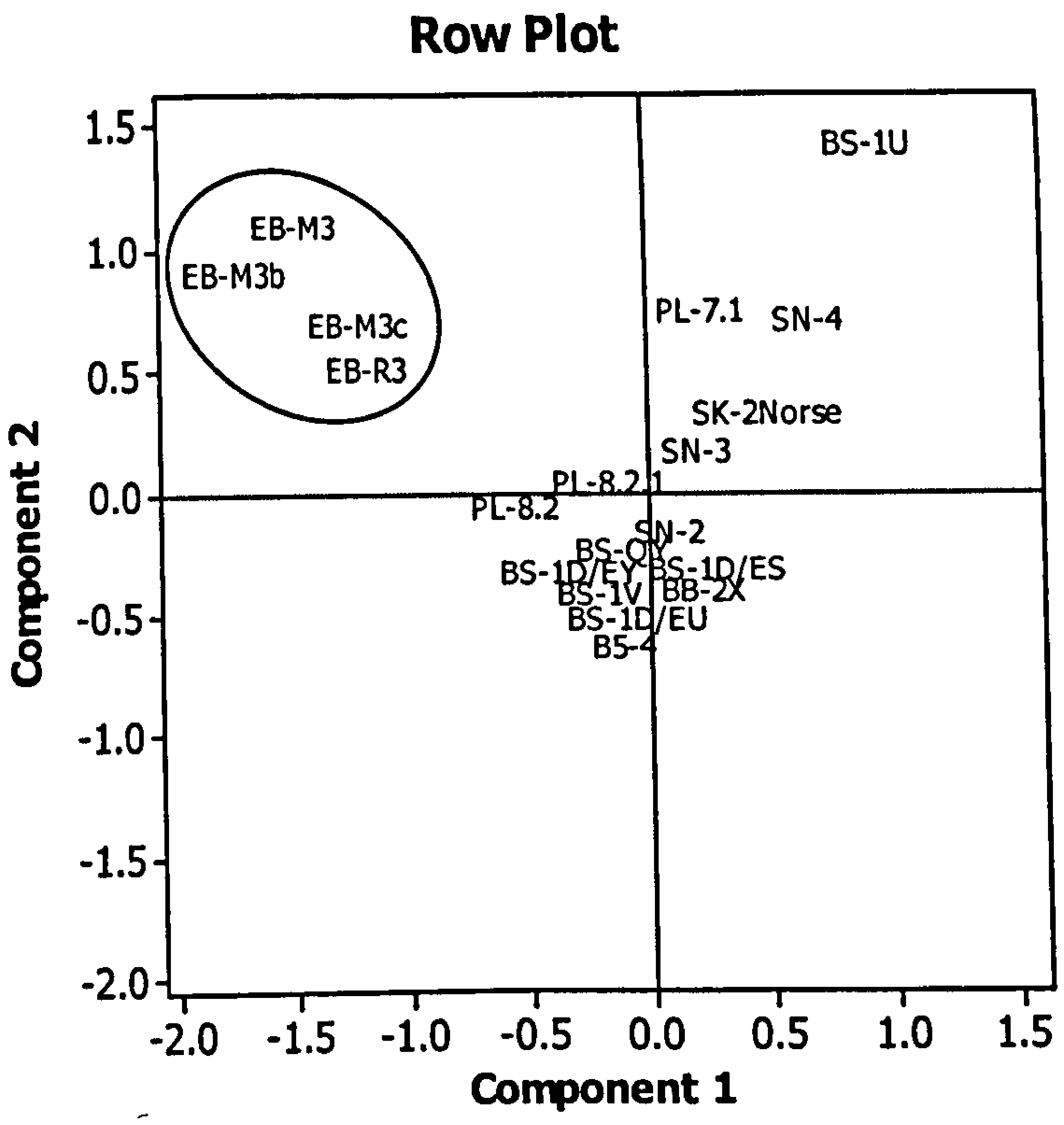
BB: Beachview Burnside

BS: Beachview Studio

SK: Skaill

EB: Earl's Bu

Figure 8.24: CA plots of cod, haddock, saithe, ling and pollack fish NISP for sites with hand collection and total NISP ≥100



SN: Sandwick North

PL: Pool

B5: Brough of Birsay Room 5

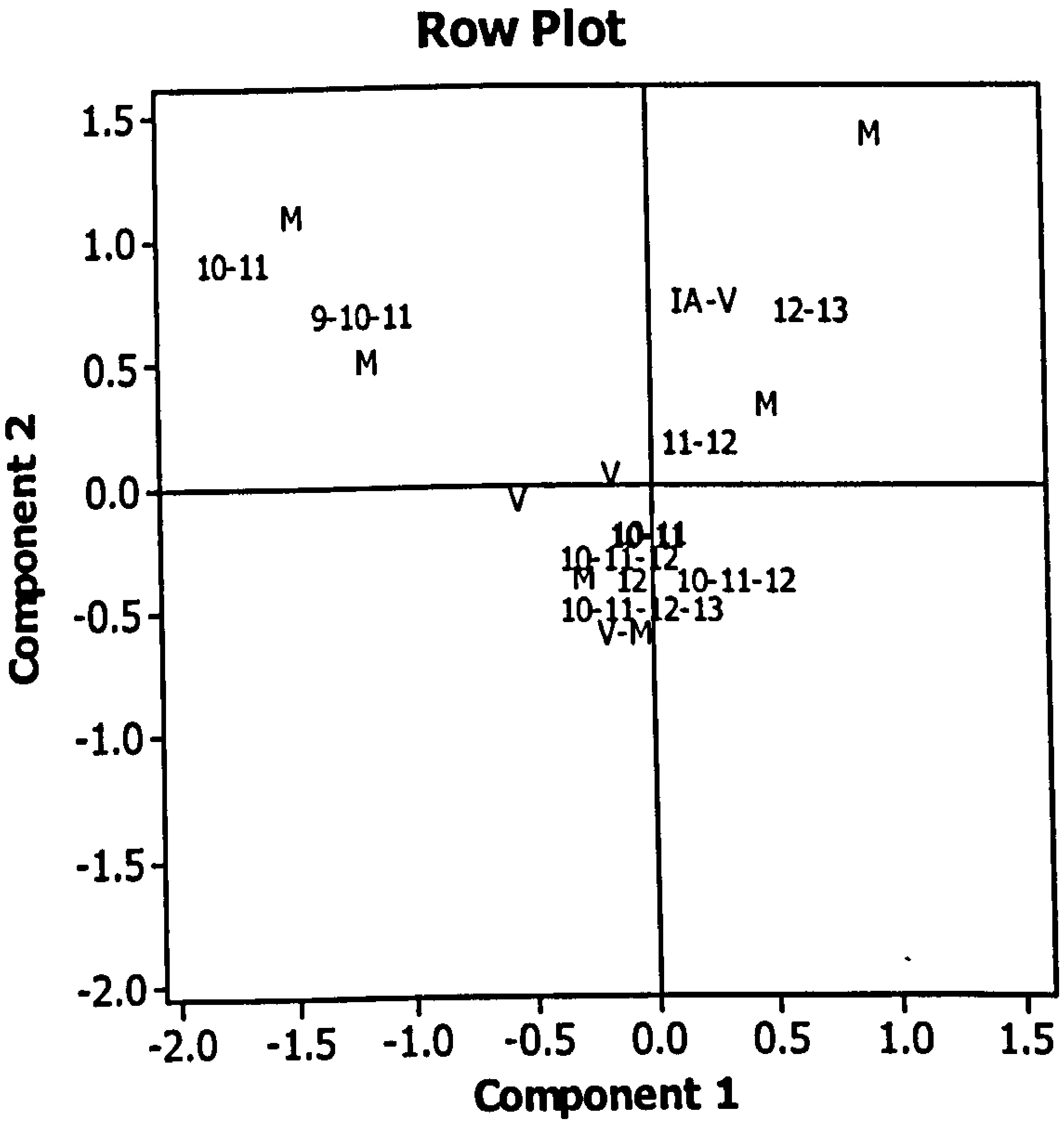
BB: Beachview Burnside

BS: Beachview Studio

SK: Skaill

EB: Earl's Bu

Figure 8.25: Row plot coded for phase groups from previous figure



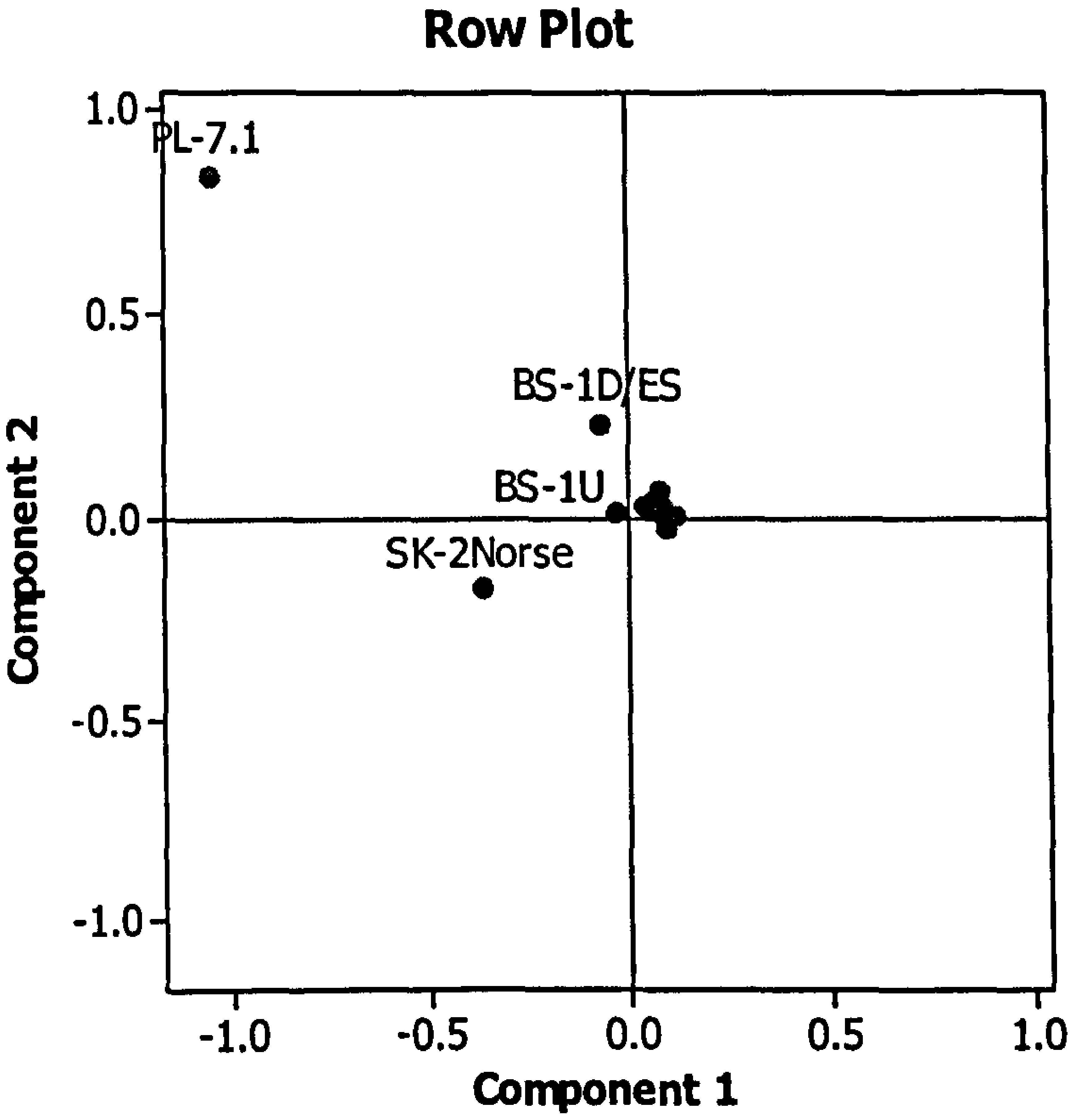
Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.26: Row plot coded for dates from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Cod	0.964	0.756	0.080	-0.057	0.061	0.011	-0.218	0.903	0.210
Haddock	0.971	0.021	0.379	-2.486	0.699	0.591	1.550	0.272	0.300
Pollack	0.634	0.035	0.178	0.988	0.384	0.152	0.798	0.250	0.130
Saithe	0.861	0.094	0.231	0.758	0.468	0.242	0.694	0.393	0.265
Ling	0.258	0.094	0.132	-0.101	0.015	0.004	0.412	0.244	0.094

Table 8.9: Contributions for CA plot Figure 8.24, Figure 8.25 and Figure 8.26



SN: Sandwick North

PL: Pool

B5: Brough of Birsay Room 5

BB: Beachview Burnside

BS: Beachview Studio

SK: Skaill

EB: Earl's Bu

The majority of points cluster around the origin and are not labelled.

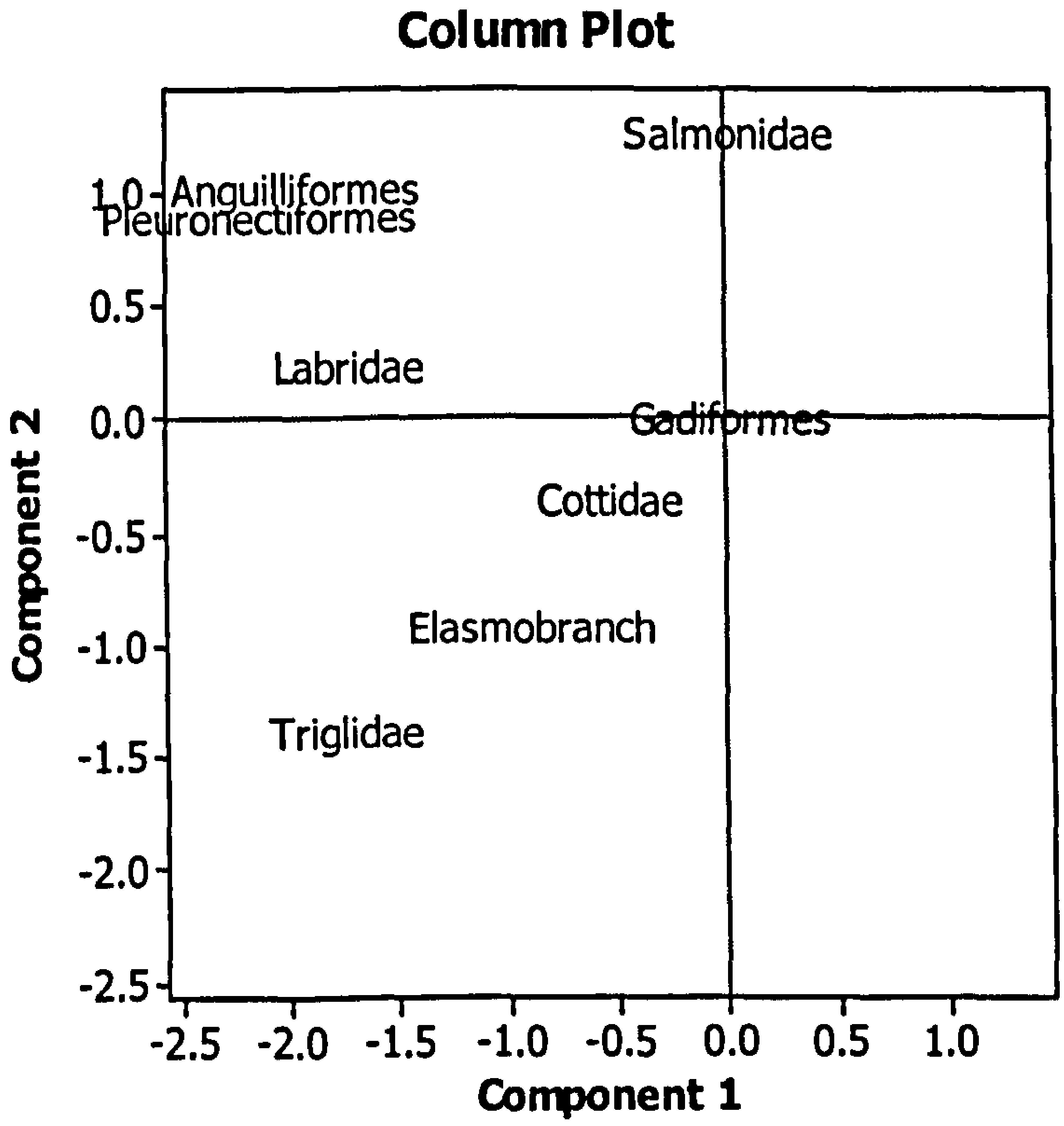


Figure 8.27: CA plots of major orders and family NISP for sites with hand collection and total NISP ≥100

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Elasmobranch	0.326	0.000	0.034	-0.889	0.155	0.009	-0.934	0.171	0.028
Salmonidae	0.064	0.000	0.067	0.018	0.000	0.000	1.263	0.064	0.020
Anguilliformes	0.937	0.003	0.198	-1.966	0.738	0.235	1.019	0.198	0.185
Gadiformes	0.996	0.986	0.008	0.024	0.993	0.013	0.001	0.003	0.000
Labridae	0.796	0.002	0.107	-1.722	0.783	0.135	0.228	0.014	0.007
Triglidae	0.987	0.005	0.324	-1.735	0.601	0.314	-1.390	0.386	0.589
Cottidae	0.179	0.001	0.035	-0.531	0.121	0.007	-0.366	0.058	0.009
Pleuronectiformes	0.942	0.003	0.226	-2.137	0.790	0.288	0.936	0.152	0.161

Table 8.10: Contributions for CA plot Figure 8.27

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	159.831	4	0.000	
Phases 2 and 3	41.982	2	0.000	
Phases 3 and 4	28.696	2	0.000	
Phases 2 and 4	163.829	2	0.000	

Table 8.11: Chi-Square results for species distributions of cod, saithe and ling from Sandwick North hand collected deposits

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	479.284	18	0.000	6 cells with expected counts <5.0
All except fish-rich Middle phase, area 2	157.985	15	0.000	4 cells with expected counts <5.0
Middle phase, areas 3 and 4	8.086	3	0.044	2 cells with expected counts <5.0
All area 3	127.234	6	0.000	
All area 4	16.218	6	0.013	4 cells with expected counts <5.0

Table 8.12: Significant Chi-Square results for species distributions of cod, saithe/pollack (equivalent to saithe), ling and torsk from Sandwick

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	202.552	4	0.000	
Phases 7 and 8	11.619	2	0.003	
Phases 8 and 9	200.607	2	0.000	
Phases 7 and 9	56.653	2	0.000	

Table 8.13: Significant Chi-Square results for species distributions of cod, saithe and pollack from St. Boniface

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Phase XIb exterior and phase XIIb	31.865	3	0.000	1 cell with expected counts <5.0
Phase XIb exterior and phase XIIIa	14.449	3	0.002	2 cells with expected counts <5.0
Phase XIb exterior and phase XIVa	834.610	3	0.000	
Phase XIc exterior and phase XIIb	135.461	3	0.000	
Phase XIc exterior and phase XIIIa	65.005	3	0.000	1 cell with expected counts <5.0
Phase XIc exterior and phase XIc exterior	1368.513	3	0.000	
Phase XIIa and phase XIIb	262.432	3	0.000	
Phase XIIa and phase XIIIa	86.642	3	0.000	1 cell with expected counts <5.0
Phase XIIa and phase XIVa	2294.134	3	0.000	
Phase XIIb and phase XIIIa	1195.610	3	0.000	
Phase XIIb and phase XIVa	1195.610	3	0.000	
Phase XIIIa and phase XIVa	1098.697	3	0.000	

Table 8.14: Chi-Square results for species distributions of cod, saithe, ling and haddock from Tuquoy midden deposits

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	899.439	24	0.000	3 cells with expected counts <5.0
7.1 and 7.2	568.698	4	0.000	2 cells with expected counts <5.0
8.2.1, 8.2.2 and 8.2.3	97.744	8	0.000	1 cell with expected counts <5.0
8.2, 8.2.1, 8.2.2, 8.2.3	141.210	12	0.000	2 cells with expected counts <5.0
8.1, 8.2, 8.2.1, 8.2.2, 8.2.3	204.778	16	0.000	2 cells with expected counts <5.0
7.2, 8.1, 8.2.2, 8.2.3 (all mixed recovery)	690.638	12	0.000	

Table 8.15: Significant Chi-Square results for species distributions of cod, saithe, ling, cod/saithe/pollack and saithe/pollack from Pool

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Area 3 X, area 2 W, X (all midden)	43.435	6	0.000	3 cells with expected counts <5.0
Area 1 Q, R, S, Y (all large sieved area 1)	46.826	9	0.000	1 cell with expected counts <5.0
Area 1 R, S (both midden)	18.761	3	0.000	

Table 8.16: Significant Chi-Square results for sieved species distributions of cod, saithe, ling and cod/saithe/pollack from Beachview

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Area 1 D and F1*, area 2 A, B2, C1*, C2* and E1	43.564	12	0.000	1 cell with expected counts <5.0
Area 1 D and area 2 C1* and C2*	28.930	4	0.000	
Area 2 C1* and C2*	19.107	2	0.000	
Area 2 B2, C1*, C2* and E1	26.930	6	0.000	1 cell with expected count <5.0

*denotes some sediment was sieved to >1mm

Table 8.17: Significant Chi-Square results for species distributions of cod, saithe and ling from Brough Road

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Phase I all, IIa, IIb, IIb/c, IIc	121.031	12	0.000	7 cells with expected counts <5.0
IIa, IIb, IIb/c, IIc	65.114	9	0.000	6 cells with expected counts <5.0
I all, IIb	89.486	3	0.000	3 cells with expected counts <5.0
I all, IIb/c	22.753	3	0.000	
I all, IIc	26.701	3	0.000	
IIa, IIc	11.594	3	0.009	3 cells with expected counts <5.0
IIb, IIb/c	31.111	3	0.000	2 cells with expected counts <5.0

Table 8.18: Significant Chi-Square results for sieved species distributions of cod, saithe, ling and cod/saithe/pollack from Saevar Howe

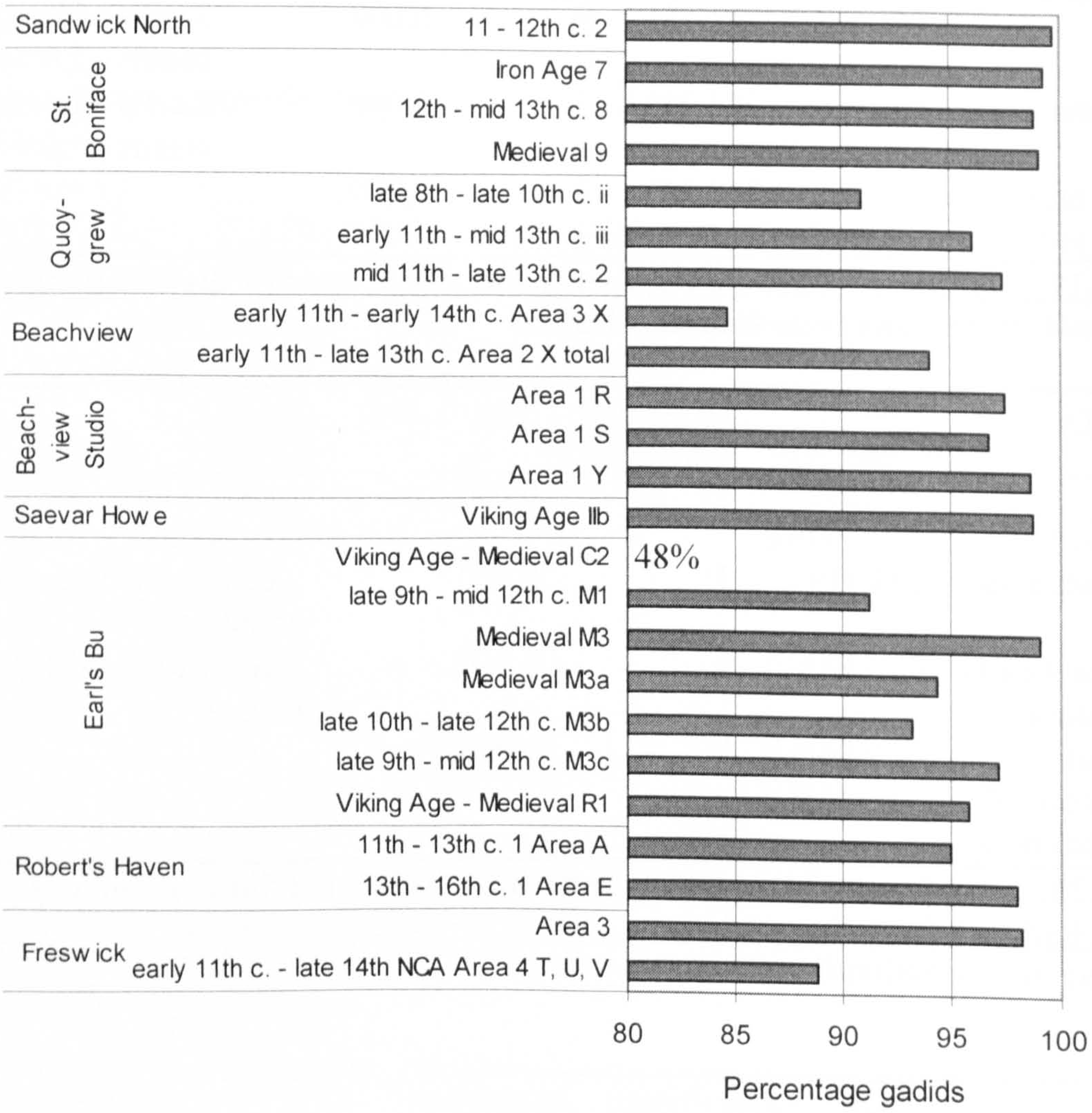
Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	311.571	9	0.000	3 cells with expected counts <5.0
Phase 1, areas A, B and area E	284.735	6	0.000	2 cells with expected counts <5.0
Phase 1, area A and area E	260.390	3	0.000	
Phase 1, area A and phase 2	38.906	3	0.000	

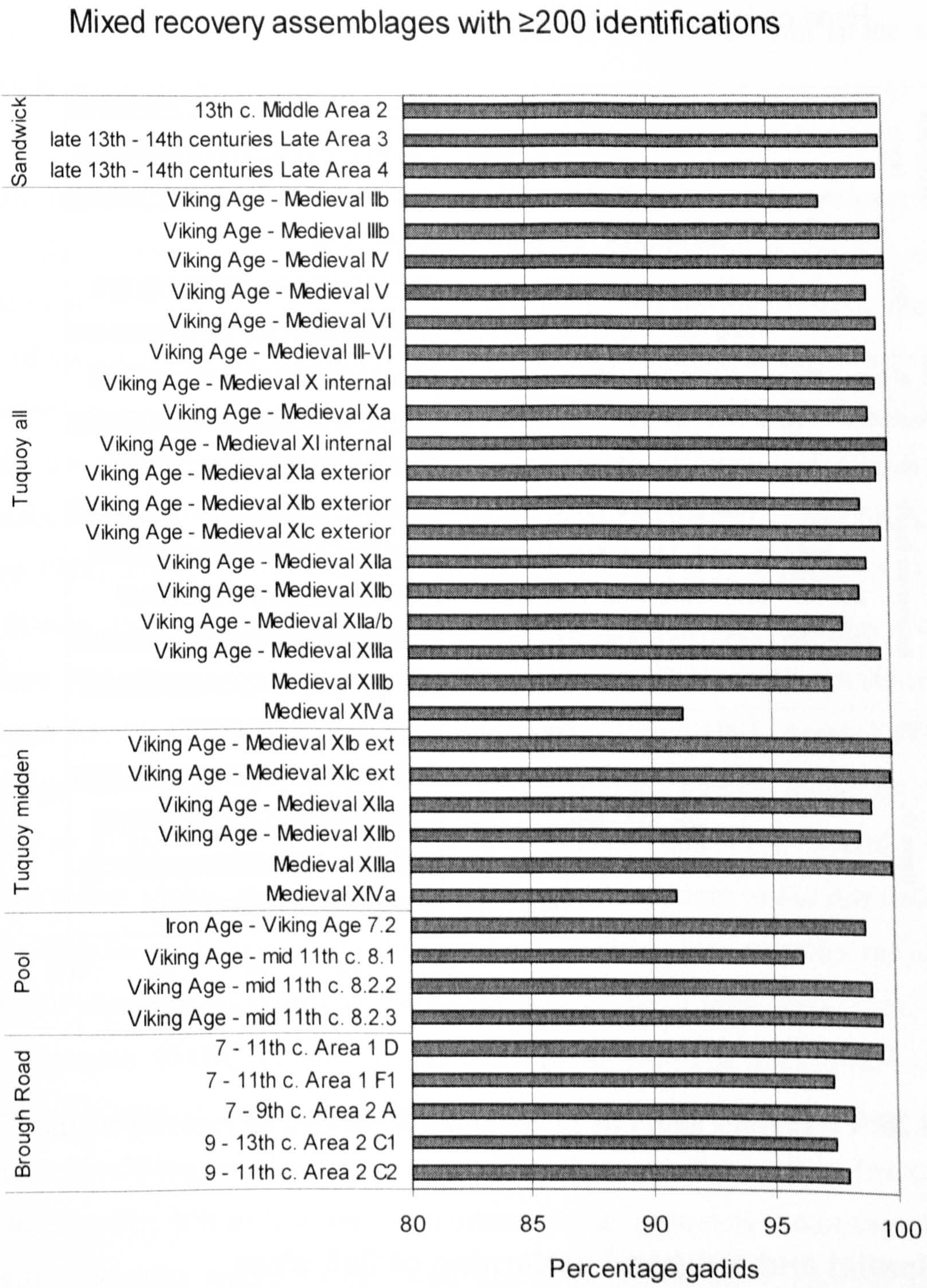
Table 8.19: Significant Chi-Square results for sieved species distributions of cod, saithe, pollack and ling from Robert's Haven

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	502.592	12	0.000	2 cells with expected counts <5.0
Inland area 3 vs. 9	223.119	3	0.000	2 cells with expected counts <5.0
NCA area 4 early vs. late phases	48.437	3	0.000	1 cell with expected counts <5.0
SCA areas 11-14, NCA area 4 earlier phases	42.947	3	0.000	

Table 8.20: Significant Chi-Square results for species distributions of cod, saithe, ling and haddock from Freswick

Sieved assemblages with ≥300 identifications




Mixed recovery assemblages with ≥200 identifications
Sandwick
13th c. Middle Area 2
late 13th - 14th centuries Late Area 3
late 13th - 14th centuries Late Area 4
Tuquoy all
Viking Age - Medieval IIb
Viking Age - Medieval IIIb
Viking Age - Medieval IV
Viking Age - Medieval V
Viking Age - Medieval VI
Viking Age - Medieval III-VI
Viking Age - Medieval X internal
Viking Age - Medieval Xa
Viking Age - Medieval XI internal
Viking Age - Medieval XIa exterior
Viking Age - Medieval XIb exterior
Viking Age - Medieval XIc exterior
Viking Age - Medieval XIIa
Viking Age - Medieval XIIb
Viking Age - Medieval XIIa/b
Viking Age - Medieval XIIIa
Medieval XIIIb
Medieval XIVa
Tuquoy midden
Viking Age - Medieval XIb ext
Viking Age - Medieval XIc ext
Viking Age - Medieval XIIa
Viking Age - Medieval XIIb
Medieval XIIIa
Medieval XIVa
Pool
Iron Age - Viking Age 7.2
Viking Age - mid 11th c. 8.1
Viking Age - mid 11th c. 8.2.2
Viking Age - mid 11th c. 8.2.3
Brough Road
7 - 11th c. Area 1 D
7 - 11th c. Area 1 F1
7 - 9th c. Area 2 A
9 - 13th c. Area 2 C1
9 - 11th c. Area 2 C2
80
85
90
95
100
Percentage gadids

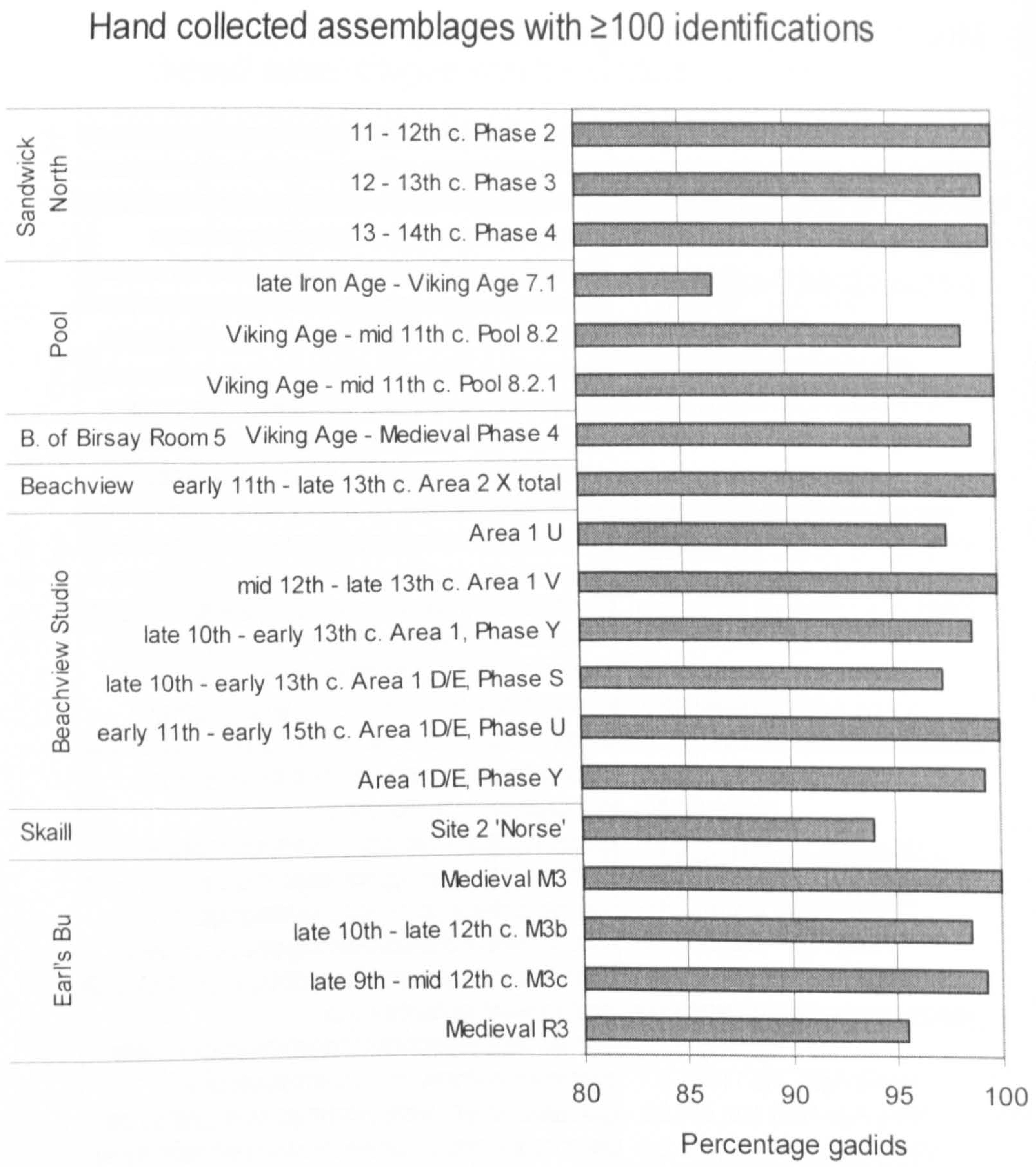


Figure 8.28: Percentage gadid by phase and site, divided by recovery method

8.3.2 Spatial and temporal patterning of fish sizes

Having considered patterning at the order, family and species level, it is now possible to look at total length estimates for cod, saithe and ling, the three major species found throughout the Northern Isles. Most of the sites with sieved or mixed recovery have provided some data on fish sizes, which makes it possible to compare at both the intra-site level, as well as between sites and through time. This is made easier by the standard set of measurements taken from fish bones, which can be turned into total length estimates by the use of regression equations. Each species shall be examined separately. Most of the evidence for haddock has already been discussed above, in the context of Earl's Bu, so although this is an important economic species, it will not be further discussed in this section. Ling was found at low levels throughout the Northern Isles, but there was little size variation; therefore, the focus of this section will be the variation found within cod and saithe sizes.

Perhaps surprisingly, fish sizes were not as influenced by variation in recovery methods as inter-class proportions or fish NISP data. Of the sites that have size data available, almost all are of mixed recovery, and only a few have total sieving. Instead, the greatest cause of variation was the analytical method used to determine sizes. Most sites used regression equations applied to a standard suite of measurements, and were therefore directly comparable. These include Sandwick North (Barrett and Oltmann 2000, Appendix C), Sandwick (Bigelow 1984, Figs 22-26), Quoygrew (Chapter Five), Tuquoy (Colley 1988), Pool (R Nicholson pers. comm. in Barrett 1995, Appendix 5.5), Brough Road (Colley 1989, Illus. 177-180, Microfiche A9-E5), the Beachview sites (Colley and Rackham 1996, Illus. 135-36), Earl's Bu (Chapter Four), Robert's Haven (Barrett 1995, Appendix 5.6; RL Parks pers. comm.) and Freswick (Barrett 1995, Appendix 5.5; Jones 1995, Figs. M74-M86). The elements used to determine fish total length estimates are included in all size histograms, presented as Appendix Figures 6.1 to 6.38. For these sites, the author applied the standard set of regression equations to the raw datasets (see Chapter Two for methods). Three sites used only ordinal size categories recorded for a number of elements: Scalloway (Cerón-Carrasco 1998a, Tables 33-37), St. Boniface (Cerón-Carrasco 1998b, Tables 50, 53) and Saevar Howe (Colley 1983b, Fig. 23). Although this method was also used at Quoygrew and Earl's Bu, and proved a valuable means for identifying populations of prepared fish that were distinct from fish caught and consumed locally, it is of less use when attempting to accurately reconstruct fish sizes. The size categories tended to be broad and thus lacked the resolution needed for comparison. The results from Scalloway and Saevar Howe are additionally limited because the fish sizes were quantified by MNI, rather than NISP. The figures that examine inter- and intra-site patterning across the Northern Isles are therefore divided into two datasets: those with metrical data, and those with only broad size categories. The few sites that were recovered with total sieving have been highlighted in bold type on these figures.

Often, measurements from a range of context types had to be combined together at the phase group level because there are relatively few measurable bones in any one deposit.

All of the measurable bones from the two Beachview sites were grouped together in the site report to provide a large enough sample size, despite being from a diversity of context types. That said, the majority of bone was derived from deposits classed as midden, so the overall pattern reflects midden material more than any other context type. However, any correlation between fish sizes and deposit types cannot be studied.

Cod total lengths have been summarised in Figure 8.29, for all sites and phase groups with metrical data, and in Figure 8.30, for those with size category data. These figures illustrate both the major modes – those represented by greater quantities of fish – as well as the minor modes, divided into 50mm intervals. There is no immediate patterning visible by recovery method. It may be expected that the three sites with total sieving might be less biased than those with mixed recovery. However, given that most cod were of 500mm total length or larger, the measurable elements from these could probably be recovered during hand collection; certainly the largest gadids of at least 800mm total length could be recovered from hand collection. As will be discussed below, saithe tended to be smaller than the cod, so might be more susceptible to recovery biases.

Most phase groups have bimodal distributions of cod, indicating the exploitation of two or more separate populations. The few phase groups with unimodal distributions are phase 7 at Pool (dating to the Iron Age – Viking Age transitional period) and the combined Beachview sites (dating to the late Viking Age to medieval periods). Phases 3 and 4 from Sandwick North may appear unimodal, but the small sample size makes these difficult to interpret, and Tuquoy phase X appears unimodal but again has a small sample size. Appendix Figure 6.8 illustrates the regression based histograms for each phase group at Tuquoy, indicating a very slight bimodality for phase X. The combination of different sites and phase groups may account for the single mode at the Beachview sites, but the unimodal distribution at Pool, phase 7, is more difficult to explain. Although there was a range of cod from 600mm to 1200mm from this phase group, with an emphasis on 1000mm and longer, the lack of a bimodal distribution suggests that the fishing strategies were very different from the Viking Age and medieval periods. The recovery methods were mixed, including both hand collection and sieving to 3mm, but the proportions sieved are not (yet) known. These results could therefore be biased towards larger fish. Unfortunately, no other phase group dates to this transitional period and has similar metrical regression data available to test this hypothesis, but in the absence of other correlates, this might be a temporal pattern.

Within the bimodal distributions, two broad patterns are visible in Figure 8.29. First, several phase groups have a major mode in the region of 800 to1000mm or greater, with a minor mode around 400 to 700mm. Examples of this pattern include a variety of sites from the Northern Isles, including Sandwick North phase 2, Sandwick early and late, Tuquoy phase XII, Pool phase 8 and Freswick SCA and non-SCA. The phase groups from the Brough Road may be added to this, but small sample sizes, as shown in Appendix Figure 6.10, have made this difficult to interpret. Secondly, some phase groups have a major mode around 400-700mm, and a minor mode around 800mm and greater. Examples of this trend include Quoygrew ii, Tuquoy XI and XIII, Earl's Bu early and later phase groups, and Robert's Haven phase 1 area A. The measurable elements from Quoygrew, Robert's Haven and Earl's Bu were recovered by sieving to 2mm, with some hand collection at Earl's Bu. Tuquoy recovery included sieving to 1mm and 5mm, as well as an unknown proportion of hand collection. The greater quantity of smaller cod at these phase groups, compared to others, could be a recovery bias. However, recovery at Freswick was only by 2mm sieving, which suggests the pattern observed there is unbiased by recovery variation, but Sandwick North, Sandwick and Pool have mixed recovery of unknown proportions. This could explain their tendency toward larger cod. It is likely that a combination of recovery biases and deliberate fishing strategies are reflected in these patterns.

There are few chronological trends visible in these size patterns, although there is some variation in both time and space. Using the total length histograms (Appendix Figures 6.1 to 6.38), it is possible to study the main and secondary modes in greater detail than is displayed in Figure 8.29. Within the first bimodal pattern, which has more of the larger fish, the main mode slightly decreases in length through time at Sandwick North (phases 2 to 3), remains unchanged at Sandwick, remains unchanged at Pool, and possibly increases at Freswick. Most of this variation within the primary mode of the first pattern is very slight. It is worth noting, moreover, that the measurements taken from different elements cause minor variations in total length estimates, but sample sizes were too small to focus solely on a single measurement from a single element.

The main mode of the second pattern – sites which have higher quantities of smaller cod – also indicates little change through time at the intra-site level. Only two sites have this second pattern in more than one phase group. At Tuquoy, the primary mode remained unchanged through time into the medieval period, but at Earl's Bu, this primary mode markedly decreases from the late 9th to mid 12th century deposits into the more broadly dated medieval phase groups.

Looking next at the minor modes within each of these two patterns, slightly more variation is visible. The minor mode of the first pattern remains unchanged at Sandwick North, decreases at Sandwick and increases substantially at Freswick. The minor mode of the second pattern remains unchanged at Tuquoy and slightly decreases at Earl's Bu. Although there is some variation, there appears to be very little spatial or temporal patterning at the intra-site level.

What is rather more interesting is to examine the sites where there is a more dramatic shift in fish sizes through time, that is, where there is a shift from the first pattern to the second, or vice versa. This occurred at Quoygrew between phase ii and phases iii and 2, and at Tuquoy between phases XI and XII. At Quoygrew, the earlier phase ii had an emphasis on the smaller fish, but by phases iii and 2 there were equal proportions of each mode. At Tuquoy, cod sizes became substantially larger between these phase groups. Both of these corresponded to the Viking Age to medieval transitional period, but cannot be dated more accurately until more work is done at Tuquoy. Only one site contained a shift from pattern one to pattern two, between phases XII and XIII at Tuquoy. This is again difficult to date, but it probably took place within the later medieval period.

These two observations can be extended to the inter-site level. Some of the phase groups with pattern two, containing a primary mode in the region of 400-700mm and a larger secondary mode, appear to either date to the Viking Age and early medieval period, or to the much later medieval period from the 13-14th centuries onwards. Phase groups from the 11th to 13-14th centuries tend to fit the first pattern, having the primary mode between 800 and 1000mm. There are, however, weaknesses with this generalising conclusion. The later phase groups from Earl's Bu appear to fit this pattern, but could easily be influenced by the other factors that have already distinguished this site from contemporary deposits. Moreover, phase 1, area A from Robert's Haven, dates to the

11th to 13th centuries yet fits the second pattern. Lastly, this observation assumes that the SCA deposits from Freswick date from the 11th to the 13-14th centuries, which is slightly later than has been previously thought. However, the only intra-site metrical patterning available for Freswick is based on otolith measurements, which can be influenced by breakage patterns and taphonomic biases that do not affect the premaxilla and dentary (at sites where premaxilla, dentary and otolith measurements were available, including Quoygrew, Tuquoy and Robert's Haven, otolith fragmentation severely underestimated the larger fish sizes).

The few sites that were only quantified by size categories, as shown in Figure 8.30, display very broad size ranges. However, although they lack the precision of the metrical data, they do fit these chronological observations. At St. Boniface, there is a shift towards larger cod between phase 7, which dates to the late Iron Age and early Viking Age, and phase 8, dating to the 12th to mid 13th centuries. This was a statistically significant increase in size (greatest difference 0.307, Kolmogorov-Smirnov Z value 1.756, significance 0.004). Then, cod sizes decrease dramatically into phase 9, loosely dated to the medieval period (although this phase group may represent non-anthropogenic deposits (Cerón-Carrasco 1998b, 153)). This was also a significant decrease in size (0.478, 2.079, significance 0.000). At Saevar Howe, there is a general increase in fish size between the late Iron Age phase I and the 8-10th century phase II. Species compositions suggested a similarity between the Iron Age phase I and the 7-9th century phase IIa (see Table 8.18), but only two cod size estimates were recorded for phase IIa, making it difficult to assess change during this crucial sub-phase.

Fish sizes were not explicitly mentioned in the Brough of Birsay Rescue Excavations report, but the cod from the earlier phase groups (late Iron Age to Viking Age) were described as ones that could be caught from the shore, while in the later Viking Age and medieval phase groups the cod, which had become more numerous, were described as caught from boats offshore (Sellar 1982, 133), thus implying an increase in size. Recovery was entirely by hand collection at this site, and the fish were not fully quantified, which makes interpretation difficult. However, assuming the earlier phase group tended more towards the Iron Age, then the increase of fish sizes into the Viking Age and medieval periods would be expected.

The saithe total length estimates are presented in Figure 8.31, for sites with metrical data, and Figure 8.32, for sites with size category data. As mentioned above, the recovery method probably had a greater influence on saithe sizes than on cod, because saithe tended to be smaller and would thus be under-represented in mixed recovery phase groups. However, the sites that were recovered with total sieving (Quoygrew, Robert's Haven and Freswick) tend not have smaller size ranges than those with mixed recovery, suggesting recovery biases were minimal. Pool is the exception to this, because phases 7 and 8 have few small saithe. The proportions of material sieved is not yet known, but this may have underestimated the proportion of small saithe.

Most saithe distributions tend to be bimodal, but there is a subset of phase groups that only have one large mode, or that have a very slight secondary mode of shorter length fish. These phase groups include Sandwick North phase 2 and Pool phases 7 and 8 (the minor mode in phase 8 consists of only one identified bone and therefore this phase group can be considered unimodal). These all have large modes of 700mm or longer, indicating open water fishing with almost no contribution of the small, probably shore-caught fish that are found in quantity at other sites. This pattern at Pool could conceivably be taphonomic, given that little is known about preservation at the site, but this is unlikely to provide an explanation for the lack of small saithe at Sandwick North, given that full taphonomic data are available. Moreover, at Quoygrew, elements from small saithe tended to be better preserved than larger cod or saithe. If this applies to Pool, this pattern may indicate a real absence of small saithe in phases 7 and 8, albeit one possibly enhanced by recovery biases. These three phase groups with unimodal distributions do not form any chronological patterns because they are from a wide chronological range, from the late Iron Age – Viking Age period to the 11th – 12th centuries.

Within the saithe bimodal size distributions, there are again two patterns. The first has a primary mode in the region of 800-000mm, and a secondary mode between 200 and 600mm. Two phase groups fit this pattern, the late phase at Sandwick dating to the late 13th to 14th centuries, and all phase groups from Earl's Bu. At the latter, very few saithe were found overall, as discussed above, which required the grouping of metrical data from all phase groups. The second pattern has a primary mode between 200 to 400mm and a secondary mode of 600 to 800mm and larger. Most phase groups fall within this category, including Sandwick North phases 3 and 4; Sandwick area 2, middle phase; Quoygrew phases iii and 2; the Beachview sites; and Robert's Haven area A (phase 1) and area E. Finally, a few phase groups fall into neither category. Freswick non-SCA (Viking Age to medieval) saithe display a trimodal distribution, Freswick SCA (late Iron Age to Viking Age) saithe are bimodal yet almost none is >600mm total length, and Quoygrew phase ii displays a slightly bimodal distribution, but almost all saithe were between 300 to 600mm in total length. Very few measurable saithe were recovered from the Brough Road sites, but there was little indication of a bimodal distribution. Instead, most saithe there were within the range of 400-800mm.

There was some intra-site variation with the second pattern in which the primary mode comprised smaller fish than the secondary mode. The primary mode remained the same at Sandwick North between phases 3 and 4, remained the same at Tuquoy, and decreased from Robert's Haven phase 1 area A to area E. The secondary mode of longer fish increased in size at Sandwick North and remained the same at Tuquoy. At Robert's Haven, the secondary mode was almost absent in area E, yet was prominent in area A (phase 1, area A contained a significantly different distribution of saithe than the other phase groups, see Table 8.22). This intra-site variation is both chronological and spatial, but given the other evidence for Robert's Haven (discussed below), it appears that small saithe were targeted for domestic consumption in area E in the 14th to 16th centuries, but deep sea, possible commercial fishing of cod and, to a lesser degree, saithe, took place in area A in the 11th to 13th centuries.

Some intra-site variation between patterns of saithe sizes occurred, from unimodal to bimodal, and from the second pattern – a primary mode of smaller fish – to the first. At Sandwick North, almost all saithe in phase 2, dating to the 11-12th centuries, were 600mm or longer. However, by phases 3 and 4, dating respectively to the 12-13th centuries and to the 13-14th centuries, the majority of saithe were between about 250mm and 400mm. There was considerable variation between the middle and late phases at Sandwick. This was statistically significant, but most significant differences were between the middle phase, area 2, and all other areas and phase groups (see Table 8.21 for details). The middle phase, area 2 deposits consisted almost entirely of saithe of 200-400mm, whereas saithe in the late phase were mostly of 700-1000mm total length. The lack of saithe in the contemporary middle phase areas 3 and 4 suggests that this pattern is spatial, rather than chronological. At Freswick, the primary mode consisted of saithe of about 150-200mm, in both phase groups. A secondary mode consisted partly of 300-400mm saithe in both phases, but then in the later Viking Age to medieval deposits, this secondary mode extended to 700mm, and a third mode of 800-1000mm fish was also present. This pattern is mainly chronological, and suggests a greater exploitation of larger saithe, probably caught in deeper water, over time.

At the inter-site level, there is little spatial or chronological patterning in saithe size estimates. Most sites tend to have large quantities of small saithe that could be caught from coastal waters, and these appear to have been a resource exploited throughout the Northern Isles. There is a slight tendency for saithe from the earlier phase groups to be bigger, as observed at Sandwick North phase 2 (11th – 12th century), Quoygrew phase ii (late 8th – late 10th century), Pool (late Iron Age to Viking Age) and Robert's Haven phase 1 area A (11th – 13th century). The Brough Road deposits that date from the 7th century to the medieval period also fit this pattern, but neither the Freswick late Iron Age to Viking Age deposits, nor the earlier phase groups at Tuquoy of Viking Age to medieval date, do so. However, it can be observed in some of the general size categories illustrated in Figure 8.32. The late Iron Age to Viking Age Scalloway saithe tend to be slightly larger than most. At Saevar Howe, species composition suggested phase IIa was closely related to the Iron Age phase I. The saithe sizes fit this pattern, showing that most of the saithe in phases I and IIa were <300mm, before increasing in phase IIb. Unfortunately, quantification by MNI has made these phase groups difficult to interpret further.

The medieval phase 9 St. Boniface saithe were smaller than those from phase 8, which dated to the 12th to mid 13th centuries (statistically significant decrease in size over time, greatest difference 0.595, Kolmogorov-Smirnov Z value 8.069, significance 0.000). Interestingly, the saithe from phase 7, which dated to the late Iron Age and did not extend into the Viking Age, were significantly smaller from those from phase 8, the 12th to mid 13th centuries (0.311, 2.669, 0.000).

Comparisons between the cod, saithe and ling total lengths can further illuminate spatial and temporal patterning. If deeper sea fishing for large cod was taking place, the presence of saithe of a similar size might indicate that they were being processed in a similar way, or that they were caught accidentally. All ling caught tended to be of a large size, of at least 800mm total length (the few phase groups with sufficient size data are illustrated in Appendix Figures 6.35 to 6.38). Most sites with large cod of 800mm and longer tended to also have saithe of approximately this size, but in much smaller quantities. Sandwick North phase 4 was an exception, because there were approximately equal quantities of 800-1000mm saithe and cod. At Robert's Haven, phase 1 area A, there tended to be more saithe than cod of 1000mm and longer, possibly indicating an intentional exploitation of these extremely large saithe. Finally, the larger cod from Freswick SCA are primarily from 700-1000mm long, but there are almost no saithe of that size, indicating deliberate exploitation of only the larger cod during that late Iron Age to Viking Age phase group. However, by the Viking Age to medieval phase groups at Freswick, large saithe of 800mm and longer were found in conjunction with higher quantities of similarly sized cod. Some of these differences may be attributable to the exploitation of different habitats, with varying proportions of each species. Ethnohistorical sources can be useful (e.g. indicating the easy availability of small saithe throughout the Northern Isles, but also indicating that the larger saithe tended only to be found around Shetland (Low 1813, 194)) but reconstructing fishing habitats is difficult given the modern changes to fish stocks (Clover 2004).

Overall, the spatial and temporal patterning of fish total length estimates can be summarised as follows:

- Cod total lengths are mostly bimodal, except Pool phase 7 (late Iron Age to Viking Age); typically one mode is in the region of 500-700mm and the other around 900-1000mm
- Two chronological shifts in cod total lengths were observed, first increasing in size from the late Iron Age – Viking Age deposits into the 11th to 13-14th centuries, then decreasing in size into the later medieval period
- The cod from Robert's Haven phase 1, area A, do not fit this pattern because they are primarily of 400-700mm, whereas contemporary deposits tend to contain larger cod
- Saithe total lengths are mostly bimodal, with one mode around 100-300mm and another about 800mm, but three phase groups have unimodal distributions of large saithe of 700mm and longer:

    - Sandwick North phase 2 (11th to 12th century)
    - Pool phase 7 (late Iron Age to Viking Age) and phase 8 (Viking Age to mid 11th century)
- Most phase groups contained large quantities of 200-400mm saithe, probably caught from the shore or by inshore fishing, and smaller quantities of 600-800mm and larger saithe, probably caught during deeper sea fishing
- Freswick saithe have a bimodal distribution in the SCA deposits (late Iron Age to Viking Age), yet almost none is longer than 600mm; in the non-SCA (Viking Age to medieval) deposits saithe have a trimodal distribution
- Very few saithe were found at Earl's Bu overall; of those, most were 800-1000mm and some were 200-600mm
- The earlier phase groups have a slight tendency towards larger saithe and the later phase groups have a slight tendency towards smaller saithe, but not all sites fit this pattern, nor is there sufficient chronological resolution to test this
- Ling are found at low levels throughout the Northern Isles and are predominantly 800mm and longer

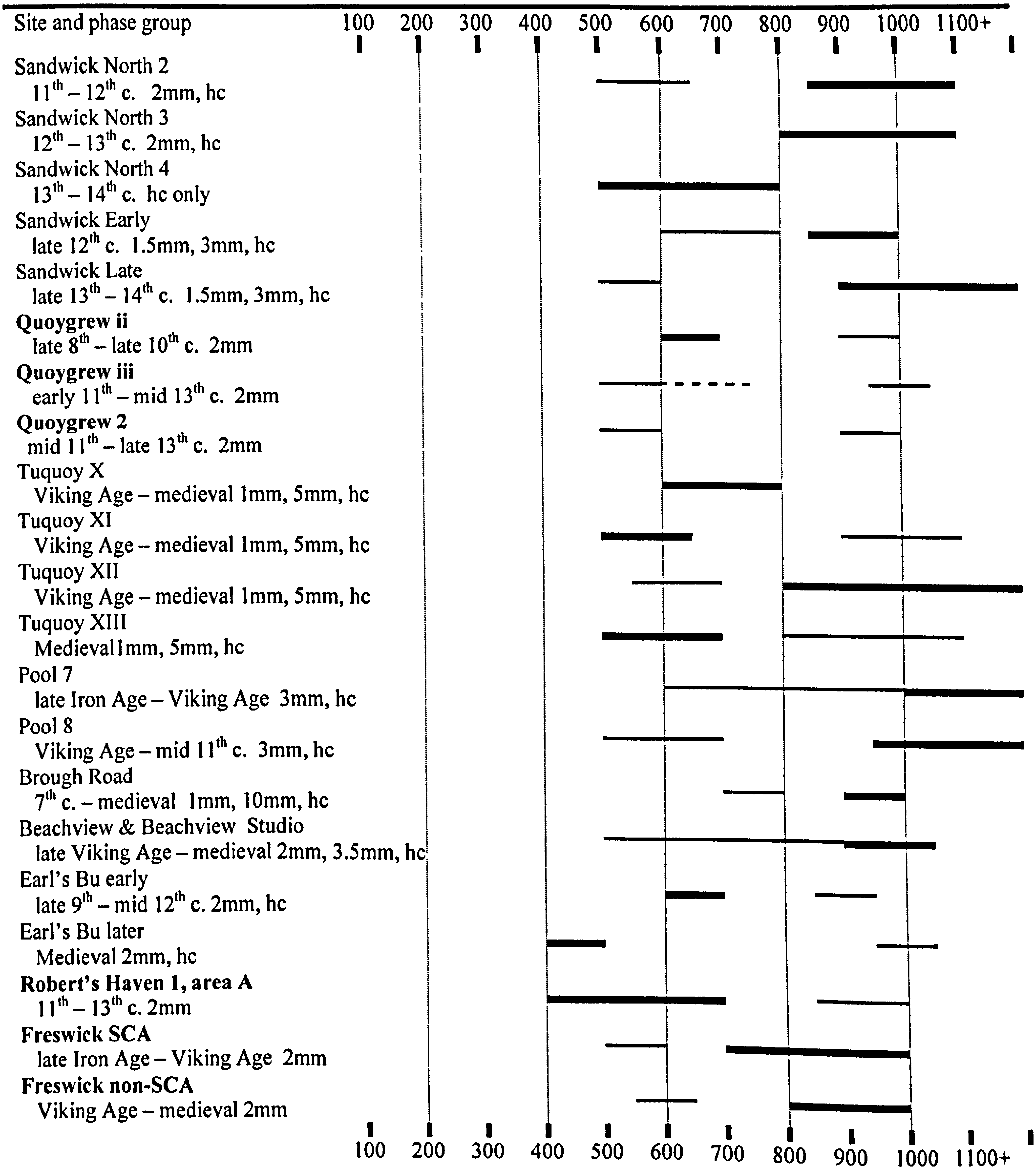


Figure 8.29: Cod total lengths (mm), primary and secondary modes (darker and lighter lines), determined using metrical data and regression equations, sites in bold are fully sieved, sieve sizes are indicated

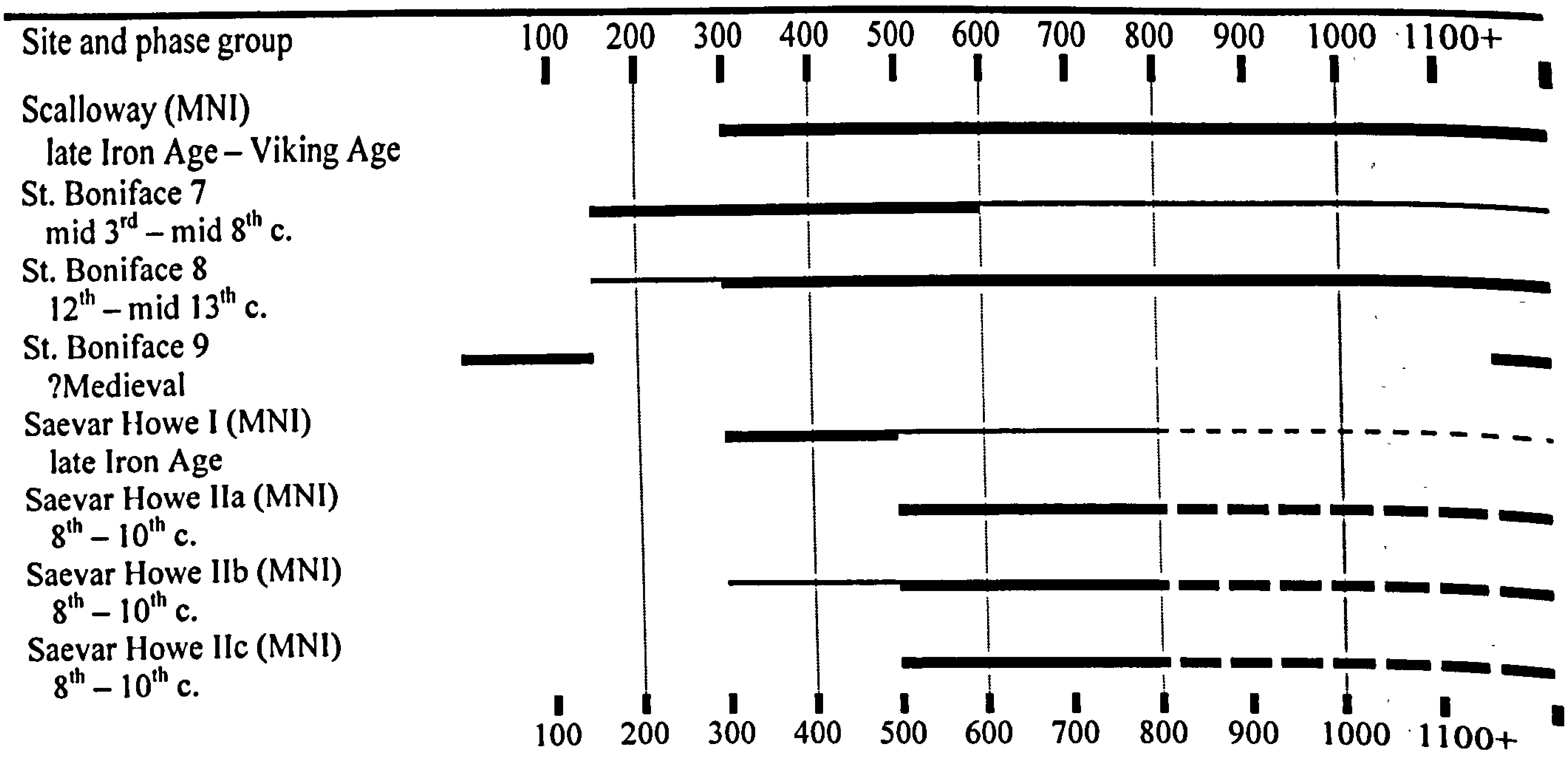


Figure 8.30: Cod sizes (mm), primary and secondary modes (darker and lighter lines), determined using general size categories only

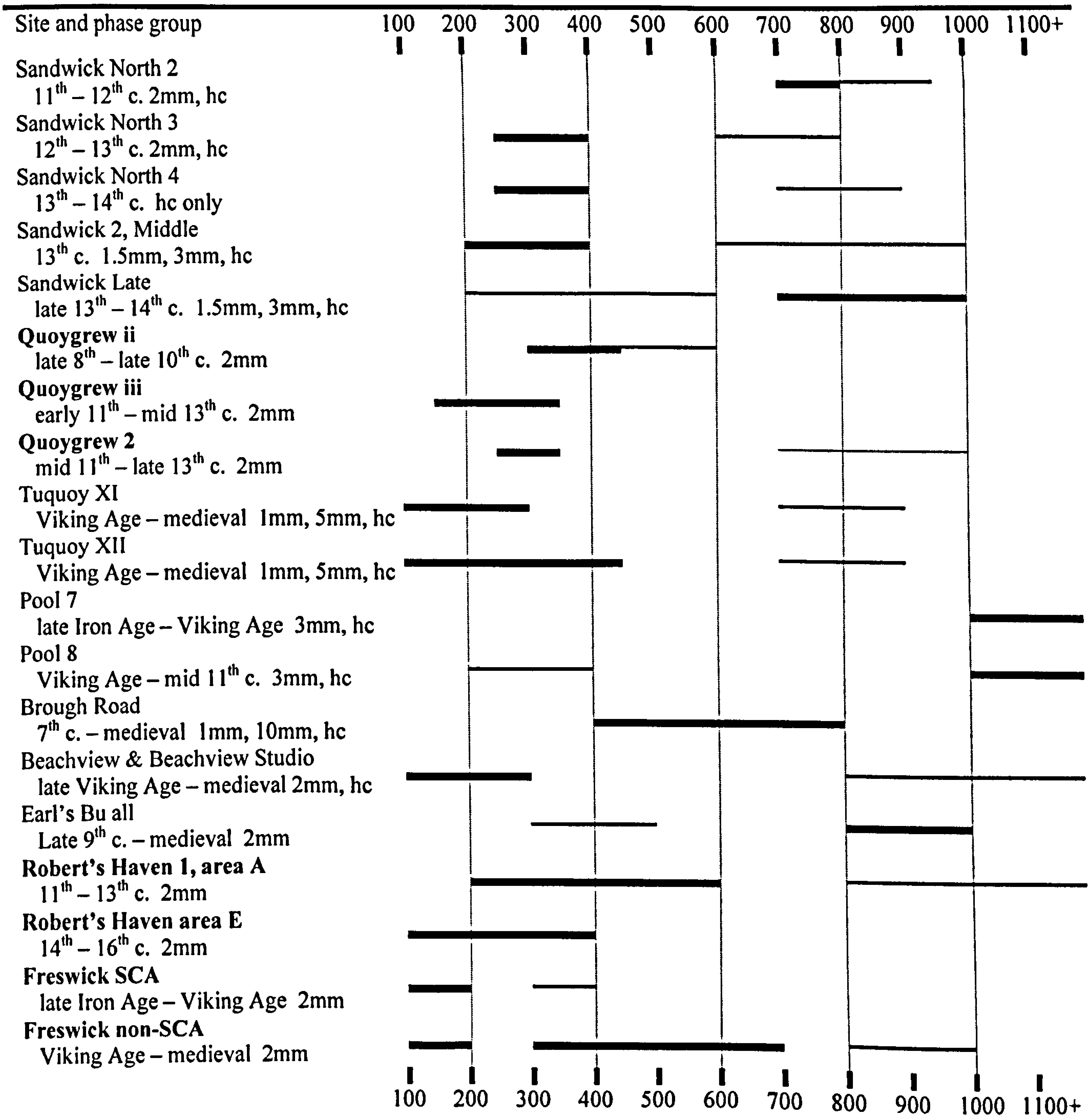


Figure 8.31: Saithe total lengths (mm), primary and secondary modes (darker and lighter lines), determined using metrical data and regression equations, sites in bold are sieved, all others are of mixed recovery

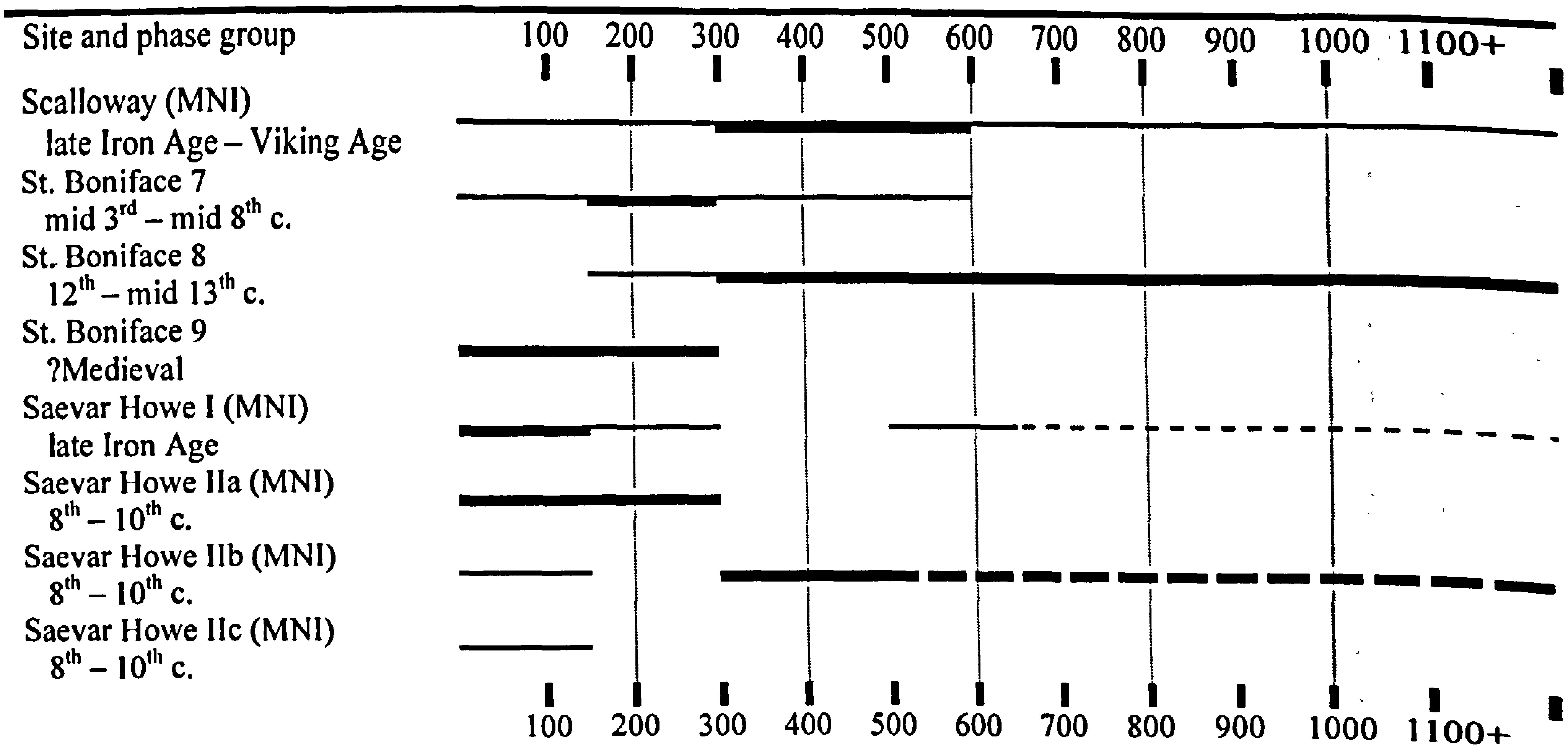


Figure 8.32: Saithe sizes (mm), primary and secondary modes (darker and lighter lines), determined using general size categories only

Element	Phases and areas	Kruskal-Wallis tests		
		Chi-Square	Degrees of freedom	Significance
Premaxilla	All	177.919	6	0.000
Dentary	All	197.982	4	0.000
		Mann-Whitney tests		
		U value	Z value	Significance
Premaxilla	Early, areas 3 and 4	3	-2.5	0.012
	Early area 3, Middle area 2	14	-4.651	0.000
	Early area 4, Middle area 2	170	-2.495	0.013
	Middle, areas 2 and 3	5.5	-3.935	0.000
	Middle, areas 3 and 4	9	-3.873	0.000
	Late area 3, Middle area 2	508	-11.855	0.000
	Late area 4, Middle area 2	64	-9.281	0.000
Dentary	Early area 3, Middle area 2	4.5	-2.020	0.043
	Middle, areas 2 and 3	66	-4.745	0.000
	Late area 3, Middle area 2	512.5	-12.346	0.000
	Late area 4, Middle area 2	161.5	-10.566	0.000

Table 8.21: Significant Kruskal-Wallis and Mann-Whitney tests for saithe premaxilla and dentary first measurements from Sandwick

Element	Phases and areas	Kruskal-Wallis tests		
		Chi-Square	Degrees of freedom	Significance
Premaxilla	All	52.022	3	0.000
Dentary	All	45.288	3	0.000
		Mann-Whitney tests		
		U value	Z value	Significance
Premaxilla	Phase 1, areas A and B	187	-2.379	0.017
	Phase 1, area A and area E	1090.5	-7.028	0.000
	Phase 1, area A and phase 2, area B	292	-2.745	0.006
Dentary	Phase 1, areas A and B	62	-3.235	0.001
	Phase 1, area A and area E	829.5	-5.98	0.000
	Phase 1, area A and phase 2, area B	193	-2.784	0.005

Table 8.22: Significant Kruskal-Wallis and Mann-Whitney tests for saithe premaxilla and dentary first measurements from Robert's Haven

8.3.3 Spatial and temporal patterning of butchery marks and element distributions

The evidence for butchery marks and element distributions can be grouped together, because both can be used as indicators of fish processing and trade. Although the evidence was substantial for both butchery and element distributions at Earl's Bu and Quoygrew, most of the comparative material has less detail available. Element distributions and butchery evidence for most of the comparative sites used in this study were recently reviewed by Barrett *et al.* (1999, 370-74). Rather than assessing the raw data again, the results from this recent paper shall be used, in conjunction with the new data available for Quoygrew and Earl's Bu, as well as Sandwick North and Robert's Haven areas B and E, not included in Barrett, *et al.* Original sources have also been used where required, but given the large variety in analytical methods employed – limiting inter-site comparison – these data do not warrant a full, quantitative approach. Analytical methods vary as to the elements quantified, and few comparative studies have taken into account element fragmentation patterns, despite these having a considerable influence on the relative representation of different parts of the skeleton (see Chapters Four and Five for examples from Earl's Bu and Quoygrew). The division of the vertebral column into a number of separate sections is crucial to determine patterning within the vertebrae, which can be used as an indicator of prepared fish arriving or leaving a site, but few analysts have explicitly defined their methods. Inter-site comparisons of relative element representation is therefore difficult. Butchery marks were usually summarised for each site, and when illustrations have been provided, these are relatively easy to compare at the inter-site level. Little or no useful element or butchery data was available for the assemblages from Saevar Howe, Buckquoy, Brough of Deerness, Skaill and Newark Bay, but some evidence was available for all other sites. Each site with evidence will be briefly discussed in turn, in geographical order, before summarising the inter-site patterns.

At Sandwick North, element proportions were interpreted as representing all of the fish skeleton for all species and sizes, with any over- or under-representation being explicable by taphonomic factors (Barrett and Oltmann 2000, 12). Thus, all parts of the fish were being consumed at Sandwick North. However, butchery marks at Sandwick North indicate the preparation of gadids in phases 2, 3 and 4, consistent with the production of dried fish (Barrett and Oltmann 2000, 10). Species with butchery marks included cod, saithe, torsk and ling, and elements marked included cleithra, posttemporals, supracleithra and vertebrae. Evidence indicated decapitation, splitting along the vertebral column, and separation of the anterior vertebrae from the posterior; this evidence is consistent with preparation of dried fish. As there is no evidence of these leaving Sandwick North, it appears likely that the fishery of large gadids was for domestic consumption and storage from the 11th to the 14th centuries.

At Sandwick, Bigelow examined the relative proportions of cranial to vertebral elements, though without providing raw data. He detected an unusual pattern in the middens from area 3 of the Late phase, which either contained an under-representation of vertebrae or an over-representation of cranial elements compared to other areas and phase groups (Bigelow 1984, 128). It is difficult to interpret this as evidence for fish processing without a better understanding of taphonomic processes, element representation, element sizes or butchery patterns, but it is hoped this site will soon be published. This may be evidence of intensive processing of large cod, saithe and ling, whereby the caudal vertebrae were removed from the site with the prepared product.

The cod and ling from Scalloway late phase 3 and Block 7.1 are within the size range of deep water fish caught for preparation and drying (see section 8.3.2). Butchery marks were found on gadids from 300mm to over 1200mm in length from Block 7.1, including at least one posttemporal (Cerón-Carrasco 1998a, 119). In the absence of any element quantification, it is difficult to positively identify the processing of large gadids or any imports or exports of processed fish from the site.

Element distribution data for gadids from St. Boniface phase 8 were provided, but these combine all sizes from all gadids, making it impossible to see if the larger cod and saithe have a different element pattern than the smaller ones (Cerón-Carrasco 1998b, Tab. 38). The vertebrae appear vastly overrepresented, but once the number of vertebrae within each fish have been taken into account, there appears to be only a slight over-representation of vertebral elements compared to cranial and appendicular elements. The position in the vertebral column was not provided, making it impossible to ascertain varying proportions of anterior and caudal vertebrae. Any interpretation of differential element representation, used to infer fish processing, is therefore reliant on the presence or absence of cranial elements. The cleithrum is present but is the second least abundant element. Taphonomic considerations were not discussed, but overall preservation appears to have been good, given the wide range of elements and sizes recovered. Based on abundance, the cleithra may be under-represented (also suggested by Cerón-Carrasco 1998b, 154).

Twenty butchery marks were found at St. Boniface, all from phase 8, on dentaries, maxillae, posttemporals, supracleithra, vomers and vertebrae from large gadids. One of the few cleithra from a gadid larger than 1200mm was "deliberately pierced, possibly for hanging up the [prepared] fish for easy transportation" (Cerón-Carrasco 1998b, 153; 1998c, 78). The vertebrae were not illustrated or described other than as "asymmetrically cut" (Cerón-Carrasco 1998b, 153), which might be interpreted as evidence for axial splitting. The butchery and element evidence combined may suggest some prepared fish were removed from the site.

Further evidence for fish processing in phase 8 at St. Boniface is suggested by the large quantities of ash deposits. These were possibly created during the rendering of fish livers into oil. The small saithe caught in large numbers at St. Boniface were ideal for liver oil production (Cerón-Carrasco 1998b, 154).

Individual element counts were not provided at Tuquoy. Groupings of vertebrae, cranial elements, jaw bones etc. were included, but these do not give the required resolution to determine patterning of cleithra, anterior abdominal and caudal vertebrae. Colley argued that "[t]here was no evidence in any context for over- or under-representation of skeletal elements which might suggest large scale butchery or fish processing... Differences in the relative representation of skeletal elements... can probably all be explained by differential preservation and sample sizes" (1988, 3-4). Butchery marks were found, primarily on the large gadids, and conform to the pattern observed in the Northern Isles (i.e. on the cleithra, supracleithra, posttemporals and on vertebrae) (Colley 1988, unlabelled butchery diagrams). However, there were very few cuts to the vertebrae, and none could be attributed to practice other than filleting (Colley 1988, 4). Barrett *et al.* (1999, Fig. 8) interpreted the relatively low proportions of appendicular elements compared to cranial as possible evidence that the Tuquoy material was butchery waste, but in the absence of taphonomic data, definite butchery marks, and full element data, this cannot be stated with certainty.

Element distributions for the Pool gadids were discussed qualitatively by Nicholson (1998), who determined that any proportional variation in elements resulted from differential taphonomic preservation of the various elements. It therefore appears that no under- or over-representation of cranial, appendicular or vertebral elements occurred, i.e. there was "no convincing evidence for stockfish production at Pool" (Nicholson 1998, 26). Until more data become available, including the butchery evidence, it must be concluded that there was no preparation, import or export of any prepared fish at Pool.

Full element quantification was provided for the main gadids at the Brough Road sites, but the variation in recovery methods and the small sample sizes of each phase group made interpretation difficult. There did not appear to be any over- or under-representation of elements associated with fish processing (Colley 1989, 255, Tab. 30, Microfiche A9 to E5), but taphonomic and recovery biases may have hidden any patterning. Butchery marks were found on 44 gadid bones, including the cleithra, supracleithra, posttemporals and vertebrae (Colley 1989, Illus. 181). However, these alone are inconclusive evidence of gadid fish processing for trade.

Beachview and Beachview Studio elements were presented by phase in microfiche, but hand collected and sieved bone was combined (Colley and Rackham 1996, Tab. M9); the results are therefore biased towards the larger and more robust elements. It is difficult to assess element distributions for any evidence of fish processing, but all element proportions can probably be explained by taphonomic patterning rather than any import or export of prepared fish. Thirteen butchery marks were found on large gadids, including some on the post-temporals, supracleithra and cleithra that match others found in the Northern Isles (Colley and Rackham 1996, Illus. 134). However, none were found on the vertebrae. Overall, the large gadids were probably caught and consumed locally.

At Skaill, butchery marks were found on gadid supracleithra, post-temporals and ceratohyals, but not on vertebrae (Nicholson 1997, 245). These could be suggestive of processing for dried fish production, but no conclusive proof is available, and the absence of sieved material makes this site difficult to interpret.

The published results from Robert's Haven indicated that cleithra were underrepresented compared to cranial elements (Barrett 1997, 631). This was particularly apparent when contrasted with the interim evidence from Earl's Bu, which had much higher proportions of cleithra: "the under-representation of cleithra at Robert's Haven was probably a behavioural rather than taphonomic pattern" (Barrett 1997, 632). The cut mark pattern on larger gadids indicated butchery was consistent with the production of dried fish, and compared to evidence at Earl's Bu, much of the fishbone at Robert's Haven was probably processing waste (Barrett 1997, 628; Barrett *et al.* 1999, 371, 373). The presence of many groups of articulated vertebrae are also consistent with butchery during the production of dried fish (Barrett 1997, 625-26). The unpublished data produced two additional butchery marks consistent with fish processing, both on the posttemporals of gadids of 500-800mm total length from area E (RL Parks pers. comm.). Although there is no definitive evidence of the removal of the finished product from the site, it is likely that both domestic consumption and exportation would have occurred.

The evidence from Robert's Haven phase 1 area 1 is similar to that from Quoygrew phase 2, the fish midden. Both date from the 11th to the 13th centuries. Proportions of cleithra were low at both compared to cranial elements, and differing proportions of abdominal versus caudal vertebrae suggested some had been removed from each site.

Robert's Haven produced more butchery evidence than Quoygrew (see Chapter Five), but both sites contained the distinctive cut marks to the vertebral column in the transverse plane, indicating butchery to sever the vertebra and discard the anterior vertebrae prior to preserving the processed fish.

The element distributions for Freswick are difficult to use because only four elements were identified for most phase groups, and although cleithra were included, there is little to compare them to. Furthermore, vertebrae were only recorded for some phase groups, but for the majority there was no division into abdominal and caudal. It is therefore difficult to assess element variation in order to identify prepared fish production, importation or exportation. Jones tried to do so, but concluded that the "numbers of fragments of cleithra are consistently lower than the numbers of dentaries, otoliths and premaxillae... the low numbers of cleithra may be attributed to differential decay rather than human activity" (Jones 1995, 190). Certainly for the phase groups where elements were fully quantified, there was no obvious patterning. Although there was evidence of butchery on gadid cleithra, supracleithra and other elements (Jones 1995, Tab. 25), because the vertebrae were not identified from every phase group, evidence of processing, if present, was lost.

In summary, the necessary evidence was not recorded from most sites, making it difficult to assess fully butchery patterns and the import or export of a dried product. Of the sites with some evidence, these can be divided into four types:

- Evidence of butchery to create a dried product, which was used locally and not removed
    - Sandwick North phases 2, 3 and 4 (11-14th century)
- Evidence of butchery to create a dried product, which was then removed from the site
    - Possibly Sandwick late phase area 3 (late 13th to 14th centuries)
    - Quoygrew phase 2 (mid 11th to mid 13th century)
    - St. Boniface phase 8 (12th to mid 13th century)
    - Robert's Haven phase 1 area A (11-13th century)
- No evidence of butchery to create a dried product

    - Possibly Viking Age to medieval phase groups from Tuquoy, but needs further work
    - Possibly some Viking Age to medieval phase groups from Pool, but final publication may reveal more information
    - Brough Road (7-13th century)
    - Beachview and Beachview Studio (late 10th to early 15th century)
- Evidence of butchered, dried fish arriving at the site
    - Earl's Bu later phase groups (M3b and M3c dated to the 10th to late 12th century, but M3 was only approximately dated to the medieval period)

The four sites with evidence for the production and removal of dried fish all date within the mid 11th to 14th centuries, although there is no overlapping date range between Sandwick and the earlier deposits from Quoygrew and St. Boniface. These are approximately contemporary with the late midden deposits at Earl's Bu, where there is evidence of dried fish being imported. While it is possible that some of the Earl's Bu processed cod originated at Sandwick, Quoygrew, St. Boniface or Robert's Haven, these sites did not process the large quantities of haddock found at Earl's Bu. The origin of the haddock is unknown at present, but further work in the Northern Isles may produce a production site with large quantities of haddock cranial elements. As seen from the excavations at Quoygrew, middens may be located only a short distance from each other, but they can be contemporary and yet serve different functions.

8.3.4 Fish bone summary

Any attempt at a concise summary of inter-site fishbone patterning must consider the interplay of a number of variables surrounding taphonomic and recovery biases, recording and inter-analyst variation and interpretation of published results. That said, a number of spatial and temporal patterns running through the entirety of the Northern Isles deposits can be recognised.

The proportion of gadids exploited increased through time, from the late Iron Age into the Viking Age and medieval periods. Within the gadids, proportions of cod, saithe and haddock varied according to time and space, while ling was present at low levels throughout most phase groups, and minor species like pollack and torsk were found in varying but mostly low proportions. Non gadids were exploited, but always as very minor fisheries, although there is a slight correlation between salmonids and eels being exploited at sites with access to fresh water streams.

The proportion of cod found in the Northern Isles increased from the Iron Age to the Viking Age, while saithe decreased. This pattern then reversed, with saithe increasing in quantity into the medieval period while cod decreased. Cod also increased in size from the Iron Age to the 11th to 13th and 14th centuries, before later decreasing in size into the later medieval period. Saithe sizes indicated a slight tendency towards being larger in the earlier phase groups and smaller in the later phase groups, but not all sites fit this pattern, suggesting local variation was partly responsible for this pattern. Most saithe tended to represent smaller and younger individuals that could have been caught from on or near the shore, most likely for domestic consumption.

As described in Chapter Four, the Earl's Bu fish are uniquely composed of large quantities of haddock and cod, and very little saithe. Only a few other sites had slightly elevated proportions of haddock, including Pool phase 8.1 and Sandwick North phase 2, and both of these had very low proportions of saithe, indicating a possible correlation between the presence of haddock and the absence of saithe.

The variation in fish species and sizes around the Birsay Bay area is worthy of discussion. Beachview and Brough Road both contained high proportions of saithe, and both dated to the medieval period, while Saevar Howe contained high proportions of cod yet dated to the Iron Age to Viking Age periods. The Brough Road saithe were unusually sized, in that most were 400-800mm long, and thus lacking the more usually recovered small saithe. In contrast, saithe from Beachview were predominantly of small size, from 100-300mm, suggesting some spatial separation of waste from different types of fishing. The cod from both sites were within similar size ranges, but the Beachview cod formed a unimodal distribution. This was unusual, but may reflect the grouping of all measurements at the site level, by the excavators. Unfortunately, little analysis of the other fish assemblages from the Birsay Bay area was possible.

Finally, the evidence for butchery and processing of fish was assessed for patterning across the Northern Isles. It was difficult if not impossible to summarise relative element abundances for most sites; any over- or under-representation was often attributed to taphonomic or natural patterning, and not to import or export of processed fish (Barrett *et al.* 1999, 371). Use of the cleithra as an indicator of trade in processed fish is made difficult by varying proportions of very robust haddock cleithra or extremely fragile cod and saithe cleithra. Varying proportions of vertebrae have been successfully used as indicators of fish trade at Quoygrew and Earl's Bu, but most other sites did not record the position in the vertebral column to such an accurate degree. Again, the smaller posterior vertebrae are more likely to be under-represented by recovery biases than the larger anterior ones. Only at Quoygrew, Earl's Bu, Robert's Haven and Sandwick North – all recorded using the same methods – was it possible to first assess taphonomic patterning, then to find any element-based evidence of fish trade. Sandwick North 11-14th century phases contained evidence of butchery to create a dried product, but this was probably used locally, while dried fish were probably created and removed from Quoygrew from the mid 11th to the mid 13th centuries, at St. Boniface from the 12th to mid 13th centuries, at Robert's Haven from the 11th to the 13th century, and possibly at Sandwick from the late 13th to 14th centuries. Deposits of 10th to late 12th century date at Earl's Bu provided the only evidence of prepared fish arriving, having been prepared elsewhere.

8.4 *The mammals*

A wide range of mammal bone data from the Northern Isles is available for comparison with the material from Quoygrew and Earl's Bu. In what follows, each comparative site is explored for spatial and temporal patterning at both the intra-site and inter-site levels. The comparative material comprises over 224,000 bones, of which just under 100,000 were identified. Unlike the fish assemblages, much of this bone was derived from hand collection, which has necessitated careful comparison of recovery methods. Correspondence analysis (CA) is used to explore the NISP data, while ageing and element distribution data are discussed qualitatively, for reasons which will be made clear below. Biometrical data are briefly summarised and assessed, but it was outside the scope of this thesis to perform a full, multivariate analysis of these data. Moreover, the sample size of measurements per element per phase group is typically very small, thus limiting the potential of this data source.

8.4.1 Mammal spatial and temporal patterning

CA can be used to explore spatial and temporal patterning within the mammal bone assemblages, in much the same way as it was applied to the fish in section 8.3.1. The mammal assemblages were divided into three types, those recovered by complete sieving, those recovered with mixed sieving, and those recovered by hand. Mammal bones are not subject to the same degree of recovery biases as fish, but smaller elements from cattle, caprines and pigs might be under-represented in the hand collected material, as would neonatal and juvenile domestic mammals (see section 8.4.2 for ageing summaries). Thresholds were established for each recovery method in order to allow inclusion of the maximum number of phase groups with adequate quantities of identified bones. These eliminate the phase groups with small quantities of bone, because these were often less representative of overall patterning. Several of these would appear as outliers on CA plots, masking the more subtle but important patterns. For the sieved and mixed recovery phase groups, a threshold was set at 150 identified bones, and for the hand collected material, a higher limit of 400 bones was chosen. These values indicate the total number of identified specimens for each phase group, but it is important to note that the actual quantities used for each CA plot can be lower. For example, when examining patterning within the minor species, sites with total NISP values over 400 may have only a small quantity of secondary species. The most common species were selected for inclusion in the CA plots, including cattle, caprines, pigs, horses, "large" mammals (cattle or horse sized) and "medium mammal 1" (caprines and pigs). Additional plots have been included that contain the minor species of economic value – red deer, seals, whales, cats and dogs – in order to find sites associated with higher than usual proportions of these secondary species. However, these exceptional sites can also be identified using the basic percentage NISP tables (Appendix Table 5.3).

CA plots for all phase groups that were sieved, and that contained at least 150 identified bones, are illustrated in Figure 8.33. The column plot includes the major domestic species, and 'large' and 'medium mammal' categories. The first axis represented about half of the variation in the dataset (axis one inertia is 0.50), but this resulted from taphonomic and inter-analyst variation in the use of the 'medium mammal' category. Intra-site variation was much lower than inter-site variation, suggesting variation in recording methods can explain much of this patterning. Axis two represented less inertia (0.046).

Both the 'large' and 'medium' mammal categories were removed to lessen their influence on intra- and inter-site patterning. Figure 8.34 displays the CA plots for the four main domestic species, for all phase groups with total sieving and at least 150 identified bones. The results accounted for only a small amount of the variation in the dataset (axis one inertia is 0.12, axis two is 0.015), but this patterning should be more meaningful in terms of past behaviour than that observed on the previous CA plots. Barring two cases from Earl's Bu, all phase groups were classed as midden material or contained significant portions of midden; this eliminates one potential source of variation in the dataset. The five phase groups from Freswick are closely associated with cattle, along with Robert's Haven phase 1 area A, and together these form a cluster away from other phase groups.

Figure 8.35 displays the row plot, coded to display site and phase group information, which can be used in conjunction with percentage NISP data to explore observed patterning (Appendix Table 5.3). Cattle represent approximately 70 to 90% of the identified domestic species at Freswick area 4 (early 11th to early 14th century), area 7 (Viking Age to medieval) and area 8 (6th to 14th century), which accounts for their strong association with cattle, while the two remaining phase groups from Freswick also have above average quantities of cattle. Robert's Haven phase 1 area A (11-13th century) comprises 64% cattle, also above average. Some of the phase groups on the right of the row plot are strongly associated with caprines, including five of the eight Earl's Bu phase groups. Caprines comprise 73 to 83% of the identified domestic species at these phase groups, and 64 to 69% at the remaining three phase groups. Earl's Bu phase group R3 is correlated with horse, identified as 3% of the domestic species, which accounts for its position as an outlier towards the top of the row plot. There was no intra-site chronological patterning at Earl's Bu visible in these plots. At Beachview Studio area 1, phase S (late 10th to early 13th century), caprines comprise 95% of the domestic species, which explains the strong correspondence observed in the CA plots; Beachview Studio area 1, phase R (early 12th to late 13th century) also contains high quantities of caprines, at 71% of the domestic species. An additional two contemporary phase groups from Beachview Studio are not included here because they do not contain enough identified bones, but they also contain high proportions of caprine. These phase groups are very unusual compared to most other sites, although they are similar to the Earl's Bu deposits. When analysed, no other sites contained such high proportions of caprines, leading the analyst to attribute this variation to 'house-keeping' activities (Rackham 1996b, 163). However, this may represent a period of deposition associated with a settlement of different status or function from others around the Birsay area; this will be discussed further, both below during the ageing discussion (section 8.4.2) and in Chapter Nine.

A further cluster of phase groups from Beachview and Quoygrew phase iii contain 33 to 39% cattle. Although these assemblages exhibited a substantial degree of intra- and inter-site variation, little of this was based on chronological changes, as illustrated by the lack of patterning in Figure 8.36, where the row plot is coded to display dates.

Only one phase group from Saevar Howe was included in the CA plots, indicating phase I, of Iron Age date, was associated with relatively high levels of caprines and pigs (66% and 15% of the domestic species respectively), and low levels of cattle (18%). However, there was a considerable level of significant intra-site variation at Saevar Howe (Table 8.38), and because this was also found within phase II, it cannot be solely attributed to the chronological changes from the Iron Age phase I to the 8th to 10th century phase II. Caprines remained the predominant species throughout the occupation of the settlement, but they did decrease slightly, representing 41% by the end of phase II; during that phase group, cattle represented 29% and pigs 23%. This high proportion of pig tends to be unusual compared to other sites in the Northern Isles.

Variation within the domestic and secondary species is investigated in Figure 8.37, for all phase groups with total sieving and at least 150 identified elements. Most of the phase groups are found near the origin of the graph, but some outliers are associated with higher than average proportions of cats and red deer. These plots describe a moderate amount of variation in the dataset, with axis one inertia being 0.16, and axis two 0.090. Earl's Bu is known to contain high proportions of cats and dogs, leading to hypotheses about skinning, but none of the Earl's Bu points are visible as outliers on these plots; patterning caused by cattle, caprines and pigs hides most of the variation surrounding the secondary species. Cats from Freswick areas 9 and 11 comprised 59% and 29% respectively of total NISP, of area 11, which accounts for their position as outliers. Freswick area 4 and Beachview area 2, phase W were the only two phase groups to contain red deer within this recovery method, thus explaining their position, but patterning within the secondary species is better investigated using NISP tables.

CA plots for all mixed recovery phase groups with at least 150 identified bones are displayed in Figure 8.38. The four main domestic species are included, as well as 'large' and 'medium mammal 1'. The resulting patterning is based entirely on taphonomic and methodological factors, because each site forms a cluster of points, independent from all other sites. Inter-analyst variability influenced the usage of the 'large' and 'medium' categories, as did preservation and fragmentation. These plots describe about half of the variation in the dataset (axis one inertia is 0.44, axis two, 0.033). Removal of the size-based categories permits a greater understanding of intra- and inter-site patterning, as illustrated in Figure 8.39. Groupings by site are still observed, particularly for the Brough Road phase groups, which tend towards pig, and the Sandwick phase groups, which tend towards cattle. Inertia within this dataset is low (axis one inertia is 0.031, axis two is 0.020), but meaningful patterns are observable.

Using the mammal NISP tables (Appendix Table 5.3), it is possible to elaborate on the patterning observed in Figure 8.39, Figure 8.40 (the row plot recoded with phase group information) and Figure 8.41 (the row plot recoded by date). All of the Brough Road phase groups have higher than average proportions of pig, ranging from 26% of the identified domestic species in area 2, phase C1, to 48% in area 2, phase E2 (also observed by Rackham (1989, 243)). Significant intra-site variation was low, with only area 2, phase C1 containing significantly lower proportions of pig from area 2, phase C2 (Table 8.36). The corresponding proportions of caprines and cattle tended to be similar, with some slight variation. No chronological patterning was observed at the Brough Road phase groups: the 10th and 11th century phase groups were found interspersed with the late Iron Age to Viking Age ones in the CA plots. Most phase groups were classed as midden, with some defined as sandy spreads, but no context-type patterning was observed.

The two phase groups from the Brough of Deerness were located at some distance from each other, indicating intra-site variation was considerable at this site. Chapel interior phase D comprised almost 30% pig but only 10% cattle, making this phase group an unusual outlier. However, this phase group may have a non-anthropogenic origins because it includes the decay and collapse of the chapel. In contrast, phase C from the Enclosure comprises 56% cattle and 26% caprine, values that are comparable with other Northern Isles phase groups.

The two 'late' phase groups from Sandwick date to the late 13th to 14th centuries and are distinct from the late 12th century 'early' phase. All Sandwick phase groups were defined as midden, yet the later phase groups contain higher proportions of cattle (70% and 63% of the identified domestic species respectively) and corresponding lower proportions of caprines, than the early and 13th century phase groups (not shown on the CA plots).

The remaining phase groups from Pool, Scalloway and Freswick are all found close to the origin of the CA plots. All tend towards similar proportions of cattle and caprines, and approximately 10% pigs. Intra-site chronological patterning appears very limited, suggesting most of the variation is spatial. However, the CA plots may lack the resolution to reveal small but significant intra-site variation. For example, statistical tests of all phase groups from Pool indicate there was considerable intra-site variation, both between phase groups and within each phase (Table 8.33). This variation was likely caused by changes in the proportions of cattle and caprines within each phase group, but this was not clearly attributable to chronology; publication of the final report may allow this intra-site variation to be studied further.

An additional set of CA plots is displayed in Figure 8.42, showing all major species for phase groups with mixed recovery. These include cat, dog, red deer, seal and whale, in addition to the main domestic species. Inertia was again low, at 0.068 for axis one and 0.037 for axis two, but there was noticeable inter-site variation. The Brough Road phase groups were associated with higher than usual proportions of red deer, and to a lesser degree, seal. However, other sites like Pool phases 7 and 8, and Freswick area 1, also have higher than average proportions of red deer (see Appendix Table 5.3), yet the contributions of other species mask these associations in the CA plots.

Figure 8.44 displays the CA plots for all hand collected phase groups with at least 400 identified bones, based on NISP for cattle, caprines, pigs, horses, large mammals and medium mammals. Several sites form discrete groups on the row plot, including Earl's Bu, Quoygrew and the Beachview sites. As above, this inter-site patterning primarily reflects methodological and taphonomic differences in the use of the 'large' and 'medium mammal' categories, and as such, displays much of the variation present in the dataset (axis one inertia is 0.50, axis two is 0.21).

Use of the same dataset, but without the 'large' and 'medium mammal' categories, produces a more meaningful pair of plots, as shown in Figure 8.45. These plots account for much less of the variation in the dataset (axis one inertia is 0.081, axis two is 0.040), but the resulting patterns are not as biased by methodological and taphonomic factors. Some grouping by site was again observed for Brough of Birsay Room 5, Buckquoy and Earl's Bu, but there was a much wider spread of data points than in the previous figures. The same dataset is coded by dates in Figure 8.47, but the lack of grouping indicates that patterning is not chronological. The cluster of points representing Earl's Bu has some of the lowest proportions of cattle and highest proportions of caprines found in the Northern Isles, along with Beachview Studio area 1D/E phase U (as was also noted above based on the sieved datasets). Cattle tended to represent less than 30% of the identified domestic species at these sites, and caprines 50% or greater, while pigs represented about 10%.

In contrast, the four Buckquoy phase groups contained slightly higher than average levels of horse, from 1.5 to 4% of the identified domestic species, as well as relatively low levels of caprines and higher proportions of cattle and pig. At Buckquoy, caprines represented approximately 15% of the identified domestics in phase I (late Iron Age), increasing to 25-30% for the later phase groups (late IA to medieval). When tested for statistical variation, significant differences were found within the entire dataset, as well as within the late Iron Age phase groups and within the late Iron Age to medieval phase groups (Table 8.39). Although much of this variation probably involved context type differences, some patterning may have been chronological, because there is a slight decrease in pigs and increase in caprines through time.

Beachview phase 2X (early 11th to late 13th century) had a low proportion of caprines, and one of the highest proportions of pig, at 18% of the identified domestic species, while Beachview Studio area 1D/E, phase U contained high proportions of caprines, as mentioned above. The intra-site variation between the Beachview phase groups was considerable and significant (Table 8.37). Given that most of the Beachview material was approximately contemporary, this variation may be related to both context types and status.

Most of the Brough of Birsay Rescue and Room 5 phase groups contained very little pig or horse, and therefore correspond with the cattle and caprine points, but there is no temporal patterning within the proportions of caprine and cattle. These phase groups were defined as industrial deposits, drain fill, floor layers, wall foundations, pit fill, hearths and abandonment debris, yet most other phase groups included on these CA plots were classed as midden. This context-type variation may explain the position of these points, particularly because phase 3, area VIII from the Brough of Birsay was classed as domestic material from floor deposits in 'Norse' structures of late Viking Age to medieval date (Hunter 1986, 137-41). This point is an outlier at some distance from all other Brough of Birsay points, and contains greater quantities of pig (12% of the domestic species).

Statistical testing of the phase groups from the two Brough of Birsay sites indicated significant intra-site variations in the quantities of cattle, caprines and pigs. At the Rescue Excavations, significant variation was noted both between phase groups and areas (Table 8.34), while at Room 5, the earlier late Iron Age to Viking Age phase groups tended to be significantly different from the later Viking Age to medieval phase groups (Table 8.35). It therefore appears that both chronological and spatial patterning contribute to the patterning observed on the Brough of Birsay.

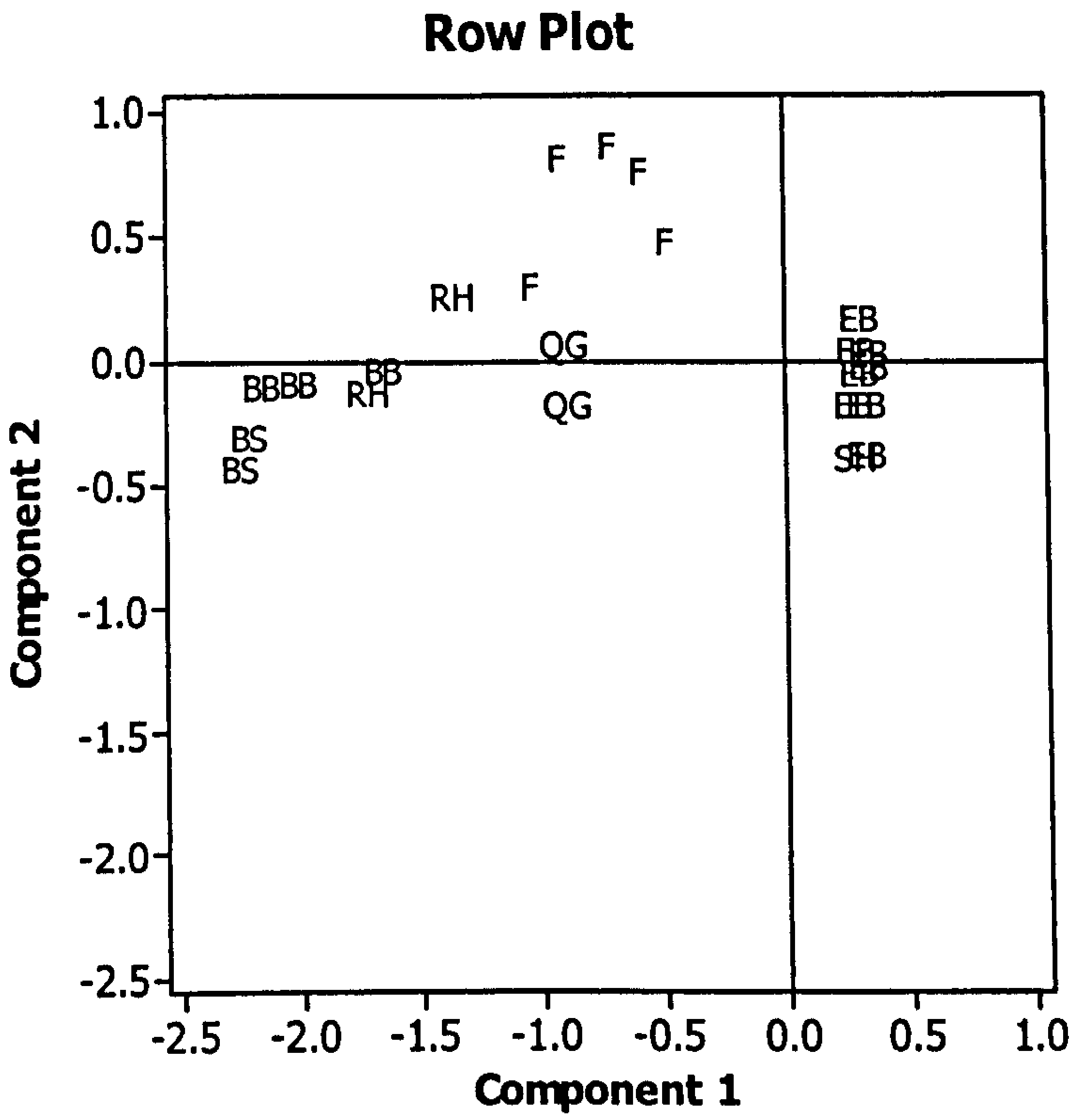
The two phase groups from Skaill are located at some distance apart on the CA plots, thus indicating considerable intra-site variation. As well as the potential for chronological variation between phase groups, there is inter-analyst variability to consider, because these two phase groups were analysed by different people. Significant variation was identified between all interventions, as well as between the assemblages identified by each analyst (Table 8.40), but given the problems of phasing and dating at Skaill, it is impossible to interpret these further.

Secondary species recovered by hand collection can be explored in conjunction with the primary domestic species, as illustrated in Figure 8.48. Cat, dog, red deer, seal and whale have been added to cattle, caprines and pigs to produce CA plots. However, phase Y from Beachview Studio Site area 1D/E has been removed because 4% of all NISP was dog, thus skewing the plots and masking real patterning. The variability accounted for was again low (axis one inertia 0.085, axis two inertia 0.042), and most of the patterning represented here corresponds to the main domestic species only. All phase groups from Earl's Bu remain closely associated, both because of their unusual proportions of cattle and caprines, and because they are closely associated with dog. Earl's Bu has higher than usual proportions of cat and dog bone (Mainland nd.b) (although partial and entire skeletons have been found at other sites, they never have similar intensities of deposition). Butchery marks recorded on some cat and dog elements were consistent with skinning for fur (Mainland 1994, 3), possibly related to the role of Earl's Bu as a high status site (metrical data suggest at least one wildcat was found here, TP O'Connor, pers. comm.). Some phase groups are associated with higher than usual proportions of red deer, including Freswick area 8 and Buckquoy phases I and II. Unlike the mixed recovery dataset discussed above, the addition of secondary species to the hand collected CA plots contributes little to an understanding of the spatial and temporal patterning.

One final pair of CA plots explores only the secondary species, including all phase groups with relevant data from the three different recovery methods. As illustrated in Figure 8.49, most of the patterning observed here was influenced by the relative proportions of cats, dogs and seals. These plots display much of the variation in the dataset because axis one inertia is 0.65, and axis two is 0.35. Red deer had relatively little influence on the dataset. Using the percentage NISP data (Appendix Table 5.3), most red deer were found in Iron Age to Viking Age or Viking Age to medieval deposits (e.g. Pool, Brough Road and Freswick), indicating that they probably became extinct in Orkney at some point in the early medieval period. Most of the Earl's Bu material is strongly associated with cats and dogs, reflecting the potential use of fur at that site, while some areas from Freswick were strongly associated with cats, as already discussed. One Beachview site was also associated with dogs, area 1D/E phase Y; there, dogs represented 4% of all identified mammals. Horses and whales were found throughout, with very little spatial or chronological patterning, while seals were also found at low levels throughout, but at slightly inflated levels at Skaill and Newark Bay. This could reflect methodological and recovery biases, given that both sites were hand collected and have had problems of phasing and publication, or given the close proximity of these sites, this could indicate ease of access to sealing grounds. The most unusual feature of Jarlshof is the seal that was found "in places preponderating over the domestic relics considerably" in the early 9th century deposits, "utilised as much as the domestic animals" in the 10-11th century midden, but only an occasional find in the 11-13th century middens (Platt 1956). Unfortunately, this site was not fully quantified so is difficult to use as comparative material, but this could again indicate ease of access to seals. It is impossible to compare the prevalence of marine resource exploitation at these three sites, because none has a thorough, sampled and phased fish bone report.

Overall, spatial and temporal patterning within the mammal NISP data can be summarised as follows:

- The 'large' and 'medium mammal' categories mostly reflected methodological and taphonomic patterning
- All phase groups at Freswick and phase 1 area A from Robert's Haven were associated with much higher proportions of cattle than any other phase groups, and cattle were the dominant species throughout all phase groups at Buckquoy
- Earl's Bu phase groups of all dates were associated with much higher proportions of caprines than any other phase groups, some phase groups from the Viking Age to the medieval period at Beachview and the Brough of Birsay contained high proportions of caprines, and caprines were the dominant species throughout the occupation of Saevar Howe from the Iron Age to the 10th century
- Unusually high proportions of pigs were identified from all Brough Road phase groups, the final 8-10th century phase at Saevar Howe and one early 11th to late 13th century phase at Beachview
- Most sites contained relatively similar proportions of cattle and caprines, and lower proportions of pigs, including Quoygrew
- Important but secondary species include red deer, horses, dogs, cats and sea mammals, particularly seals
    - Red deer were present at low levels in late Iron Age to medieval deposits, but decreased through time
    - Horses were ubiquitous but at low levels
    - Dogs and cats may have had value as fur bearing species, particularly at Earl's Bu, and a few phase groups from Freswick and Beachview also had inflated quantities
    - Unusually high proportions of seals were found at Jarlshof (albeit qualitatively summarised) and Newark Bay



QG: Quoygrew
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

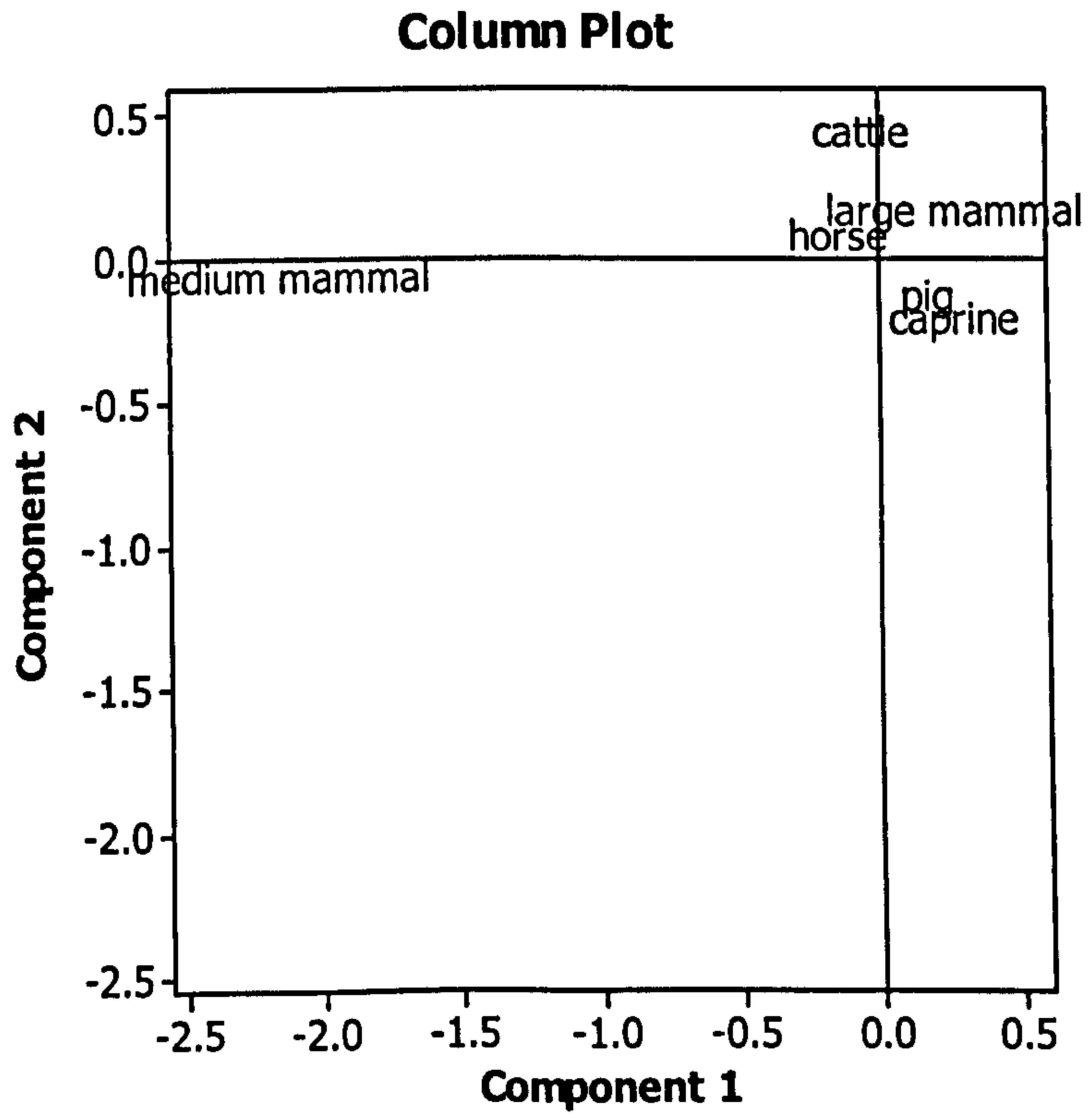


Figure 8.33: CA plots of cattle, caprines, pig, horse, large mammal and medium mammal 1 NISP for phase groups with total sieving and total NISP≥150

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Horse	0.002	0.000	0.014	0.154	0.001	0.000	0.127	0.001	0.000
Pig	0.280	0.054	0.017	0.180	0.178	0.004	-0.136	0.102	0.022
Cattle	0.671	0.105	0.052	-0.054	0.010	0.001	0.435	0.661	0.435
Caprine	0.965	0.393	0.083	0.270	0.601	0.058	-0.210	0.364	0.380
Medium Mammal	0.999	0.094	0.762	-2.159	0.999	0.888	-0.063	0.001	0.008
Large Mammal	0.759	0.353	0.073	0.265	0.590	0.050	0.142	0.169	0.155

Table 8.23: Contributions for CA plot Figure 8.33

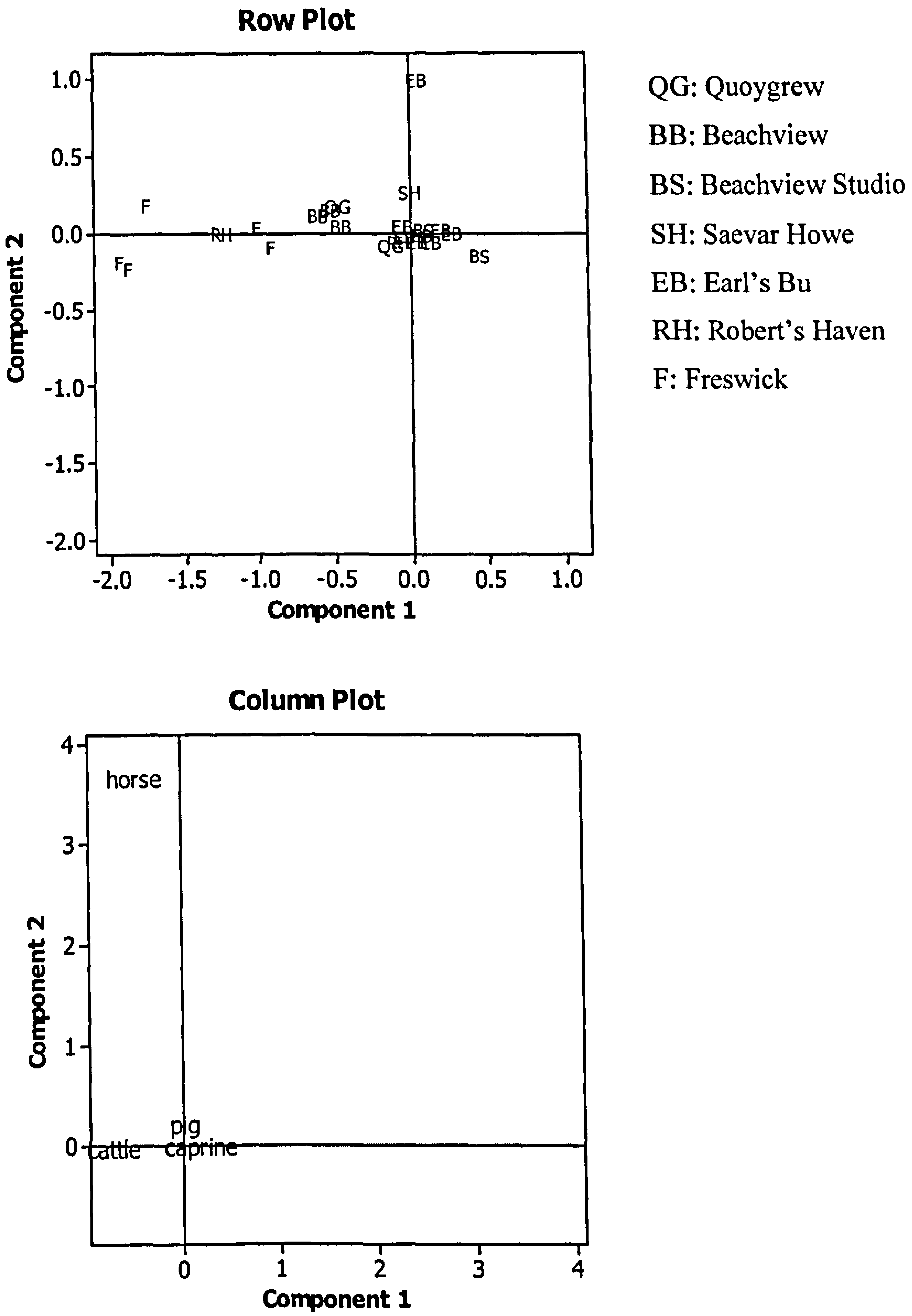
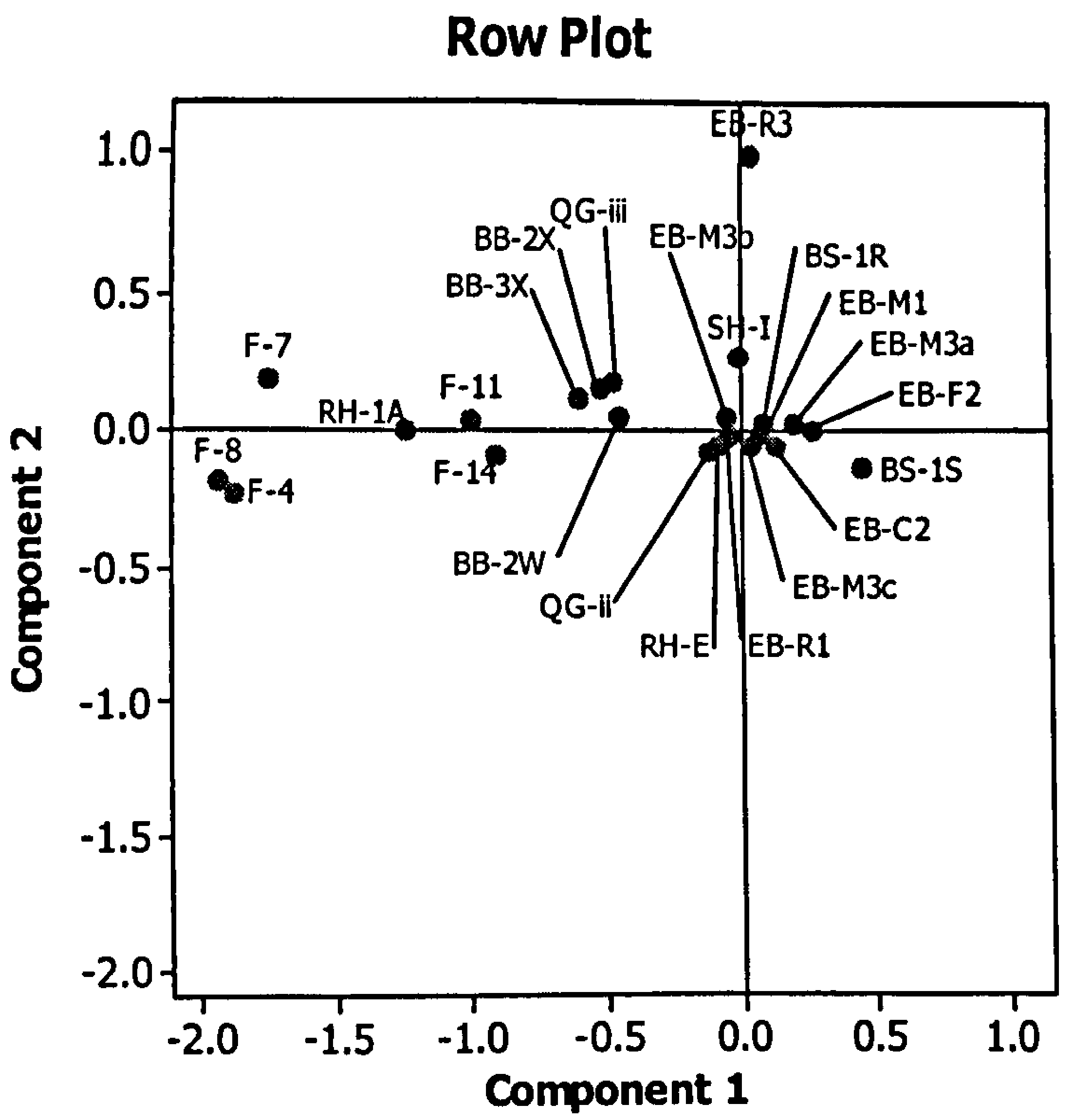
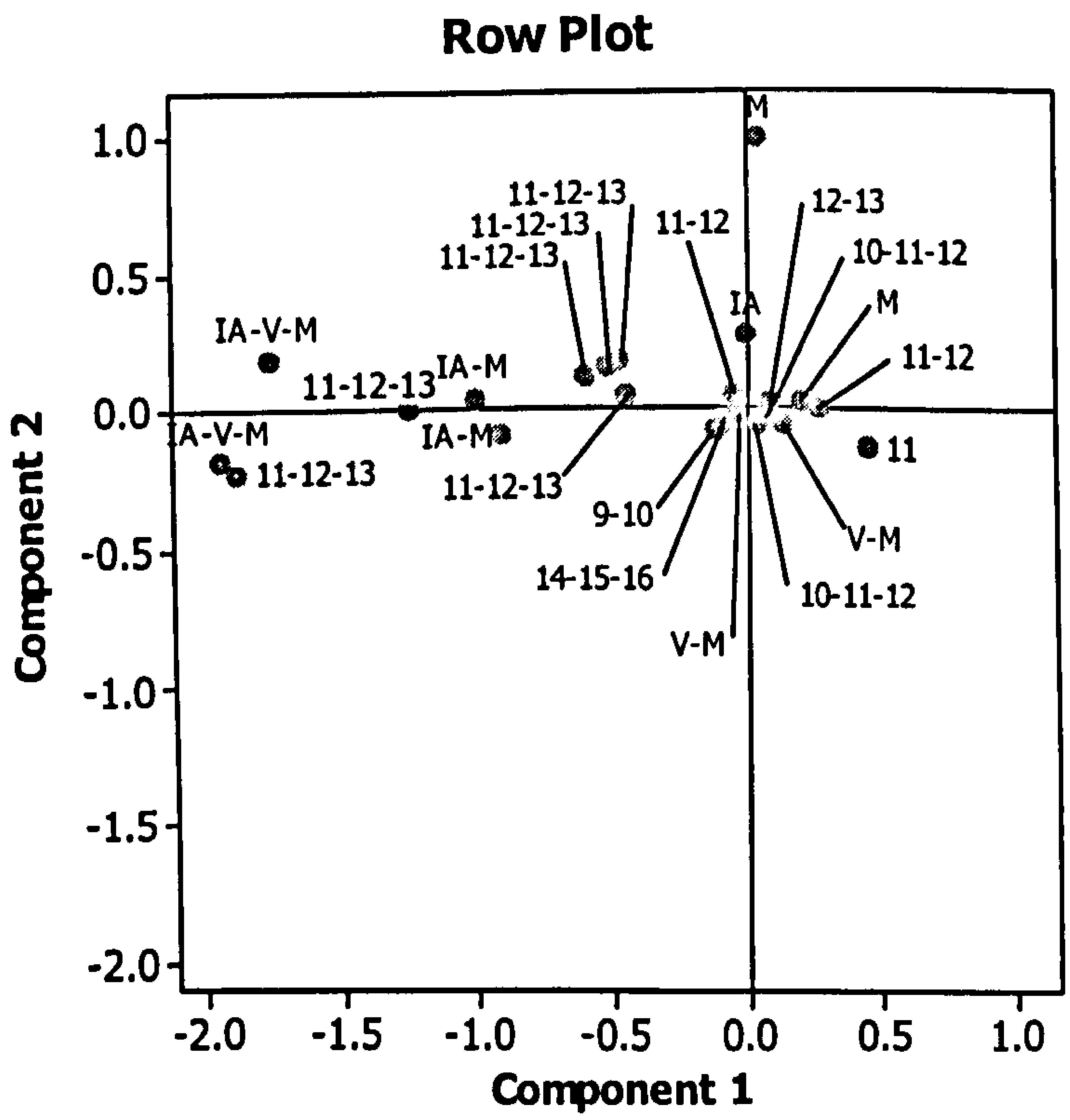


Figure 8.34: CA plots of cattle, caprines, pig and horse NISP for phase groups with total sieving and total NISP≥150



QG: Quoygrew
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

Figure 8.35: Row plot recoded to display phase group data, from the previous figure



Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.36: Row plot coded for dates from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Horse	0.776	0.001	0.095	-0.471	0.013	0.001	3.654	0.763	0.700
Pig	0.374	0.097	0.073	0.020	0.004	0.000	0.204	0.370	0.262
Cattle	0.999	0.191	0.654	-0.712	0.997	0.791	-0.031	0.002	0.012
Caprine	0.978	0.711	0.178	0.189	0.96	0.207	-0.024	0.015	0.026

Table 8.24: Contributions for CA plots Figure 8.34, Figure 8.35 and Figure 8.36

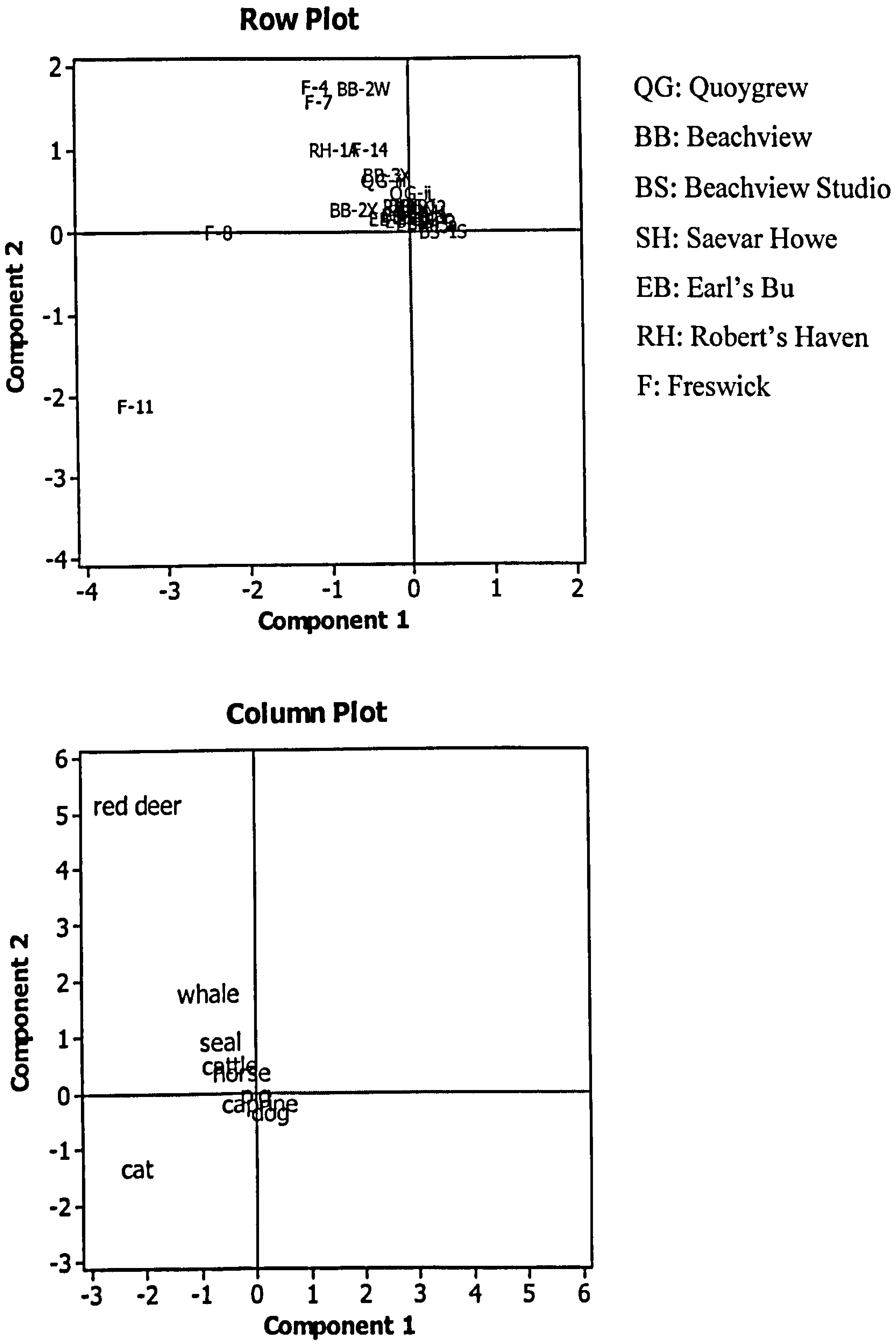
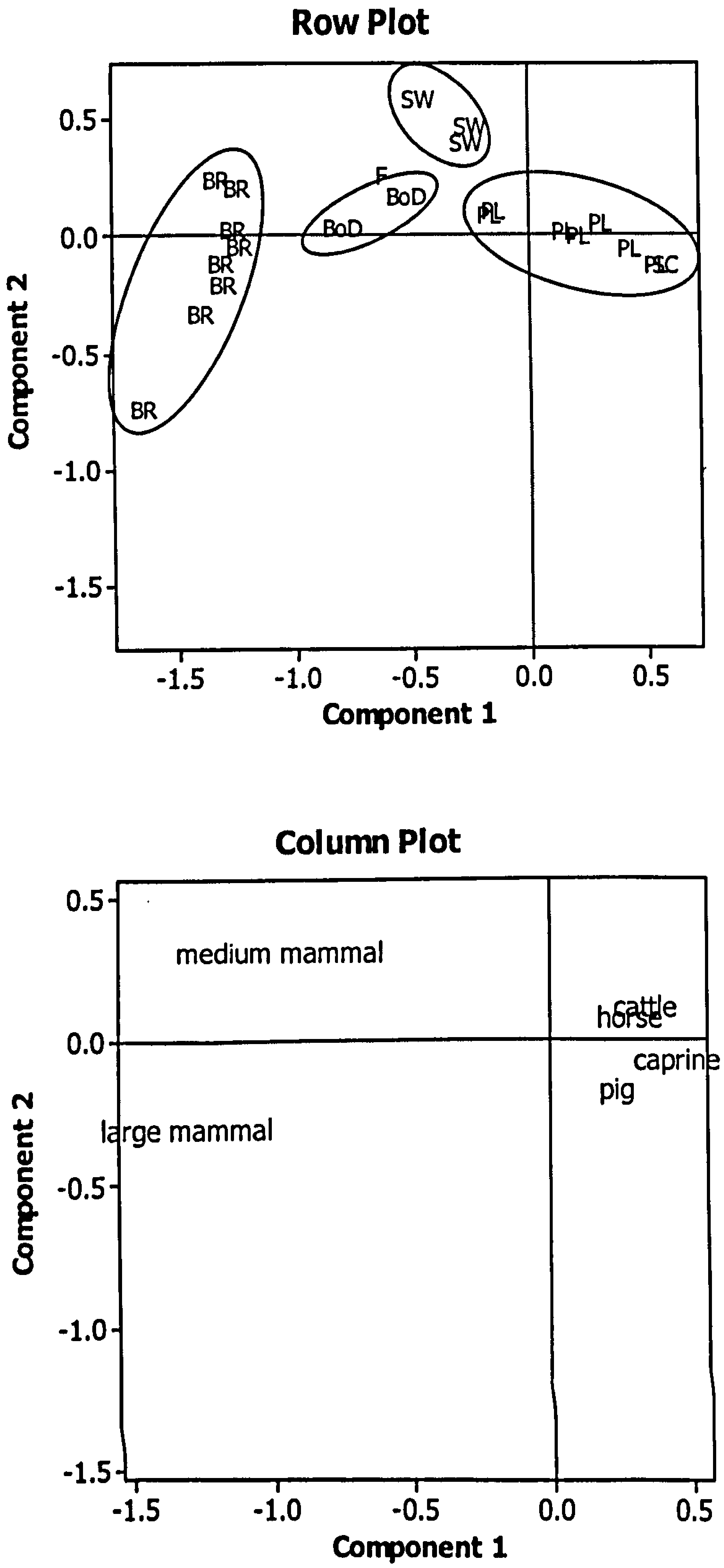


Figure 8.37: CA plots of cattle, caprines, pig, horse, cat, dog, red deer, seal and whale NISP for phase groups with total sieving and total NISP≥150

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Seal	0.066	0.001	0.040	-0.584	0.022	0.002	0.821	0.044	0.006
Whale	0.210	0.000	0.022	-0.864	0.041	0.002	1.758	0.169	0.013
Dog	0.163	0.013	0.023	0.234	0.096	0.005	-0.195	0.067	0.006
Cat	0.998	0.020	0.381	-2.142	0.710	0.563	-1.363	0.288	0.403
Horse	0.014	0.001	0.041	-0.278	0.004	0.000	0.413	0.010	0.001
Pig	0.019	0.094	0.030	0.006	0.000	0.000	-0.044	0.019	0.002
Red Deer	0.130	0.000	0.109	-2.127	0.020	0.004	5.067	0.111	0.045
Cattle	0.982	0.184	0.263	-0.485	0.497	0.272	0.479	0.485	0.470
Caprine	0.956	0.687	0.092	0.187	0.797	0.152	-0.084	0.158	0.053

Table 8.25: Contributions for CA plot Figure 8.37



SW: Sandwick

SC: Scalloway

PL: Pool

BR: Brough Road

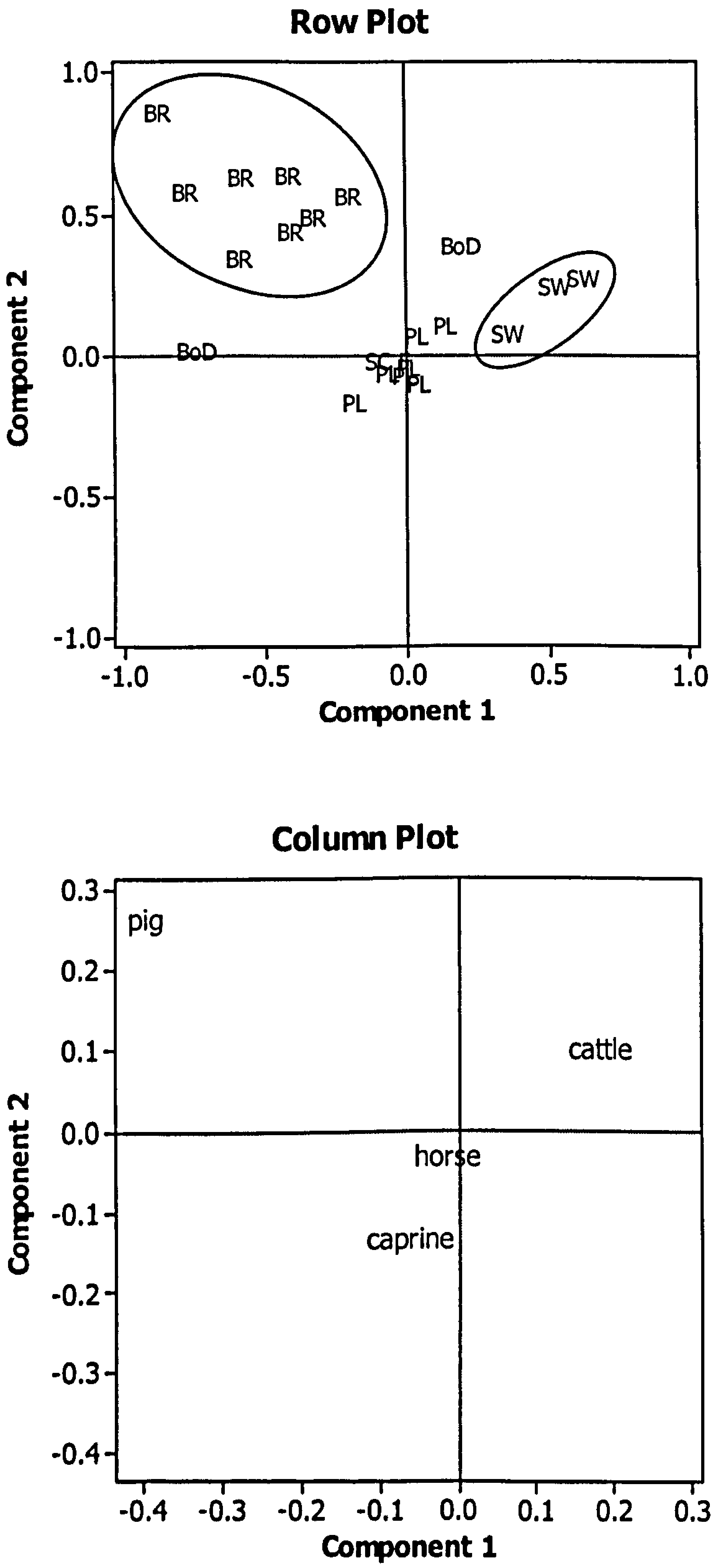
BoD: Brough of Deerness

F: Freswick

Figure 8.38: CA plots of cattle, caprines, pig, horse, large mammal and medium mammal 1 NISP for sites with mixed recovery and total NISP≥150

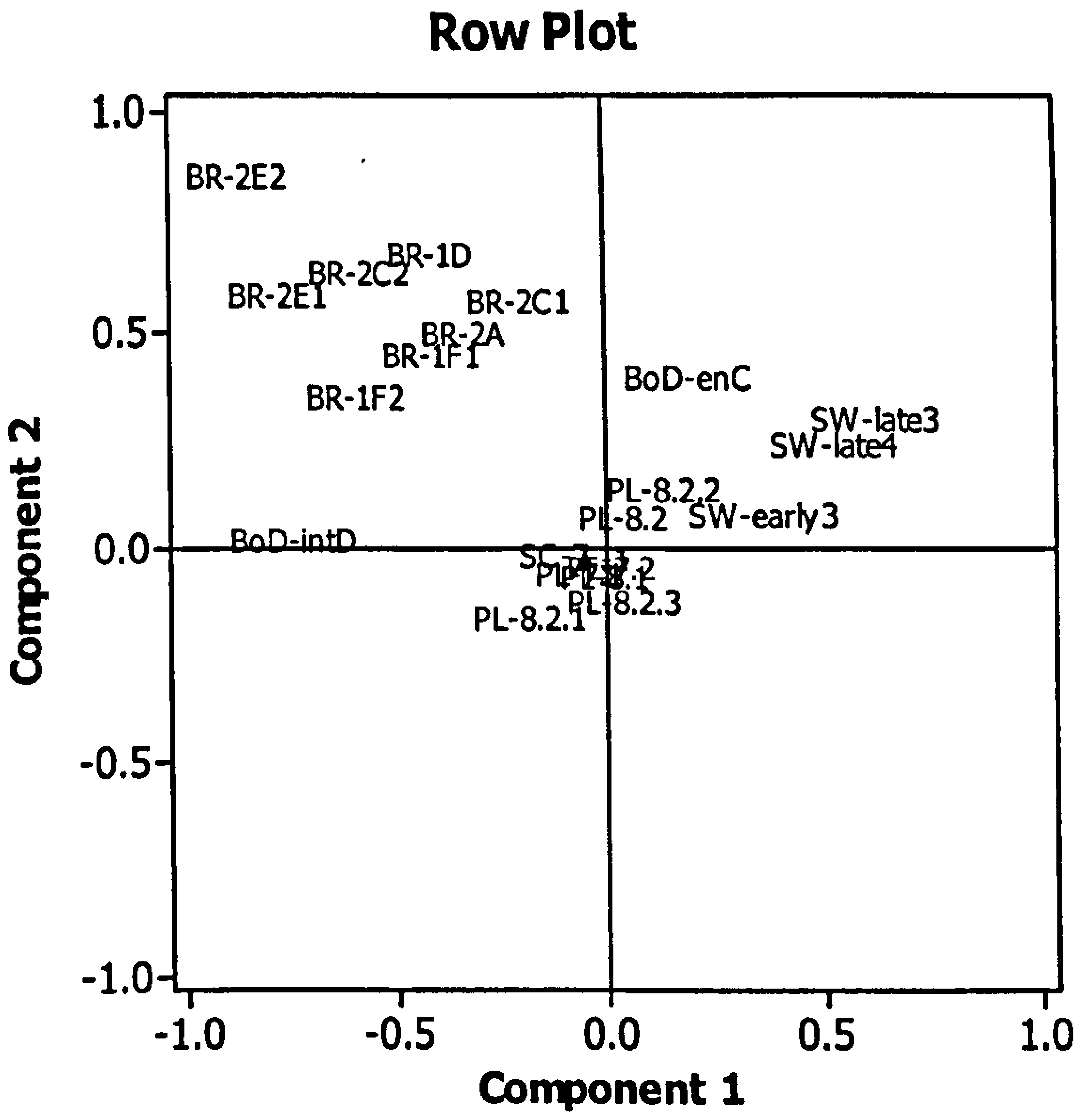
Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Horse	0.244	0.020	0.018	0.318	0.223	0.005	0.096	0.020	0.006
Pig	0.685	0.078	0.021	0.245	0.447	0.010	-0.179	0.238	0.075
Cattle	0.854	0.287	0.089	0.348	0.779	0.078	0.108	0.075	0.101
Caprine	0.973	0.355	0.160	0.461	0.947	0.170	-0.076	0.026	0.062
Medium Mammal	0.988	0.144	0.295	-0.956	0.895	0.297	0.308	0.093	0.414
Large Mammal	0.994	0.117	0.416	-1.289	0.940	0.439	-0.310	0.054	0.342

Table 8.26: Contributions for CA plot Figure 8.38



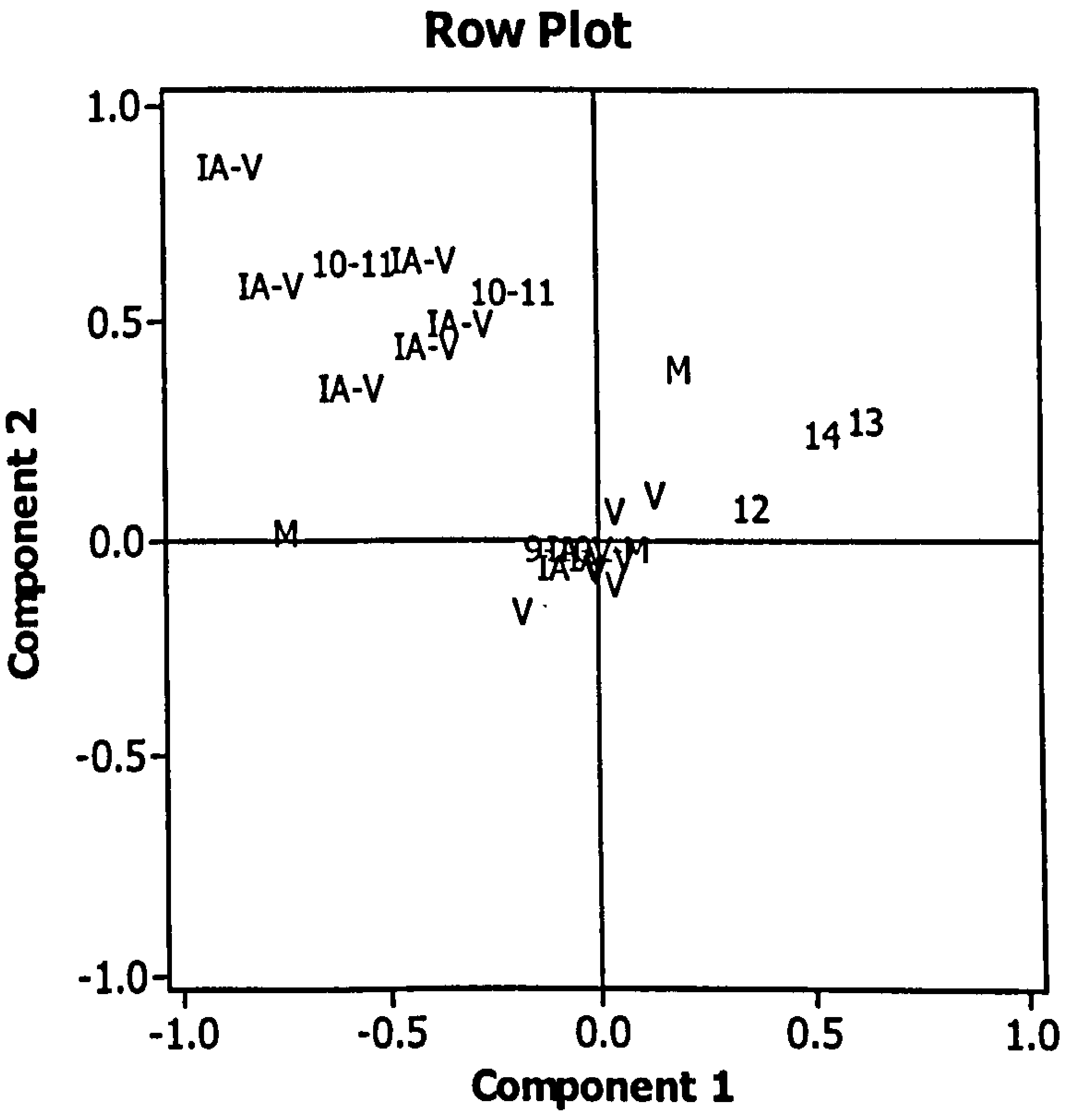
SW: Sandwick
SC: Scalloway
PL: Pool
BR: Brough Road
BoD: Brough of Deerness
F: Freswick

Figure 8.39: CA plots of cattle, caprines, pig and horse NISP for sites with mixed recovery and total NISP≥150



SW: Sandwick
SC: Scalloway
PL: Pool
BR: Brough Road
BoD: Brough of Deerness
F: Freswick

Figure 8.40: Row plot coded for phase groups from previous figure



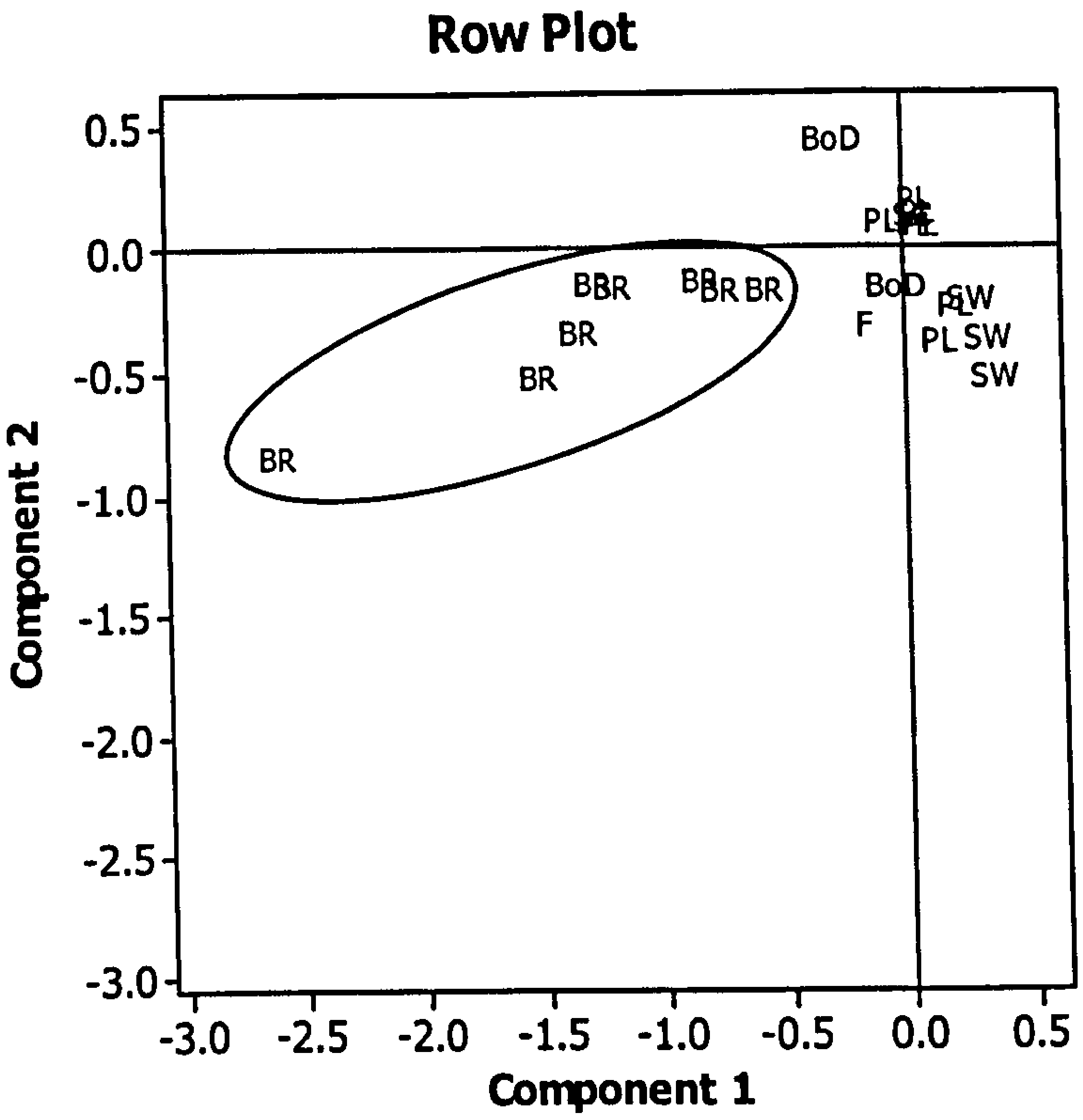
Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.41: Row plot coded for dates from previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Horse	0.004	0.027	0.145	-0.013	0.000	0.000	-0.032	0.003	0.001
Pig	0.999	0.105	0.395	-0.396	0.691	0.529	0.264	0.308	0.365
Cattle	0.997	0.388	0.279	0.182	0.769	0.415	0.099	0.227	0.190
Caprine	0.983	0.480	0.180	-0.060	0.161	0.056	-0.136	0.822	0.444

Table 8.27: Contributions for CA plots Figure 8.39, Figure 8.40 and Figure 8.41



SW: Sandwick

SC: Scalloway

PL: Pool

BR: Brough Road

BoD: Brough of Deerness

F: Freswick

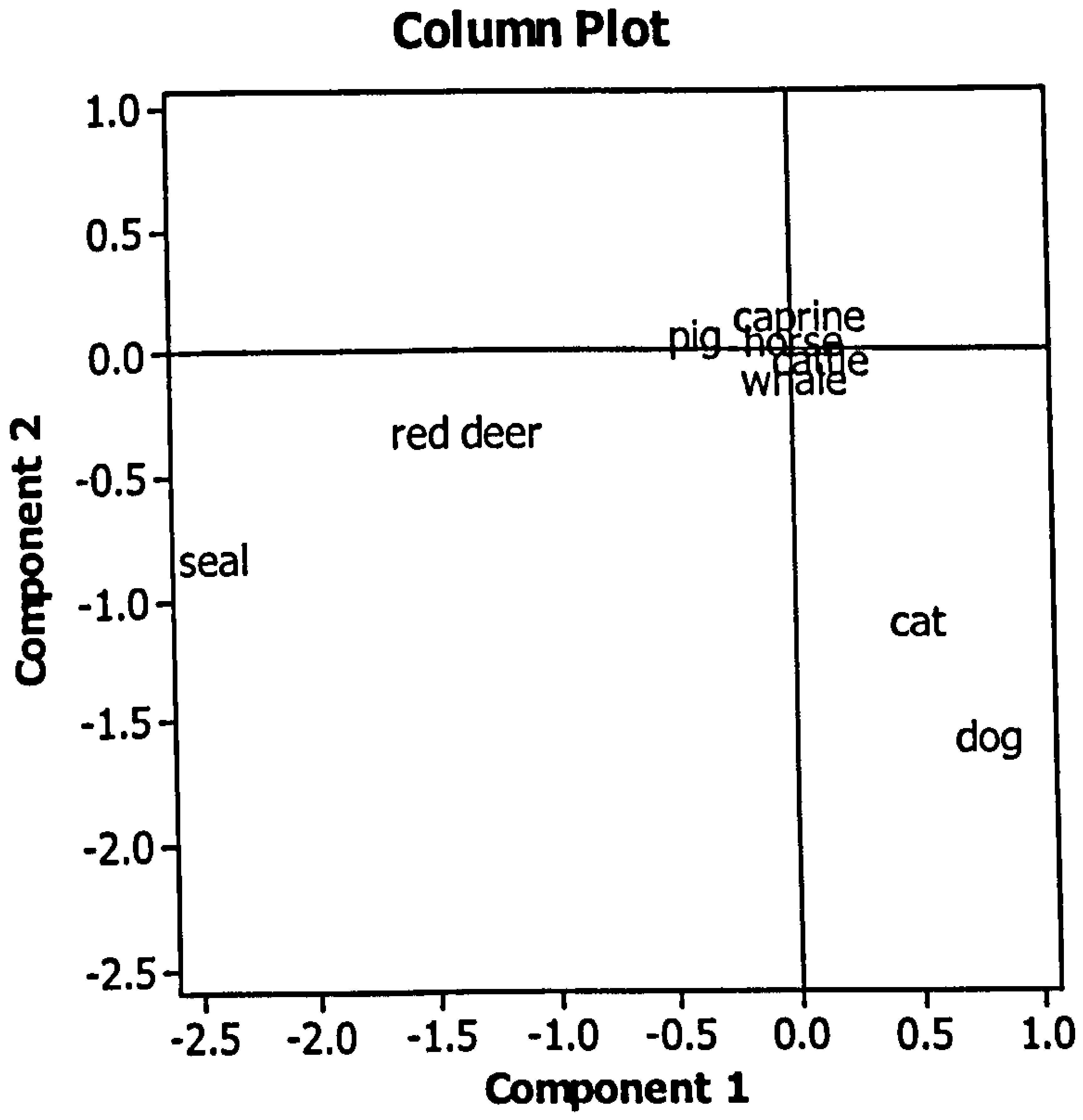
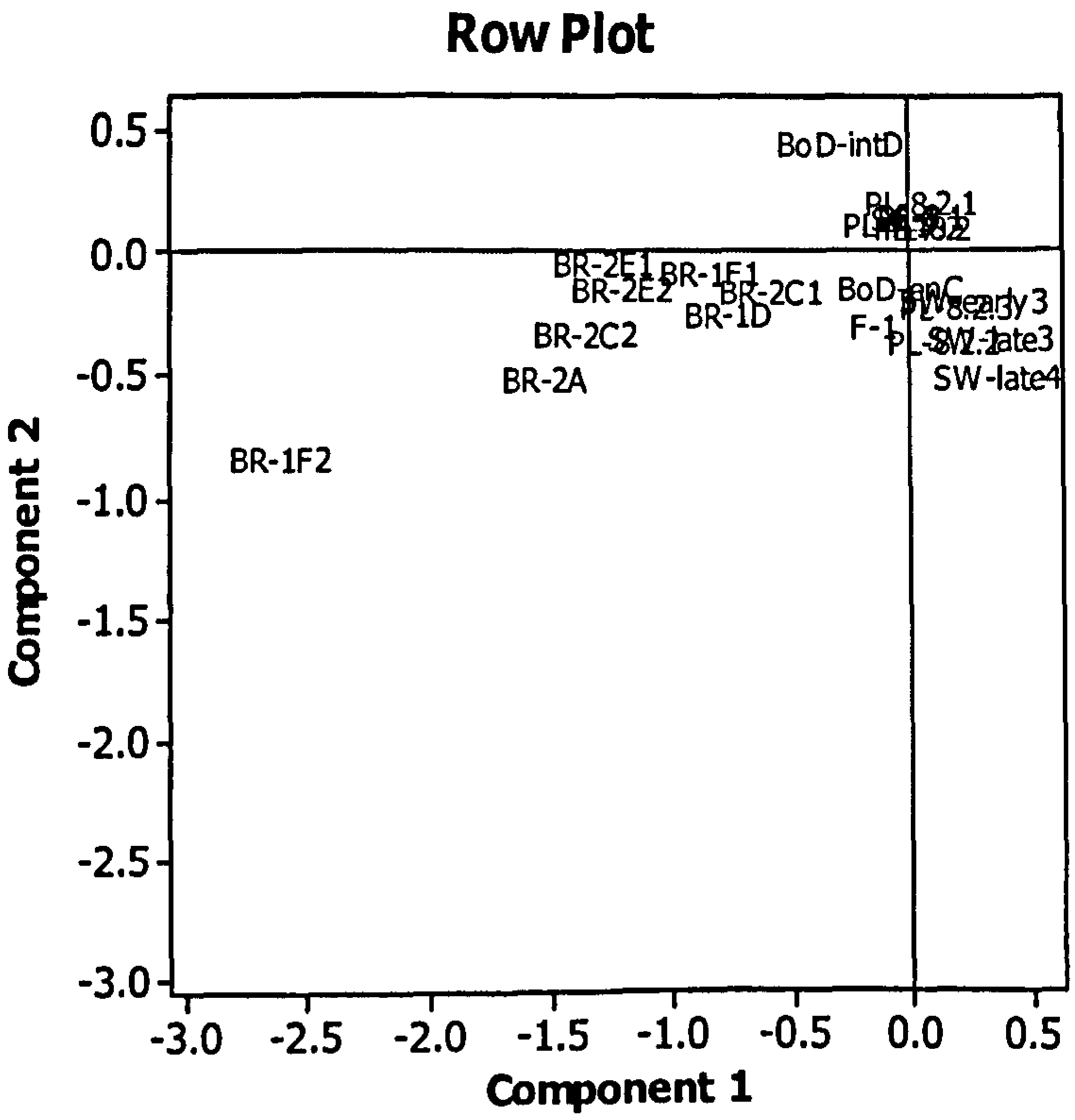


Figure 8.42: CA plots of cattle, caprines, pig, horse, cat, dog, red deer, seal and whale NISP for sites with mixed recovery and total NISP≥150



SW: Sandwick
SC: Scalloway
PL: Pool
BR: Brough Road
BoD: Brough of Deerness
F: Freswick

Figure 8.43: Previous row plot recoded by phase group

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Seal	0.780	0.003	0.175	-2.410	0.696	0.290	-0.835	0.084	0.065
Whale	0.027	0.008	0.028	0.037	0.002	0.000	-0.120	0.025	0.003
Dog	0.382	0.002	0.083	0.790	0.076	0.015	-1.585	0.306	0.113
Cat	0.626	0.013	0.184	0.510	0.109	0.048	-1.112	0.517	0.422
Horse	0.006	0.026	0.052	0.018	0.001	0.000	0.039	0.005	0.001
Pig	0.766	0.101	0.122	-0.383	0.748	0.217	0.059	0.018	0.010
Red Deer	0.905	0.014	0.179	-1.341	0.855	0.365	-0.326	0.051	0.040
Cattle	0.518	0.373	0.099	0.097	0.218	0.052	-0.114	0.299	0.132
Caprine	0.697	0.461	0.078	0.045	0.073	0.014	0.131	0.624	0.215

Table 8.28: Contributions for CA plots Figure 8.42 and Figure 8.43

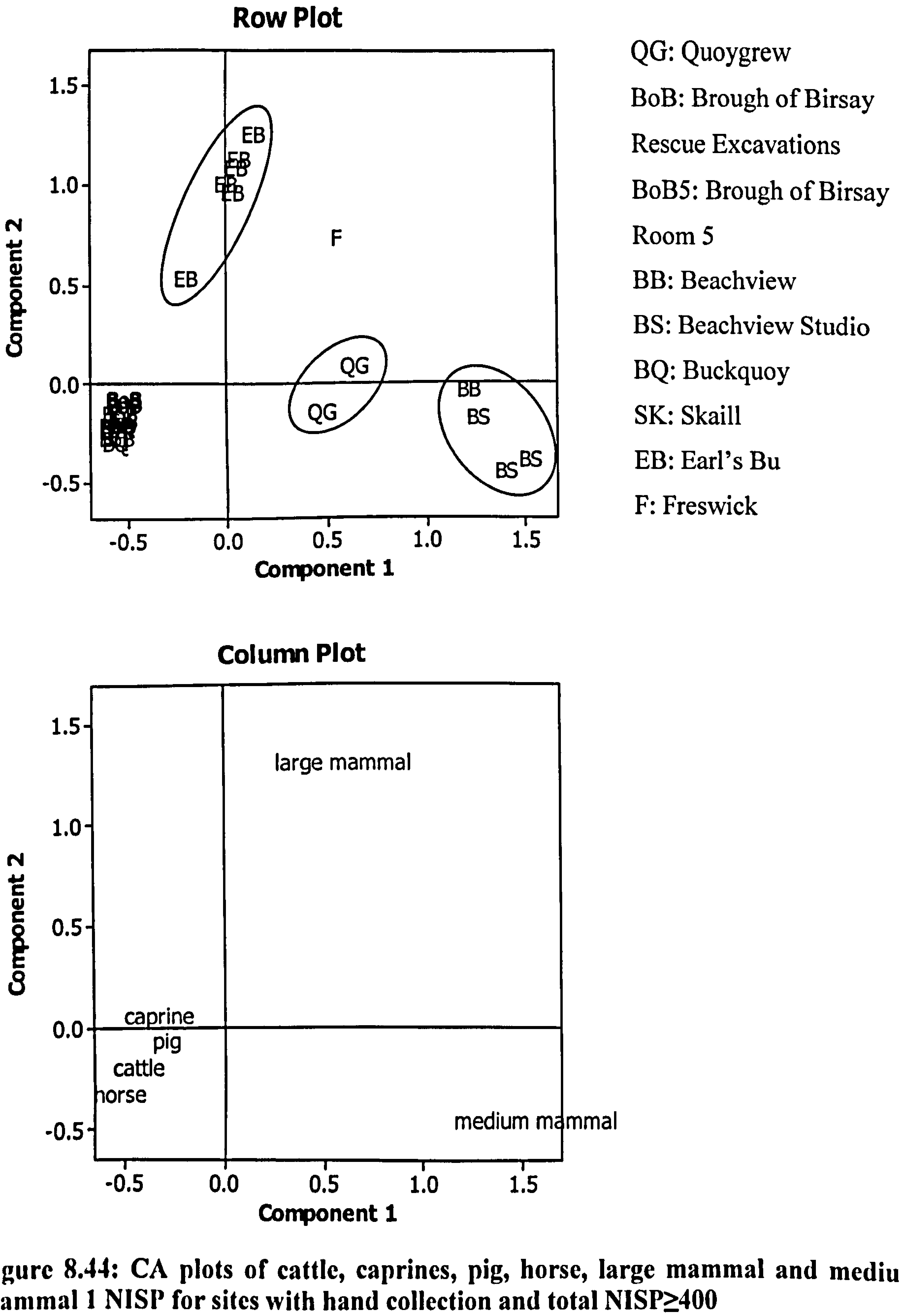
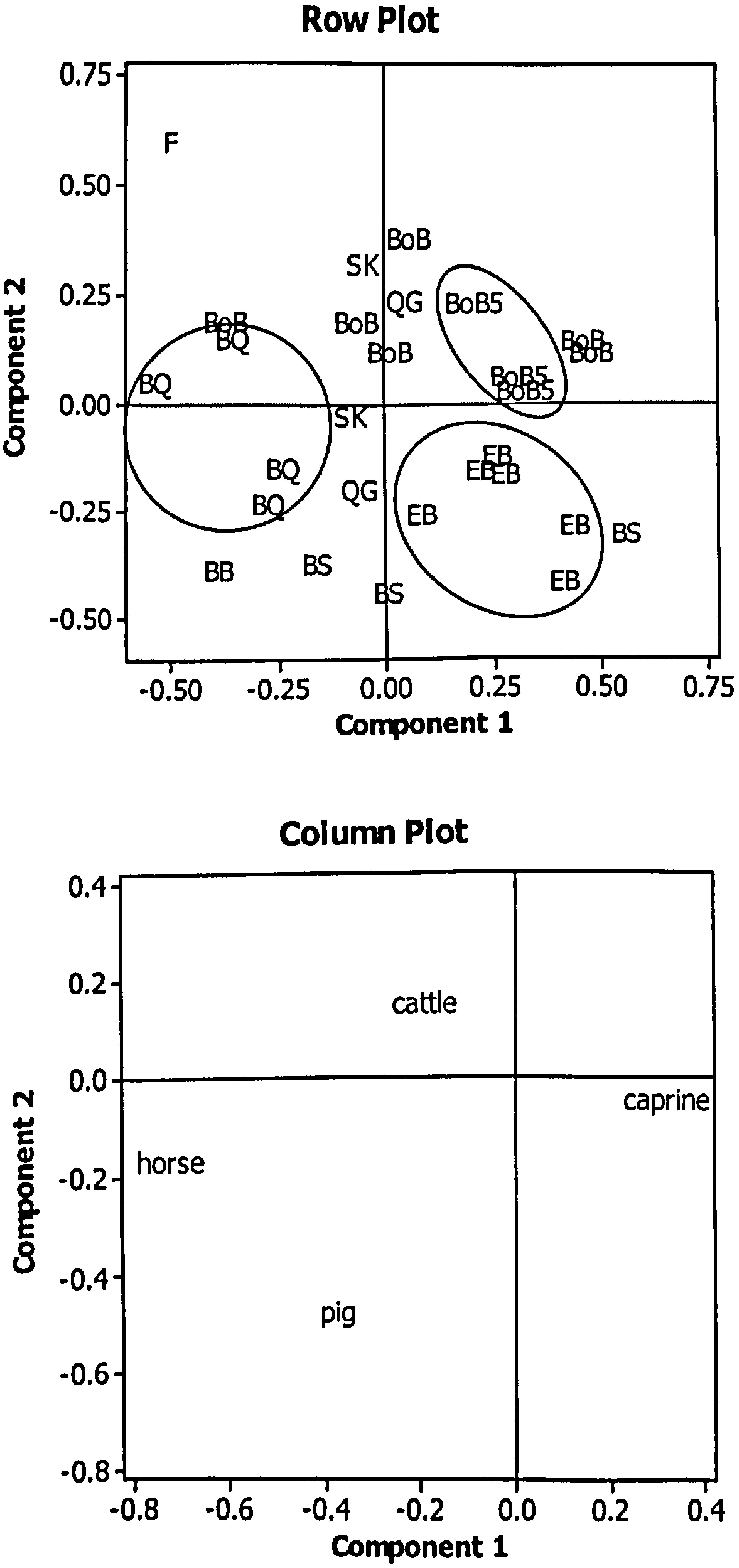


Figure 8.44: CA plots of cattle, caprines, pig, horse, large mammal and medium mammal 1 NISP for sites with hand collection and total NISP≥400

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Horse	0.252	0.009	0.017	-0.523	0.181	0.005	-0.328	0.071	0.005
Pig	0.182	0.079	0.046	-0.283	0.172	0.013	-0.070	0.010	0.002
Cattle	0.861	0.353	0.115	-0.431	0.715	0.131	-0.195	0.146	0.064
Caprine	0.504	0.319	0.088	-0.328	0.491	0.069	0.053	0.013	0.004
Medium Mammal	1.000	0.144	0.482	1.570	0.922	0.712	-0.456	0.078	0.142
Large Mammal	0.989	0.096	0.253	0.602	0.173	0.070	1.306	0.815	0.783

Table 8.29: Contributions for CA plot Figure 8.44



QG: Quoygrew

BoB: Brough of Birsay Rescue Excavations

BoB5: Brough of Birsay Room 5

BB: Beachview

BS: Beachview Studio

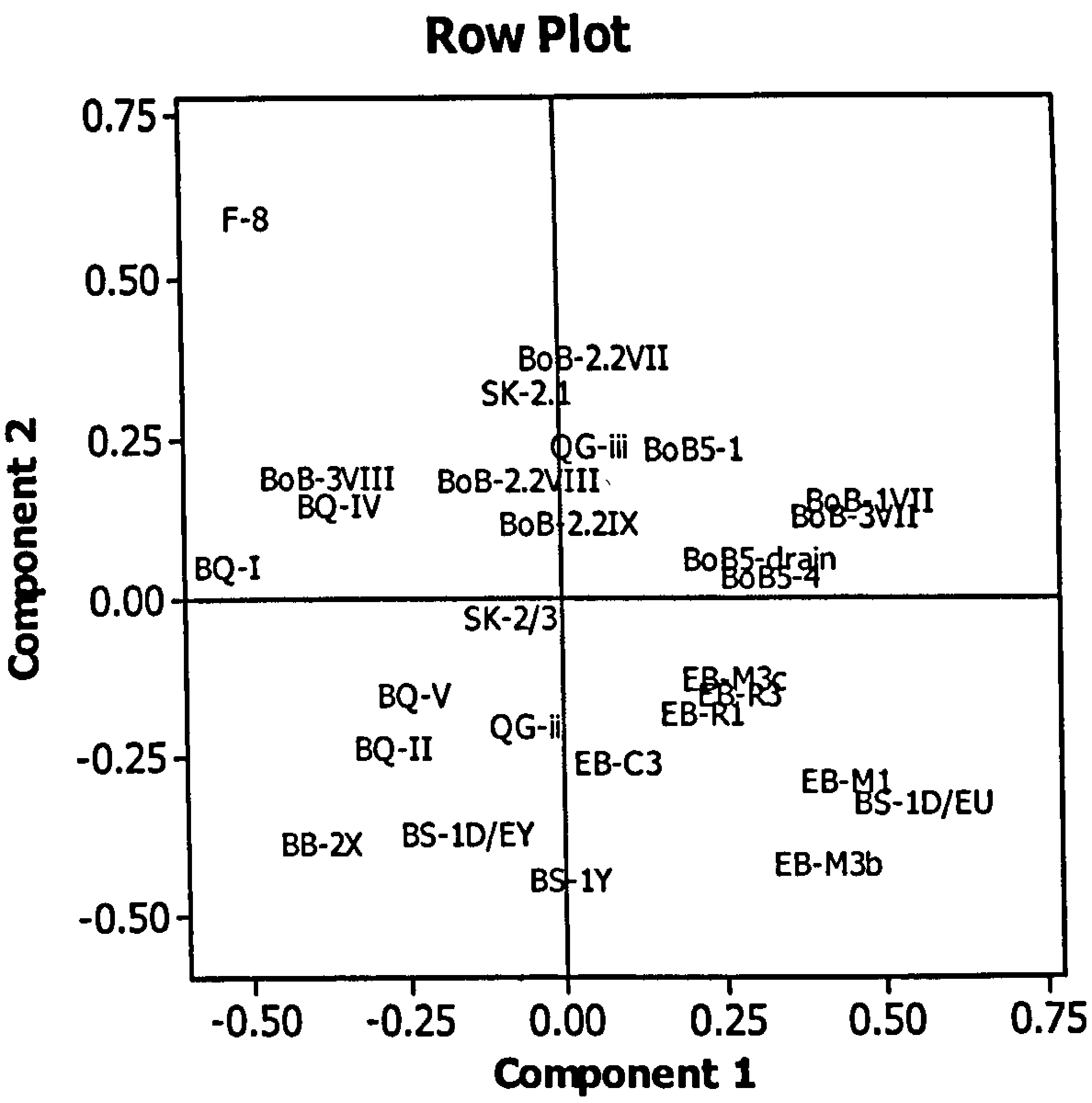
BQ: Buckquoy

SK: Skaill

EB: Earl's Bu

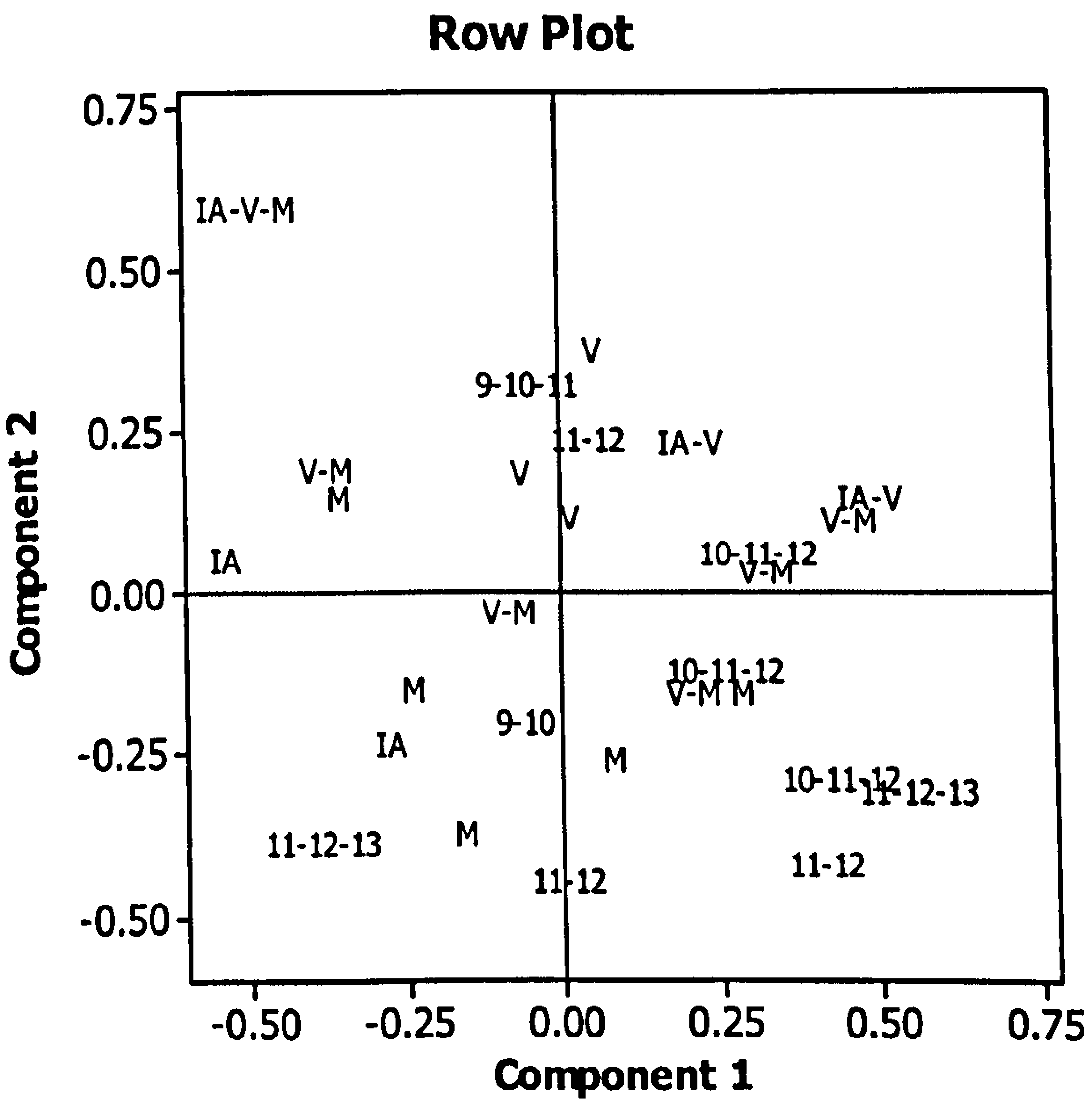
F: Freswick

Figure 8.45: CA plots of cattle, caprines, pig and horse NISP for sites with hand collection and total NISP≥400



QG: Quoygrew
BoB: Brough of Birsay
Rescue Excavations
BoB5: Brough of Birsay
Room 5
BB: Beachview
BS: Beachview Studio
BQ: Buckquoy
SK: Skaill
EB: Earl's Bu
F: Freswick

Figure 8.46: Row plot coded for phase groups from previous figure



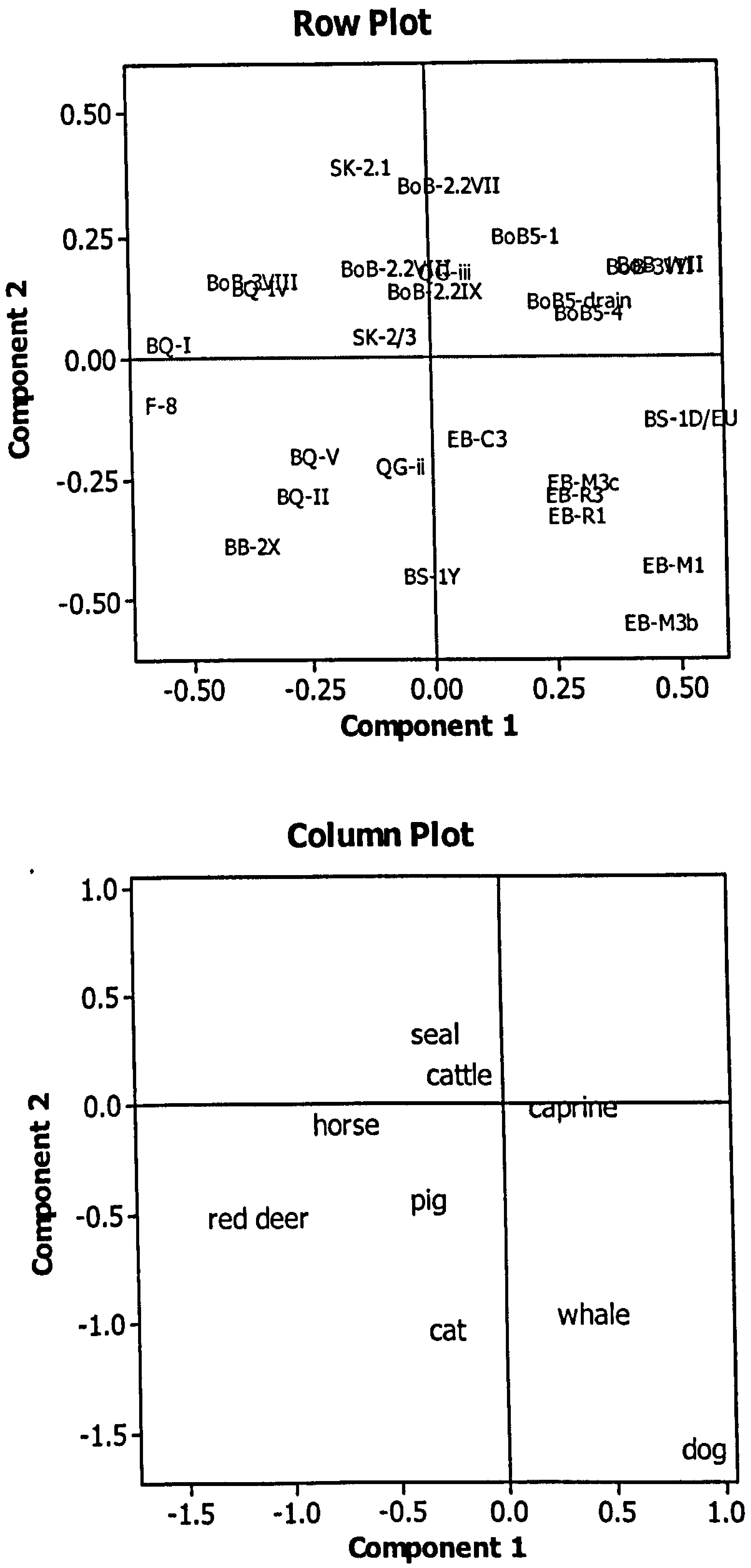
Phase groups are coded by century (i.e. 12 = 12th century), but to simplify, each century is included only if the date range includes at least 50 years from that century.

Less securely dated phase groups are classed as:
IA: late Iron Age
V: Viking Age
M: Medieval

Figure 8.47: Row plot coded for dates from the previous figure

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Horse	0.521	0.012	0.099	-0.716	0.493	0.074	-0.170	0.028	0.010
Pig	0.990	0.104	0.311	-0.373	0.378	0.178	-0.474	0.612	0.660
Cattle	0.995	0.464	0.226	-0.191	0.607	0.208	0.153	0.388	0.305
Caprine	0.998	0.420	0.364	0.323	0.978	0.540	-0.046	0.020	0.025

Table 8.30: Contributions for CA plots Figure 8.45, Figure 8.46 and Figure 8.47

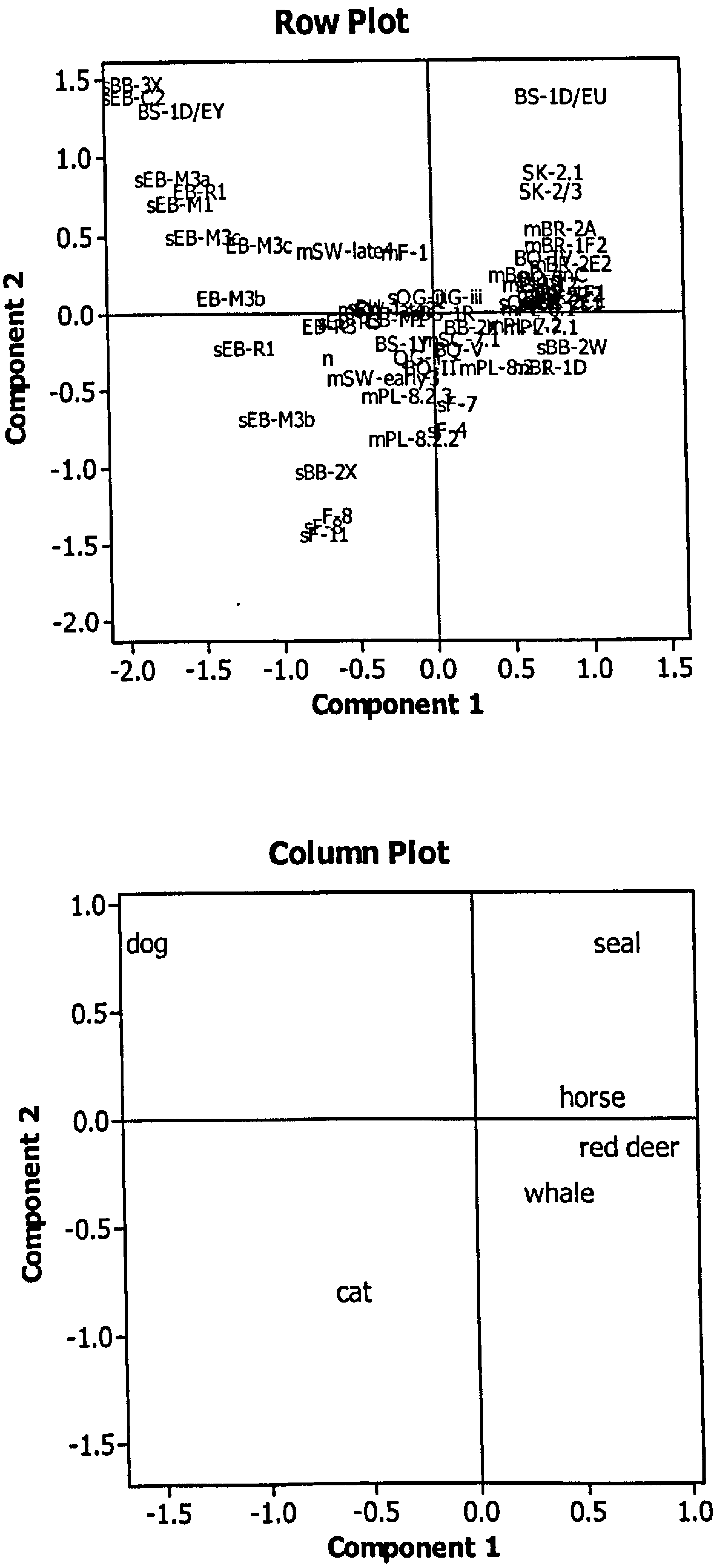


QG: Quoygrew
BoB: Brough of Birsay
Rescue Excavations
BoB5: Brough of Birsay
Room 5
BB: Beachview
BS: Beachview Studio
BQ: Buckquoy
SK: Skaill
EB: Earl's Bu
F: Freswick

Figure 8.48: CA plots of cattle, caprines, pig, horse, cat, dog, red deer, seal and whale NISP for sites with hand collection and total NISP≥400

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Seal	0.099	0.008	0.080	-0.307	0.048	0.008	0.316	0.051	0.018
Whale	0.129	0.001	0.063	0.407	0.020	0.003	-0.963	0.110	0.030
Dog	0.576	0.003	0.082	0.904	0.142	0.025	-1.579	0.434	0.156
Cat	0.298	0.005	0.110	-0.270	0.019	0.005	-1.041	0.279	0.135
Horse	0.526	0.012	0.064	-0.730	0.517	0.072	-0.100	0.010	0.003
Pig	0.890	0.101	0.194	-0.352	0.347	0.147	-0.441	0.543	0.463
Red Deer	0.518	0.001	0.017	-1.153	0.430	0.016	-0.520	0.088	0.006
Cattle	0.911	0.457	0.149	-0.196	0.628	0.205	0.131	0.283	0.187
Caprine	0.985	0.413	0.242	0.327	0.984	0.519	-0.013	0.002	0.002

Table 8.31: Contributions for CA plot Figure 8.48



SN: Sandwick North
SW: Sandwick
SC: Scalloway
QG: Quoygrew
PL: Pool
BoB: Brough of Birsay Rescue Excavations
BoB5: Brough of Birsay Room 5
BR: Brough Road
BB: Beachview
BS: Beachview Studio
SH: Saevar Howe
BQ: Buckquoy
BoD: Brough of Deerness
SK: Skaill
EB: Earl's Bu
RH: Robert's Haven
F: Freswick

Prefix m: Mixed recovery
Prefix s: Sieved
No prefix: Hand collected

Figure 8.49: CA plots of horse, cat, dog, red deer, seal and whale

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Seal	0.486	0.114	0.168	0.688	0.204	0.084	0.808	0.281	0.215
Whale	0.156	0.073	0.082	0.394	0.088	0.018	-0.343	0.067	0.025
Dog	0.963	0.140	0.287	-1.554	0.752	0.524	0.823	0.211	0.275
Cat	0.870	0.248	0.182	-0.587	0.300	0.132	-0.809	0.570	0.470
Horse	0.500	0.315	0.131	0.561	0.484	0.153	0.104	0.017	0.010
Red Deer	0.252	0.110	0.150	0.722	0.244	0.089	-0.130	0.008	0.005

Table 8.32: Contributions for CA plot Figure 8.49

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	1523.802	42	0.000	5 cells with expected counts <5.0
7.1 and 7.2	517.299	7	0.000	
8.2.1, 8.2.2, 8.2.3	131.218	14	0.000	2 cells with expected counts <5.0
8.2, 8.2.1, 8.2.1, 8.2.3	177.347	21	0.000	4 cells with expected counts <5.0
8.1, 8.2, 8.2.1, 8.2.1, 8.2.3	386.808	28	0.000	2 cells with expected counts <5.0

Table 8.33: Significant Chi-Square results for species distributions of cattle, caprines, pig, horse, cat, red deer, medium mammal 1 and large mammals from Pool

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	681.810	16	0.000	
All phase 1	214.495	4	0.000	
All phase 2	63.861	6	0.000	
All phase 2.2	38.886	4	0.000	
All phase 3	374.727	2	0.000	
All area VIII	53.170	4	0.000	
All area IX	35.411	4	0.000	

Table 8.34: Significant Chi-Square results for hand collected distributions of cattle, caprines and pigs from Brough of Birsay Rescue Excavations

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	74.018	10	0.000	
Phases 1 to 4	72.630	8	0.000	
Phase 1 and phase 2	27.841	2	0.000	1 cell with expected counts <5.0
Phase 1 and 3b	12.484	2	0.002	
Phase 1 and 4	44.467	2	0.000	
Phase 1 and 'drain fill'	19.992	2	0.000	
Phase 2 and 3b	22.780	2	0.000	
Phase 2 and 4	22.667	2	0.000	
Phase 2 and 'drain fill'	20.475	2	0.000	

Table 8.35: Significant Chi-Square results for hand collected distributions of cattle, caprines and pigs from Brough of Birsay Room 5

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Area 2, C1 and area 2, C2	6.268	2	0.044	

Table 8.36: Significant Chi-Square results for mixed recovery distributions of cattle, caprines and pigs from Brough Road

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Area 2, phase X total, area 1D/E phase U, area 1D/E phase Y, area 1 phase Y	154.075	6	0.000	
Area 2 phase X total and area 2 phase W total	9.155	2	0.010	
Area 1D/E phase S, area 1D/E phase U, area 1D/E W, area 1D/E Y, area 1 Y	133.554	8	0.000	
Area 1D/E phase S, area 1D/E phase U, area 1D/E W, area 1D/E Y	127.927	6	0.000	

Table 8.37: Significant Chi-Square results for hand collected distributions of cattle, caprines and pigs from the Beachview sites

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	26.356	10	0.003	
IIa, IIb, IIc	11.359	4	0.023	
IIa, IIb	6.521	2	0.038	
Ia, Ib, Ic, IIb	17.791	6	0.007	

Table 8.38: Significant Chi-Square results for sieved species distributions of cattle, caprines and pigs from Saevar Howe

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All	205.347	8	0.000	
Phases I and II	94.394	2	0.000	
Phases III, IV, V	34.575	4	0.000	

Table 8.39: Significant Chi-Square results for hand collected distributions of cattle, caprines and pigs from Buckquoy

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All: Noddle and Potts	142.432	12	0.000	2 cells with expected counts <5.0
Noddle's Viking and Post-Viking	13.777	3	0.003	1 cell with expected counts <5.0
Potts' Site 2, Midden 1 and Midden 3	18.547	2	0.000	1 cell with expected counts <5.0

Table 8.40: Significant Chi-Square results for species distributions of cattle, caprines, pig and horse from Skaill, Deerness

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Inland (combined), SCA (combined), NCA (combined) and CCA (combined)	38.827	6	0.000	1 cell with expected counts <5.0

Table 8.41: Significant Chi-Square results for hand collected species distributions of cattle, caprines, pig and horse from Freswick

8.4.2 Evidence for cattle, sheep and pig ageing

Summary ageing data were available for most sites, but methods varied and included tooth wear, epiphyseal fusion and general size and texture. These were not always easy to compare, which has lead to a qualitative approach, but one which aims to discuss the patterning present in the most illuminating way possible. It was not always possible to determine ageing methods used or precise definitions for categories such as 'juvenile', 'immature', 'sub adult' or 'adult'. Not all sites and phase groups are included, because some had no ageing data, and others only provided summary data for all periods combined (e.g. Scalloway). Because the presence of neonatal cattle has been shown to be important at Quoygrew, and other sites in the Northern Isles, an emphasis has been placed on assessing the relative proportions of neonates in each assemblage. As introduced in Chapter One, an important aspect of this thesis is the intensification of dairying in the Northern Isles during the time periods included in this study. The presence of increasing proportions of neonatal cattle has been interpreted as evidence for deliberate culling, in order to maximise the milk available for human use. In order to understand the importance of neonates in any assemblage, recovery methods must be understood – because smaller bones could be under-represented if hand collected – and preservation needs to be considered. Sites with poor bone preservation are less likely to have large quantities of neonatal bone surviving. Survival of neonatal bone can also be adversely influenced by scavenging and other destructive actions (Munson 2000, 400), and even phase groups with excellent overall bone preservation may contain neonatal bone that is not as well preserved (Symmons 2005). Preservation was not always directly discussed in each site report, which has made this issue difficult to control for. The presence of neonatal pigs are less indicative of economic patterning, so the assessment of the pig ageing data will consider the overall age structure of the pigs in each site or phase group.

The ageing data were made more complex by the lack of explicit sample sizes provided in some of the published reports. In some cases, the quantity of bones with ageing information was provided, but in other cases, only summary data were provided at a qualitative or semi-quantitative level. It was therefore difficult to apply a threshold level to restrict the discussion to the sites with larger and therefore more representative datasets. All evidence for cattle, caprine and pig ageing is summarised in Table 8.42,

Table 8.43 and Table 8.44. These tables list all available ageing information, including the methods used to determine age, the qualitative proportions of neonates and adults for cattle and caprines, the mostly commonly occurring age category for pigs, and any information relating to preservation and recovery methods. Because of the problems of quantifying these data, descriptive terms have been used to illustrate the relative importance of each age category, from 'none' and 'a few' to 'many'.

A few sites provided detailed fusion information that made it possible to display the data in figures, and although these were then directly comparable with Quoygrew, most of the evidence for ageing could not be compared in detail. These sites included Brough Road, Saevar Howe and Freswick, displayed in Figure 8.50, Figure 8.51, Figure 8.52 and Figure 8.53. Other sites with quantified general age category data include the Brough of Birsay Rescue Excavations and Brough of Birsay Room 5, both analysed by Sellar.

All information related to cattle ageing is provided in Table 8.42. Three patterns are immediately apparent: phase groups with no neonatal bone, phase groups with "a few" neonatal bones, and phase groups where neonatal bones were found in quantity, representing a significant proportion of all cattle bone. As already mentioned, the presence of neonatal bone may be correlated with both preservation and recovery. Statistical testing of the Quoygrew cattle bone indicated neonatal bone was significantly better preserved in the hand collected subset – possibly indicating that poorly preserved neonatal bone was found less frequently during hand collection – and both juvenile and neonatal cattle were under-represented by hand collection (see Chapter Six, section 6.2). Reviewing the comparative dataset as a whole, there was remarkable consistency at the intra-site level in the quantities of neonatal bone found. This result could indicate that preservation was similar throughout all phase groups from a given site, that recovery methods were the same, or that there were consistent age profiles through time indicative of little economic change in the use of cattle. Aside from Quoygrew (discussed in Chapter Six), few sites displayed considerable intra-site variation. One was Freswick, where the late Iron Age to Viking Age SCA deposits contained no neonatal bone. At Pool, the final zooarchaeological report is not yet available, but there is evidence to indicate an increase in neonatal bone through time. This is first evident during the transitional late Iron Age to Viking Age phase 7, when compared to the Iron Age phase 6 age profile. A later increase in phase 8 brings the total of cattle neonatal bone to over 60% (Bond 2003, 108).

Sites with no neonatal cattle include the Brough of Birsay Rescue Excavations (late Iron Age to early medieval), the Brough of Birsay Room 5 (late Iron Age to medieval), Brough Road (late Iron Age to medieval; Figure 8.50), Saevar Howe phase I (late Iron Age), Buckquoy (late Iron Age to medieval), and Freswick SCA (late Iron Age to Viking Age; Figure 8.53). Unfortunately, all of these sites span a considerable chronology, but using the individual dates for the phase groups contributing to this pattern, it appears to have Iron Age origins and extend into the Viking Age and medieval periods. However, no phase group exclusively dated to the medieval period exhibits this pattern. Aside from Freswick, all of these sites are located in the Birsay Bay area, which may prove significant. Furthermore, the material from Freswick SCA was described as poorly preserved compared to the other phase groups at Freswick, which implies that this is more likely to be a taphonomic pattern than an economic one at this site (Gidney 1995, 200).

Some sites have only small quantities of neonatal bone, including Sandwick North (11-13th century), Beachview (late 10th century to medieval), Saevar Howe phase II (8th – 10th century), and Freswick areas 3 (?late Iron Age to medieval) and 9 (medieval). This cluster is less geographically confined, but does include the two remaining phase groups from the Birsay Bay area. Thus, all Birsay Bay sites have little or no neonatal bone. Moreover, Beachview contains the only phase groups from Birsay Bay that date wholly to the medieval period. The one 'outlier' in this Birsay Bay cluster may be Saevar Howe phase II, which contains very little neonatal bone, but most cattle were "very young" (Rowley-Conwy 1983, Tab. 6).

In contrast with the sites discussed above, neonatal bone was found in moderate to substantial quantities at St. Boniface (Iron Age to medieval), Pool (late Iron Age to mid 11th century), Skaill (Viking Age to medieval), Newark Bay (Viking Age to medieval), Robert's Haven (11th to 13th century), Freswick NCA (early 11th to early 14th century), Freswick CCA (?late Iron Age to medieval) and Freswick Inland 1 (?late Iron Age to medieval). Sandwick (late 12th to 14th century) and Jarlshof (only explicitly mentioned for the 9th century middens) were not quantified, but both contained high quantities of very young cattle. These sites again span a considerable chronology, but unlike the examples with no neonatal cattle, a number of phase groups of exclusively medieval date are included.

The sites from the Birsay Bay area form a coherent pattern: most contain no neonatal bone and a few contain very little neonatal bone; overall they date from the late Iron Age to the medieval period, but only the Beachview sites date predominantly to the medieval period (from the late 10th century, and thus extending very slightly into the Viking Age). While it may be suggested that area-wide taphonomic biases have caused this pattern, a number of factors suggest it is real. Firstly, at Beachview, the presence of at least five neonatal cattle bones suggests they can survive, confirmed by the presence of five partially articulated neonatal or juvenile caprine skeletons which suggest that young bone survives well (Rackham 1996b, 165, 168). Secondly, although bone preservation is generally not explicitly stated, it was described as "very good" at Brough Road (Rackham 1989, 246). Finally, the presence of substantial quantities of fish bone at Beachview and Brough Road suggests these sites had good overall preservation. This is more difficult to assess at the Brough of Birsay sites, which were entirely recovered by hand (but see Appendix One regarding recovery at the Rescue Excavations). The absence of neonatal bone cannot be attributed to recovery methods either, because although the Brough sites and Buckquoy were hand collected, Brough Road, Beachview and Saevar Howe were of mixed recovery or were completely sieved. In sum, neonatal cattle may have been more common in later (medieval) sites overall, and less common in the Birsay Bay area. This will be revisited in the concluding chapter.

Within the caprines, any patterning was less clear. Neonatal bone was recovered from some sites, but rarely to the same quantity as cattle. There tended to be a correlation between the sites with no neonatal cattle and those with no neonatal caprines. At the two sites on the Brough of Birsay, most of the caprines tended to be fully adult individuals older than three years, but at other sites in the Northern Isles, a wider age range was recovered. Brough of Birsay Rescue Excavations, phase 2.1, area IX (late Viking Age) was unusual because it contained equal quantities of two to three year old caprines and those older than 3 years[•]. No differences were observed in the cattle age profiles for this phase group. At the Brough Road sites, although there was no neonatal bone, most of the caprines were between one and three to four years of age (Figure 8.51). At Beachview, most were between one and two years of age, and at Saevar Howe, a range of ages was recovered from both phase groups (Figure 8.52). An unusual deposit of five partially articulated neonatal or juvenile sheep skeletons was found in an unspecific area of Beachview (Rackham 1996b, 168). These were interpreted as evidence of skinning, and are unique in the Northern Isles, although single finds of articulated or semi-articulated cats have been found elsewhere. These may represent a unique event at Beachview, but its nature is unknown.

Two patterns were observed among the evidence for pig ageing. Either phase groups tended to contain a range of ages, with most representing younger individuals, or pigs tended to be fully adult. Sites with predominately juvenile, immature or sub-adult pigs include Sandwick (late 12th to 14th century), Jarlshof (9th century), Pool (late Iron Age to medieval), Brough of Birsay Room 5 'drain fill' (late 9th to late 12th century), Brough Road (7th to 13th century), Beachview (late 10th to medieval), Saevar Howe (Iron Age to 10th century), probably Buckquoy (Iron Age to medieval), and Freswick areas 1 and 3 (?late Iron Age to medieval). These are drawn from a wide geographical and chronological range, and include different recovery methods. In contrast, the sites which contain primarily fully adult pigs are the Brough of Birsay Rescue Excavations (late Iron Age to early medieval) and all except one of the phase groups from Brough of Birsay Room 5 (late Iron Age to medieval).

Drawing together the evidence from cattle, caprines and pigs, two main age profiles are observed. The group of sites around Birsay Bay contain very little neonatal cattle in contrast to all other sites from the Northern Isles. These low quantities of neonatal cattle tend to correspond to low levels of neonatal caprines. Sites from the Brough of Birsay itself tend to contain only adult pigs, yet the other sites from the Birsay Bay area contain a wider range of pig ages more comparable to other sites. These patterns are unlikely to be taphonomic or caused by differential recovery, but the two sites on the Brough were

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[•] According to the NISP data in Sellar's Table 30, this phase was composed almost entirely of 2 to 3 year old caprines. However, upon closer examination of summary and percentage data, the "78" recorded by Sellar should read "7", thus making this phase similar to all others.

analysed by Sellar, which might suggest inter-analyst variation. Preservation at the Brough of Birsay was not explicitly discussed, but was likely to have been relatively poor compared to other sites in the Northern Isles (Rackham 1989, 258). This may partly explain the paucity of neonatal bone there, but given the absence of neonatal cattle in the well preserved, sieved phase groups from the Brough Road suggests the pattern is real for at least this species. These issues will be further investigated below, when evidence of mammal element patterning and species composition will be compared with the ageing evidence to draw conclusions about the nature of settlement in the Birsay Bay area.

Site and phase group	Dates	Method	Neonates and juveniles	Older animals	Recovery	Notes, source
Sandwick North phases 2 and 3	11-13th c.	Fusion, teeth	A few neo., a few juv.	A few	Mixed	Barrett and Oltmann 2000, 17-18, Table 26, 27
Sandwick	Late 12th – 14th c.	Teeth, fusion	Most <6 months	?few	Mixed	Bigelow 1984, 133-34
Jarlshof	9th c.	?	"in most cases" young	?	Selective hand collection	Platt 1956, 214
St. Boniface	Iron Age – 1250	Fusion, teeth	Some neo., mostly juv.	?few	Sieved	McCormick 1998b, 147-48
Pool phase 7	Late Iron Age – Viking Age	Teeth	Half neo./juv.	?few	Mixed	Bond 1994, Bond *et al.* Forthcoming, 9; Bond 2003, 108
		Fusion	One third neo./juv.	?few	Mixed	
Phase 8	Viking Age – mid 11th c.	Teeth	Half neo./juv.	?few	Mixed	
		Fusion	Some neo./juv.	?few	Mixed	
Brough of Birsay Rescue Exc. phase 1	Late Iron Age – early Viking Age	?	None	Most	Hand collection	Sellar *et al.* 1986, Tables 16, 23, 30
Phase 2.1	Late Viking Age	?	None	Most	Hand collection	
Phase 2.2	Late Viking Age	?	None	Most	Hand collection	
Phase 3	Late Viking Age – early medieval	?	None	Most	Hand collection	
Brough of Birsay Room 5, phase 1	late Iron Age – Viking Age	Teeth, fusion	No neo., a few juv.	Most	Hand collection	Sellar 1982, Table 6
Phase 2	640-880	Teeth, fusion	None	Most	Hand collection	
Phase 3a	890-1190	Teeth, fusion	No neo, a few juv.	Most	Hand collection	
Phase 3b	Viking Age – medieval	Teeth, fusion	None	All immature to sub-adult, 1.5-3.5 years	Hand collection	
Phase 4	Viking Age – medieval	Teeth, fusion	None	Most	Hand collection	
"Drain fill"	890-1190	Teeth, fusion		All >3.5 years	Hand collection	
Brough Road area 1, D, area 2, C1 and C2	7th – 13th c.	Teeth, fusion	No neo., some juv.	Some	Mixed	"Very good" preservation; Rackham 1989, 246
Area 1, F1 and F2, area 2 E1, E2	7th – 11th c.	Teeth, fusion	No neo., a few juv.	Some	Mixed	
Beachview, all sites	Late 10th – medieval	Teeth, fusion	Almost no neo., some juv.	Most	Mixed	Rackham 1996b, 165
Saevar Howe	Iron Age	Mixed	No neo., a	A few	Sieved	Rowley-Conwy

phase I			few juv.			1983, Table 10, 11
Phase II	8th – 10th c.	Mixed	A few neo., most "very young"	A few	Sieved	
Buckquoy, phases I and II	Late Iron Age	Fusion	?no neo., some juv.	Some	Hand collection	Noddle 1976-77, 205
Buckquoy, phases III to V	Viking Age	Fusion	?no neo., some juv.	Some	Hand collection	
Skaill	Viking Age – medieval	Teeth, fusion	Half	Some	Hand collection	Noddle 1997, Table 17.3
Newark Bay	Medieval	Mixed	Some	Some	Hand collection	Harland 2001b
Earl's Bu (interim results)	Viking Age – medieval	Fusion	Some, most juv. or immature	A few	Mixed	Mainland 1993; I Mainland, pers. comm.
Robert's Haven phase 1 area A	11-13th c.	General categories	Half were neo. or juv.			Mainland nd.a, Table 5
Freswick NCA	Early 11th – early 14th c.	General categories, fusion	Half	Some	Mixed	Gidney 1995, 195
CCA	?late Iron Age – medieval	General categories, fusion	Some	Some	Mixed	
SCA	Late Iron Age – Viking Age	General categories, fusion	No neo., very little juv.	Most	Mixed	Poor preservation compared to other areas at Freswick; Gidney 1995
Inland 1	?late Iron Age – medieval	General categories, fusion	Half neo.	Some	Mixed	
Inland 3	?late Iron Age – medieval	General categories, fusion	A few neo.	Some	Mixed	
Inland 9	Medieval	General categories, fusion	A few neo.	Some	Mixed	

Table 8.42: Summary of cattle ageing data

Site and phase	Dates	Method	Neonates and juveniles	Older animals	Recovery	Preservation, notes, source
Sandwick North phases 2 and 3	11-13th c.	Fusion, teeth	A few juv.	A few	Mixed	Barrett and Oltmann 2000, 17-18, Table 28, 29
Sandwick	Late 12th – 14th c.	?teeth, fusion	?very few	Most	Mixed	Bigelow 1984, 133-34
Jarlshof	9th c.	?	?immature mentioned	?	Selective hand collection	Platt 1956, 214
St. Boniface	Iron Age to 1250	Fusion, teeth	?some	?some	Sieved	Increasing neo. and juv. in medieval phase 8; McCormick 1998b, 148
Pool phase 7	Late Iron Age – Viking Age	Teeth, fusion	Some neo.	A few	Mixed	Bond *et al.* Forthcoming, 10-11
Phase 8	Viking Age – mid 11th c.	Teeth, fusion	A few neo.	A few	Mixed	
Brough of Birsay Rescue Exc. phase 1	Late Iron Age – early Viking Age	?	None	Most	Hand collection	Sellar *et al.* 1986, Tables 16, 23, 30
Phase 2.1	Late Viking Age	?	None	Most 2-3 years	Hand collection	
Phase 2.2	Late Viking Age	?	None	Most	Hand collection	
Phase 3	Late Viking Age – early medieval	?	None	Most	Hand collection	
Brough of Birsay Room 5, phase 1	late Iron Age – Viking Age	Teeth, fusion	No neo., some juv.	Most	Hand collection	Sellar 1982, Table 6
Phase 2	640-880	Teeth, fusion	No neo., some juv.	Most	Hand collection	
Phase 3a	890-1190	Teeth, fusion	None	Some	Hand collection	
Phase 3b	Viking Age – medieval	Teeth, fusion	No neo., some juv.	Most	Hand collection	
Phase 4	Viking Age-medieval	Teeth, fusion	No neo., some juv.	Some	Hand collection	
"Drain fill"	890-1190	Teeth, fusion	None	Most	Hand collection	
Brough Road area 1, D, area 2, C1 and C2	7th – 13th c.	Teeth, fusion	No neo., some juv.	Most imm. to sub-adult, 1 to 3 or 4 years	Mixed	Rackham 1989, 246
Area 1, F1 and F2, area 2 E1, E2	7th – 11th c.	Teeth, fusion	No neo., some juv.	Most imm. to sub-adult, 1 to 3 or 4 years	Mixed	
Beachview, all sites	Late 10th – medieval	Teeth, fusion	A few neo., some juv.	Some	Mixed	Rackham 1996b, 165, 168, Illus. 131
Saevar Howe phase I	Iron Age	Mixed	Some neo.	A few	Sieved	Rowley-Conwy 1983, Table 10, 11
Phase II	8th – 10th c.	Mixed	Some neo.	Most	Sieved	
Buckquoy,	Late Iron	Fusion	? no neo.,	Some	Hand	Noddle 1976-77,

phases I and II	Age		some juv.		collection	205
Phases III to V	Viking Age – medieval	Fusion	?no neo., some juv.	Some	Hand collection	Noddle 1976-77, 205
Skaill	Viking Age – medieval	?	Some	Some	Hand collection	Noddle 1997, Table 17.3
Newark Bay	Medieval	Mixed	Some	Most 1-2 years	Hand collection	Harland 2001b
Earl's Bu (interim results)	Viking Age – medieval	Fusion	Some	Some	Mixed	Mainland 1993; I Mainland, pers. comm.
Freswick Inland 1	?late Iron Age to medieval	General categories, fusion	Some juv.?	Some	Mixed	Gidney 1995, 200
Inland 3	?late Iron Age to medieval	General categories, fusion	Some juv.	Some	Mixed	
Inland 9	Medieval	General categories, fusion	None	All >2 years	Mixed	

Table 8.43: Summary of caprine ageing data

Site and phase	Dates	Method	Age range and predominant category	Recovery	Preservation, notes, source
Sandwick	Late 12th to 14th c.	Teeth, fusion	Sub-adult	Mixed	Bigelow 1984, 133-34
Jarlshof	9th c.	?	Variety noted, including young and old	Selective hand collection	Platt 1956, 214
Pool	Late Iron Age to medieval	Fusion	Most immature, 1 to 2.5 years	Mixed	Bond *et al.* Forthcoming, 11
Brough of Birsay Rescue Exc. phase 1	Late Iron Age – early Viking Age	?	Most adult, >3 years	Hand collection	Sellar *et al.* 1986, Tables 23, 30
Phase 2.1	Late Viking Age	?	Most sub-adult to adult, 2-3 years	Hand collection	
Phase 2.2	Late Viking Age	?	Most adult, >3 years	Hand collection	
Phase 3	Late Viking Age – early medieval	?	Most adult, >3 years	Hand collection	
Brough of Birsay Room 5, phase 1	late Iron Age - Viking Age	Teeth, fusion	Some <1 year, most >3 years	Hand collection	Sellar 1982, Table 6
Phase 3a	890-1190	Teeth, fusion	All >3 years	Hand collection	
Phase 3b	Viking Age – medieval	Teeth, fusion	Most >3 years	Hand collection	
Phase 4	Viking Age – medieval	Teeth, fusion	Some 1-2 years, most >3 years	Hand collection	
"Drain fill"	890-1190	Teeth, fusion	All <2 years	Hand collection	
Brough Road	7-13th c.	Teeth, fusion	Most <2 years	Mixed	Rackham 1989, 246
Beachview, all sites	Late 10th – medieval	Teeth, fusion	Wide age range without predominant category	Mixed	Rackham 1996b, 168
Saevar Howe	Iron Age – 10th c.	Mixed	Mostly juvenile	Sieved	Rowley-Conwy 1983, Table 10, 11
Buckquoy	Iron Age – medieval	Fusion	Wide range, some adult	Hand collected	Noddle 1976-77, 205
Skaill	Viking Age – medieval	Teeth, fusion	Mostly immature	Hand collected	Noddle 1997, Table 17.3
Earl's Bu (interim results)	Viking Age – medieval	Fusion	Most 1 to 2 years	Mixed	Mainland 1993; Mainland 1994; pers. comm.
Freswick Inland 1	?late Iron Age to medieval	General categories, fusion	Mostly 1 year old	Mixed	Gidney 1995, 200
Inland 3	?late Iron Age to medieval	General categories, fusion	Mostly 1 year old	Mixed	Gidney 1995, 200

Table 8.44: Summary of pig ageing data

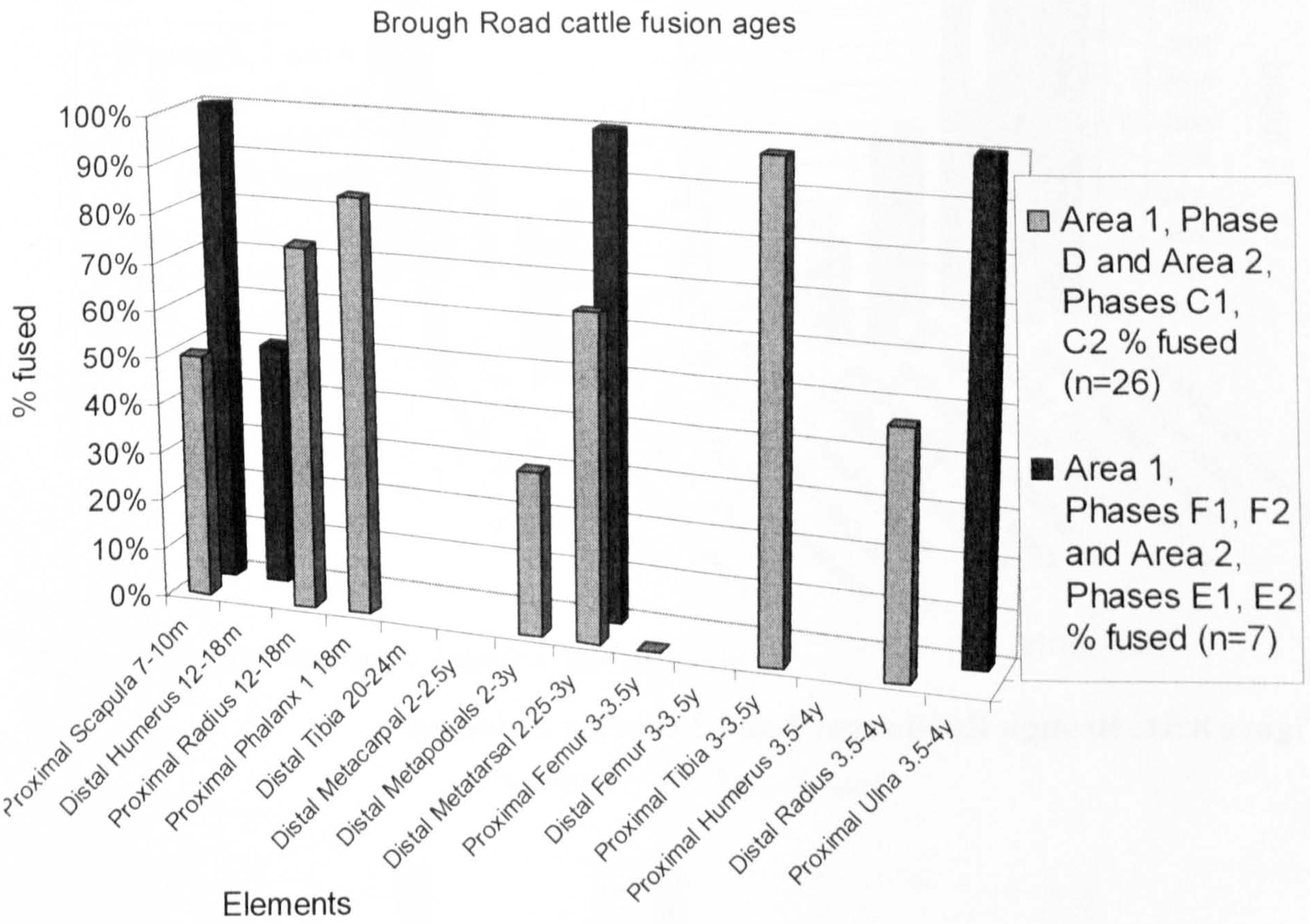


Figure 8.50: Brough Road areas 1 and 2 cattle fusion ages

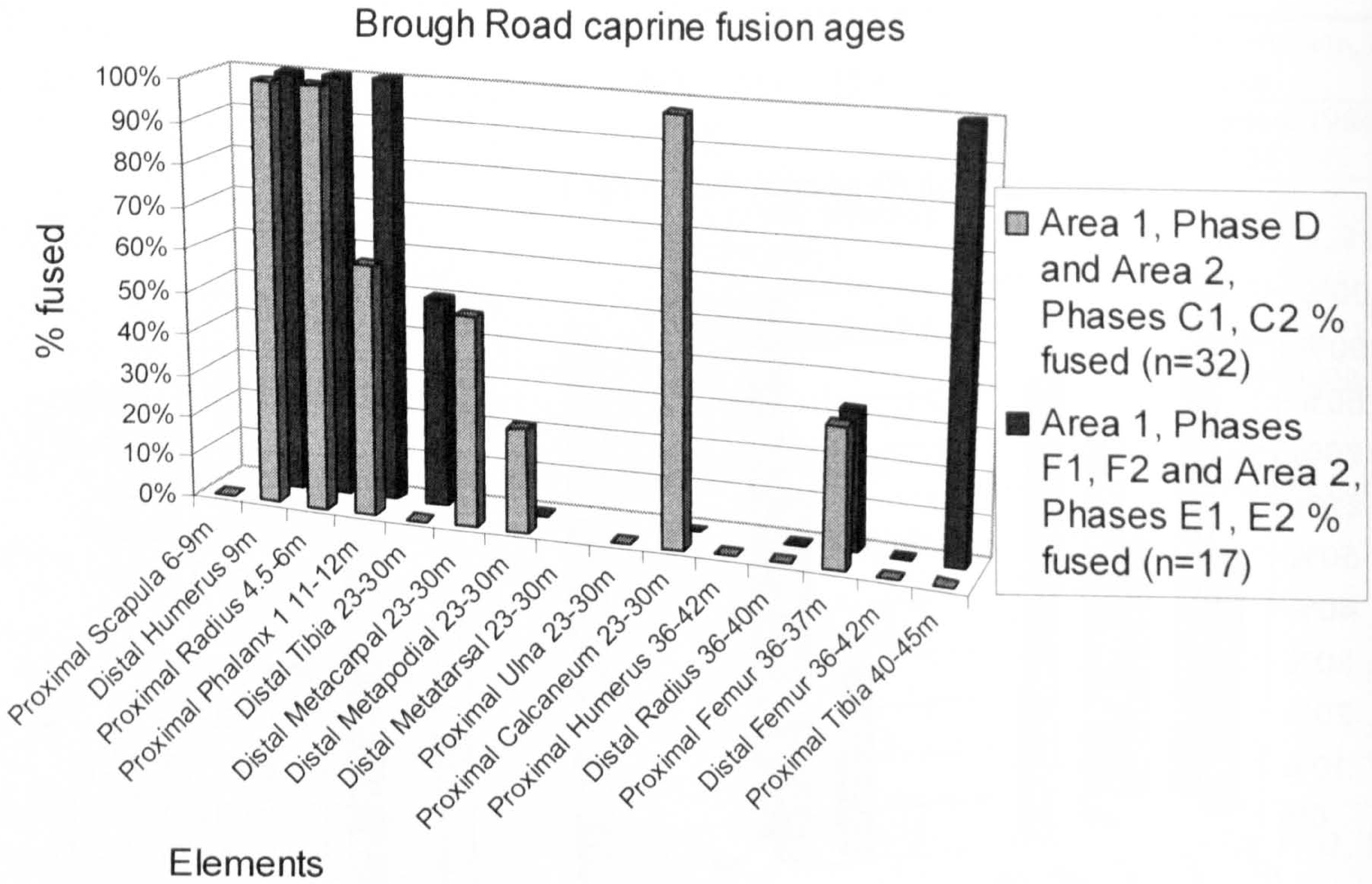


Figure 8.51: Brough Road areas 1 and 2 caprine fusion ages

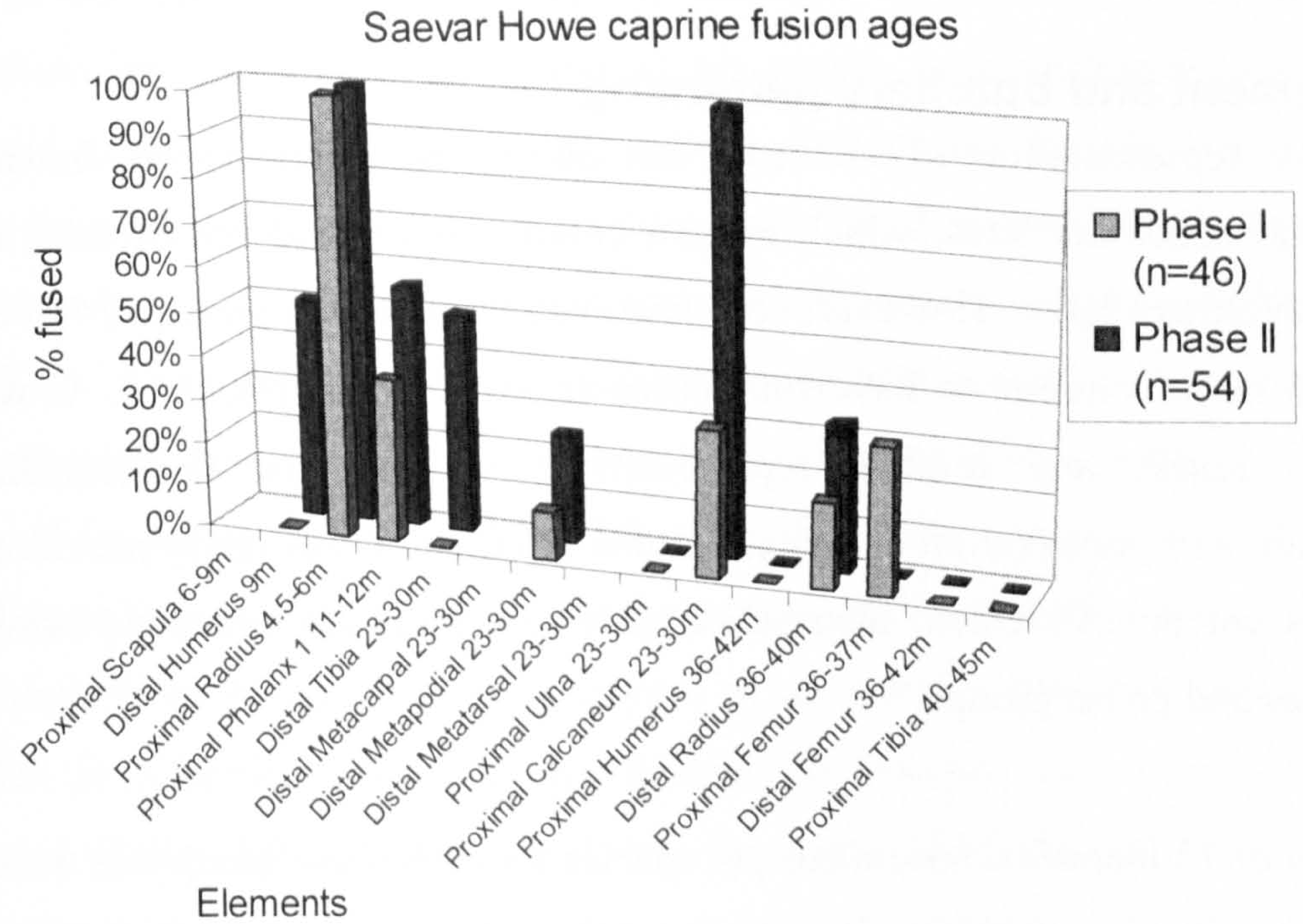


Figure 8.52: Saevar Howe caprine fusion ageing

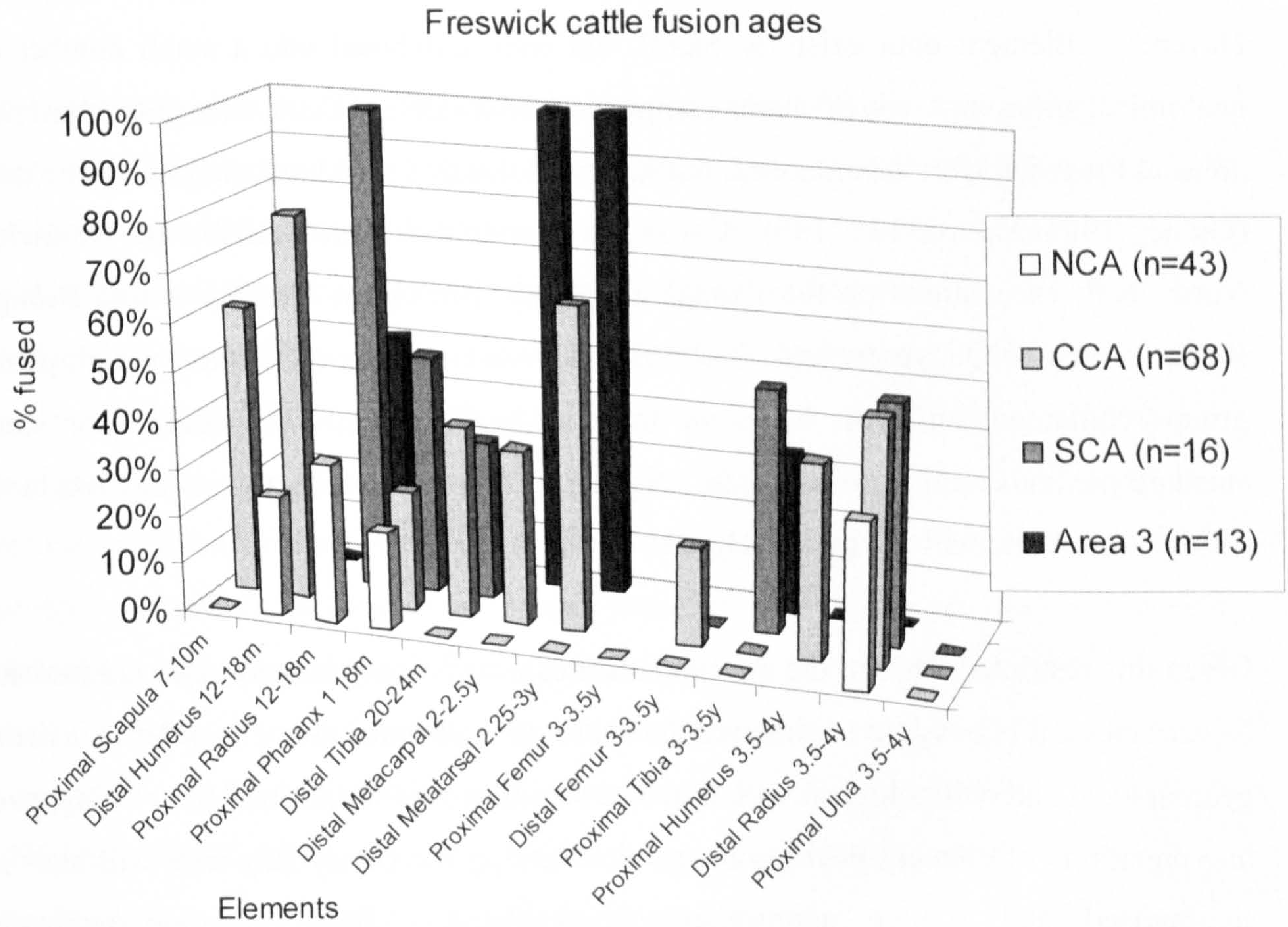


Figure 8.53: Freswick cattle fusion ages

8.4.3 Element and butchery patterning

The relative representation of elements can allow conclusions to be drawn about producer and consumer sites, which in turn could provide evidence of meat moving around the Northern Isles. However, very few excavation reports presented full element data; it was more common to have summaries or grouped data discussed. It was also difficult to assess any relative representations without first understanding the fragmentation and preservation at a site, but this information was rarely provided. Few reports thus contained element distribution data in a form that permitted comparison between sites and phase groups.

A minimum of 75 identified specimens per species for each phase group was treated as a threshold for inclusion in this study. Element data were not available for Sandwick, Scalloway, Jarlshof, St. Boniface, Tuquoy, Pool, Saevar Howe, the Brough of Deerness and most of Freswick, and were insufficient to consider at Newark Bay and Robert's Haven. Element data exist for Skaill, but were combined into a small number of anatomical groupings which made comparison impossible. Cattle elements from two areas at Freswick were summarised, but not in a form that permitted analysis of raw data (Gidney 1995, Figures 135, 136). Cattle and caprine data were available for Sandwick North, both excavations on the Brough of Birsay, Buckquoy, Beachview and Brough Road, as well as Quoygrew and Earl's Bu. However, within these sites, not all phase groups contained sufficient bones to fully analyse element distributions, nor were standard methods applied to each site. Pig element distribution data were only available for a few sites and will not be reanalysed.

Given this restricted dataset, the questions that can realistically be addressed are limited. Nevertheless, it is possible to compare the subset of sites noted above in order to address geographical and chronological variation at a broad level of resolution. In so doing, past interpretations of element distribution patterns among the Birsay Bay sites will also be summarised and (where appropriate), re-evaluated. Data regarding recovery, preservation and inter-analyst variability will also be considered where practicable.

Sellar (1986) grouped cattle and caprine elements from the two Brough of Birsay excavations into 10 groups, and displayed his results as percentages; these were then converted to raw counts by the current author. Sellar used his element data from the Rescue Excavations to infer that sheep were slaughtered on the Brough, but cattle were killed elsewhere and only prepared beef was carried over from the Mainland (Sellar *et al.* 1986, 215). As an alternative, he also suggested that both species may have been brought to the Brough dead, but the sheep were carried over whole, while the cattle were butchered for easier transport. Phase 2.2 of site IX is the one exception to this pattern, according to Sellar (1986, 215), because fewer meat-rich elements were found there. The assemblage from Room 5 was not analysed to the same extent, but element data were provided in a similar format to the Rescue Excavations and can thus be directly compared (Sellar 1982, Tables 3 and 4). Two sets of caprine data from the Rescue Excavations could not be used. Phase 1, site IX contained insufficient identified elements, while the percentages for phase 2.2, site IX were incorrectly printed, totalling over 100%, and were therefore not used.

In contrast to element data from the Brough, any use of the element distribution data from Buckquoy is somewhat fraught. Consultation of the Noddle archive indicated some of the values recorded in Noddle's Tables 2, 3 and 4 were incorrect (1976-77). Unfortunately, only certain layers (the stratigraphic unit used during excavation) were included in the analysis, and no record was kept of the elements found in the smaller layers. All cattle from phase III and all caprines from phase Ia have therefore been excluded from this discussion. Nevertheless, the present author has attempted to reconstruct element data, assigning all known elements and layers to the correct phase groups. Noddle's original bone report made no explicit mention of provisioning, although a higher proportion of meat rich elements were recorded for caprines and pigs than for cattle. Noddle attributed this discrepancy to recovery biases, with the small waste elements from the smaller species recovered less frequently than those from cattle (Noddle 1976-77, 203). This was further discussed by Ritchie, when it was speculated that Buckquoy provided provisions for the Brough (1983).

The element quantification for the Brough Road phases grouped together deposits that were approximately contemporary, despite representing different deposit types (Rackham 1989, Tab. 25). For all three domestic species, there is an additional problem: the element totals displayed in Rackham's Table 25 do not match those from his NISP tables. In most cases, the element totals greatly exceed the NISP totals; while this may indicate the use of a diagnostic zone system, in which each uniquely identifiable region of an element is counted, this was not mentioned in his methodology. For this reason, the data cannot be investigated in any detail, but Rackham did not note any unusual over- or under-representation of elements (Rackham 1989, 244).

The Beachview element data can be used to compare with the sites from the Brough and Buckquoy, but they are grouped by area without regard to phase. Along with the Viking Age and medieval phase groups, used throughout this study, there is another phase group included in the element data that dates to the modern period. This unfortunately contained almost 40% of the cattle elements from Area 1. The cattle data are summarised for hand collected deposits only, but the caprine elements from both hand collected and sieved deposits were combined, thus making it difficult to examine variation between species. Element proportions were discussed in the final report. Cattle and cattle sized vertebrae and ribs were both under-represented, interpreted as evidence of butchery located offsite, but other elements of low meat value were recovered. It was therefore concluded that most butchery occurred on site (Rackham 1996a, 165). Caprine elements indicated little over- or under-representation, according to Rackham, but Area 1D/E contained a slightly lower proportion of hind limbs compared to other areas (Rackham 1996a, 167). Both cattle sized and caprine sized elements were included in the zooarchaeological report, but were separately quantified. These data were not used in the current reassessment, because element distributions for most other sites were only available for more securely identified taxonomic categories.

Raw element data were not available for Saevar Howe, but a summary of meat and waste elements was discussed, albeit as a by-product of an examination of differences between "interior" and "exterior" contexts (Rowley-Conwy 1983, 74). Results indicated that all elements were present for caprines and pigs, but for cattle, the proportion of waste elements was higher. This was not discussed further by the authors of the excavation report, but it could indicate that meat-rich cattle elements were removed from Saevar Howe. However, these results were not linked to particular dates, nor is there any way of testing these conclusions.

Faunal assemblages from the Birsay Area were assessed by Gilmour and Cook during a discussion of Iron Age material from the Western Isles, but they did not reanalyse any of the published material, instead relying on conclusions drawn by the original zooarchaeologists (Gilmour and Cook 1998). They summarised that meat was likely transported to the Brough from sites like Buckquoy, following the suggestions made by Ritchie (1983). The evidence from Birsay Bay thus needs to be reanalysed, focussing on the best available data.

Element data from Brough of Birsay Rescue Excavations, Brough of Birsay Room 5, Buckquoy and Beachview are displayed as bar graphs in Figure 8.54 to Figure 8.61 (for cattle) and Figure 8.64 to Figure 8.70 (for caprines). Each figure displays the same range of elements for each phase group, using the same scale to facilitate comparisons. There were a number of anatomical categories that had to be excluded from this analysis, because not all elements were routinely recorded at all sites. Ribs were only recorded to species by Sellar at the two Brough of Birsay sites, and are therefore excluded. Vertebrae were recorded at some sites, but again were rarely identified to species and are also excluded. Skull fragments were identified to species in considerable quantities by Sellar, but not by other zooarchaeologists, and it is not known if loose teeth were included in this category, or if Sellar used any diagnostic zone systems. Likewise, the mandible category was probably defined differently, sometimes including loose mandibular teeth. These two categories have therefore also been excluded. This leaves the long bones, scapulae, pelves, carpals and tarsals, metapodials and phalanges. This approach loses some resolution, particularly by using Sellar's "long bone" category rather than separately presenting each long bone proportion, but the use of this lowest common denominator approach maximises the number of sites that can be included. Figures have also been produced using the material from Quoygrew and Sandwick North, matched to the recovery methods used at other sites (Figure 8.62 and Figure 8.63 for cattle, and Figure 8.71 to Figure 8.73 for caprines). These two sites can be used as comparative material for all sites in the Birsay Bay area, and are particularly useful given that recovery, preservation, fragmentation and age profiles are all known, and all parts of the body were consumed without any export or import of meat (see Chapter Six; Barrett and Oltmann 2000, 16).

Using the raw data provided, intra-site variation will first be examined, taking into account any preservation and recovery data, in order to determine trends in time or space within each of the Birsay Bay sites. Then secondly, inter-site variation within the Birsay Area will be analysed in order to draw conclusions regarding the movement of livestock or meat in the area. These data will then be used in conjunction with age and species composition to draw conclusions about the movement of animals and animal products. Comparisons between cattle and caprines may aid interpretations regarding both livestock usage and transport, as well as recovery biases. Element data from Earl's Bu will not be used, as the recovery method differed from the other assemblages considered here.

Element proportions from both Quoygrew and Sandwick North indicated no meat was imported or exported from either site. Long bones were the predominant elements for both cattle and caprines, followed by metapodials (Figure 8.62, Figure 8.63, Figure 8.71 and Figure 8.73). There is the possibility that caprine metapodials were treated differently at both Quoygrew and Sandwick North, because bi-perforated examples were found only at these sites (see Appendix Four), but only small quantities were found at both sites. Based on Chi-square tests applied to the subset of elements considered in this section, no significant differences were found between phases at either site for either species.

The element proportions from the Brough of Birsay Rescue Excavations indicate cattle and caprine long bones dominate all phase groups (Figure 8.54 to Figure 8.56 for cattle, Figure 8.64 and Figure 8.65 for caprines). Scapulae were also found in higher than usual proportions in some phase groups, but when compared to Quoygrew and Sandwick North, most other element categories were poorly represented. Unfortunately, there is no means of assessing levels of fragmentation or other taphonomic processes. These unusual proportions were also apparent in Sellar's results from Brough of Birsay Room 5 (Figure 8.57 and Figure 8.58 for cattle, Figure 8.66 to Figure 8.67 for caprines), but to a less extreme extent. At Room 5, long bone proportions were generally lower for both species than at the Rescue Excavations, and scapulae, carpals and tarsals, metapodials and phalanges were correspondingly higher. Compared to Quoygrew and Sandwick North, long bones and scapulae were still over-represented, and pelves, carpals and tarsals and metapodials were still under-represented. The age profiles for the two sites on the Brough indicate very little neonatal bone was recovered, most cattle and caprines being at least two years of age (Sellar 1982, Table 6; Sellar *et al.* 1986, Tables 16, 23, 30). By that age, not all elements would be fused, but most would be of robust, adult-like texture and therefore would probably survive well. The low proportions of phalanges, carpals and tarsals at the two Brough of Birsay sites is very unusual, because these robust elements often survive well. Chi square tests were attempted, but the small quantities of many element groups made it difficult to produce valid results. Using the total element counts for each site, significant differences were calculated for both Brough of Birsay sites, when compared to Quoygrew and Sandwick North (Table 8.45 for cattle and Table 8.48 for caprines). This is unsurprising given the visual differences in distributions between these sites.

Looking at the Beachview areas, a more balanced distribution of cattle elements was produced (Figure 8.59). These compare favourably with the results from Quoygrew and Sandwick North, but significant differences were still found using Chi-square tests (Table 8.46 for cattle and Table 8.49 for caprines). These could result from differences in mortality profiles at the two sites, with more adults found at Beachview and thus more of the smaller elements, including phalanges, recovered at this site. Caprine long bones were also slightly over-represented at Beachview, compared to Quoygrew, when mixed recovery datasets were contrasted (Figure 8.68 and Figure 8.72). These differences could be explained by the varying proportions of hand collected and sieved material, combined with the differences in age profiles at each site.

At Buckquoy, a range of elements was again identified, without any of the extremes observed on the Brough (Figure 8.60 and Figure 8.61 for cattle, and Figure 8.69 and Figure 8.70 for caprines). Compared to Quoygrew and Sandwick North, proportions of cattle long bones appear lower, while phalanges, carpals and tarsals and pelves were over-represented for some phase groups. The Viking Age cattle elements from Buckquoy were statistically different from both Quoygrew and Sandwick North (Table 8.46). In contrast, there were few differences in the caprine element proportions compared to Quoygrew and Sandwick North. The one exception was the unusually high proportion of caprine long bones recovered from late Iron Age phase IIib. Significant differences were not observed between the Viking Age caprines and those from Quoygrew, but were found when compared to Sandwick North (Table 8.49). The differences in age profiles between the two sites may explain some of the differences in proportions, because fully fused cattle phalanges, carpals and tarsals would all survive very well and would probably be found by hand collection. However, it is unlikely that the low proportion of cattle long bones from Buckquoy can be solely attributed to these biases. It appears there was an over-representation of cattle waste elements at Buckquoy, and a correspondingly low occurrence of meat-rich long bone elements. These may have been exported as prepared meat to other sites.

Turning now to overall inter-site comparisons, a number of factors make this a difficult problem to assess. Differences in recovery methods are mostly minimal, except at Beachview. Differences in preservation between the Brough – relatively poor compared to other sites – and the Mainland sites – generally good – could influence element survival. Inter-analyst variability may have had a large and unmeasurable influence, because Sellar identified the two most abnormal sites: those from the Brough. Because he did not identify the assemblages from any other sites, and he did not make his methods explicit, it is difficult to determine whether much of the variation between the Brough and all other sites is simply the result of different identification and quantification methods. It is possible that Sellar identified all large mammal long bone fragments as cattle, whereas most other analysts would be more conservative. Furthermore, the use of diagnostic zone systems, as at Quoygrew, require at least half of a zone to be present before a specimen is recorded, but Sellar does not appear to have used such a system. However, the removal of some of the element categories used, including skulls, mandibles, ribs and vertebrae, has eliminated some of the more extreme differences between the Brough and all other sites. Age profiles were at least similar throughout most of the Birsay Bay area, thus limiting another potential source of variation, but the Quoygrew and Sandwick North cattle and caprine data used for comparison contained much high proportions of young animals. Finally, element data were not available for two of the sites in the Birsay Bay area, making any conclusions drawn for the area necessarily incomplete.

Using Quoygrew and Sandwick North as examples of sites where no transport of meat has occurred, it is apparent that Beachview contained similar element distributions, whereas the two sites from the Brough both displayed abnormally high proportions of long bones. At Buckquoy, cattle element proportions indicated a slight but significant under-representation of long bones, possibly indicating some were removed from the site, while waste elements, including phalanges, were much higher than at other sites. There was no indication of any elements over- or under-represented at Beachview, while at Saevar Howe, there may have been an under-representation of meat-rich elements. Considering all sites together, it is possible that cattle were butchered at Buckquoy, and possibly at Saevar Howe, the meat then transported to the Brough of Birsay for consumption there (with the caveat that methodological differences may have artificially inflated the proportion of long bones at the Brough). There is less evidence for caprines; contrary to Sellar's analysis, some may have arrived ready-butchered at the Brough, but their potential origin is less clear.

To summarise, element proportions could only be examined for a small number of sites, but fortunately, this included several from the Birsay Bay area. A number of authors had already speculated about meat being prepared on Mainland and transported ready-butchered to the Brough. This was shown to be possible, because the unusual element proportions found at both excavations on the Brough of Birsay, including substantial over-representation of long bones, could represent prepared beef and mutton. Element data from Buckquoy indicated slightly inflated proportions of waste elements for cattle, suggesting some meat may have been exported. Both sites were occupied during the Viking Age: it is therefore possible cattle were butchered at Buckquoy and prepared meat was taken to the Brough for consumption. Meat may also have been exported from Buckquoy in the later Iron Age phases. Saevar Howe may also have provided meat to other sites in the late Iron Age or Viking Age, possibly including the Brough, while it appears likely that cattle and caprines were consumed in their entirety at the later Viking Age and medieval site of Beachview. The evidence from the Brough itself relies heavily on Sellar's methods, which were not made explicit, but potential biases have been minimised by using a selected subset of elements that were routinely recorded at all sites. The use of MNE and MNI quantification, as applied to the Quoygrew mammal and fish element distributions in Chapters Five and Six, reduces these problems and aids comparison. Regardless, the evidence from Buckquoy, and possibly Saevar Howe, indicates that meat was likely exported from these sites. This will be discussed further in Chapter Nine.

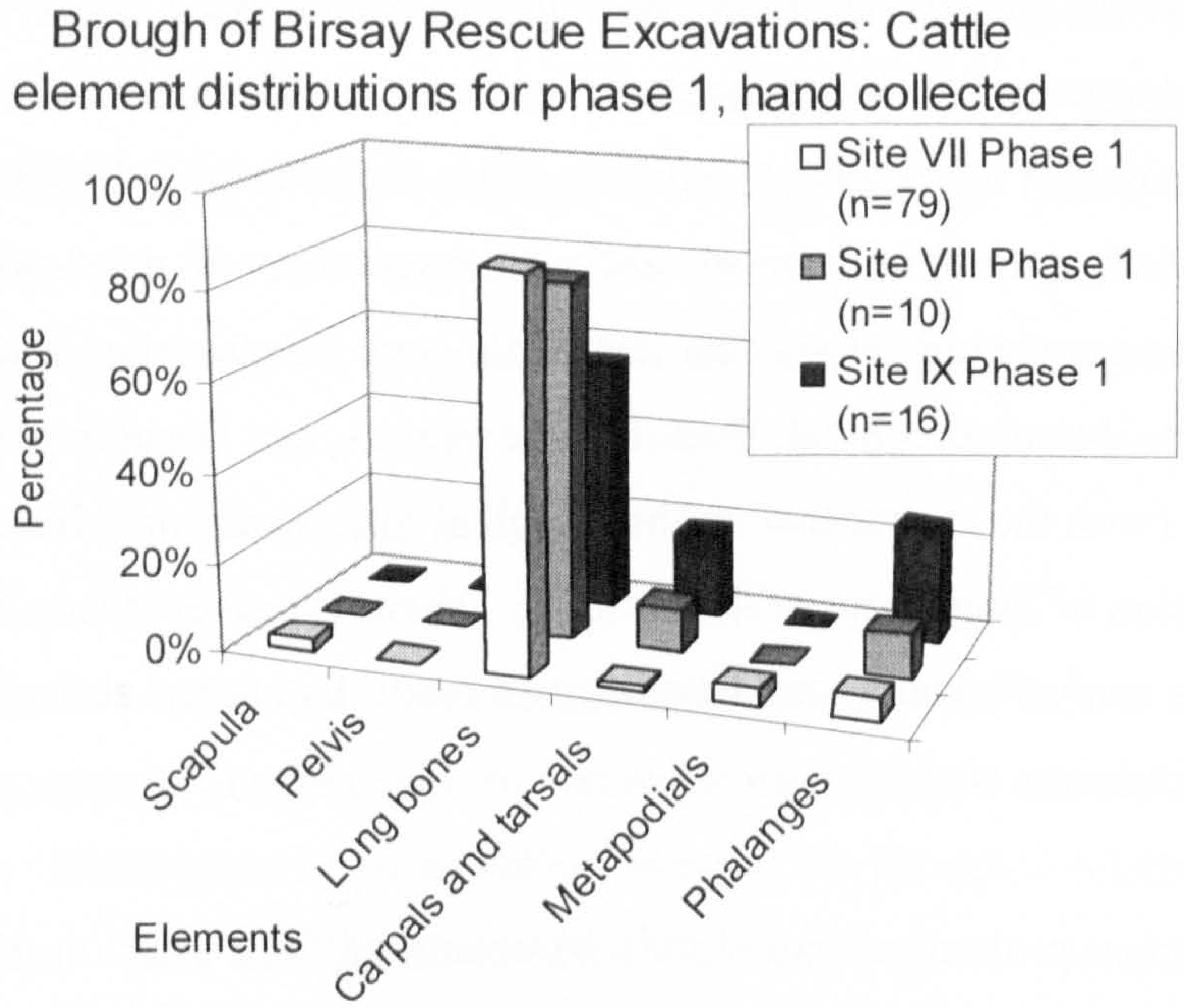


Figure 8.54: Cattle element proportions from the Brough of Birsay Rescue Excavations, phase 1 (from Sellar *et al.* 1986, Tables 12, 19, 26)

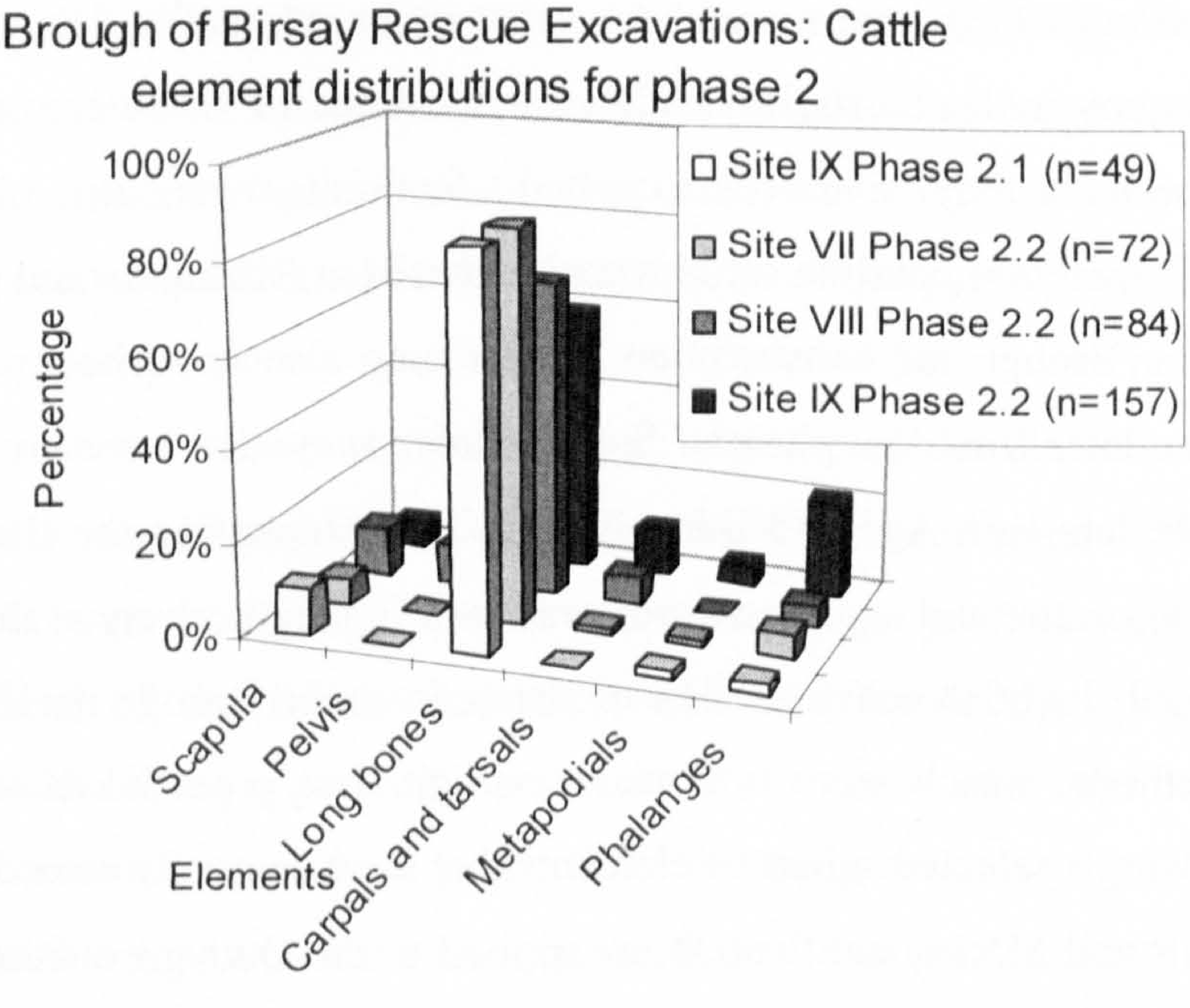


Figure 8.55: Cattle element proportions from the Brough of Birsay Rescue Excavations, phase 2 (from Sellar *et al.* 1986, Tables 12, 19, 26)

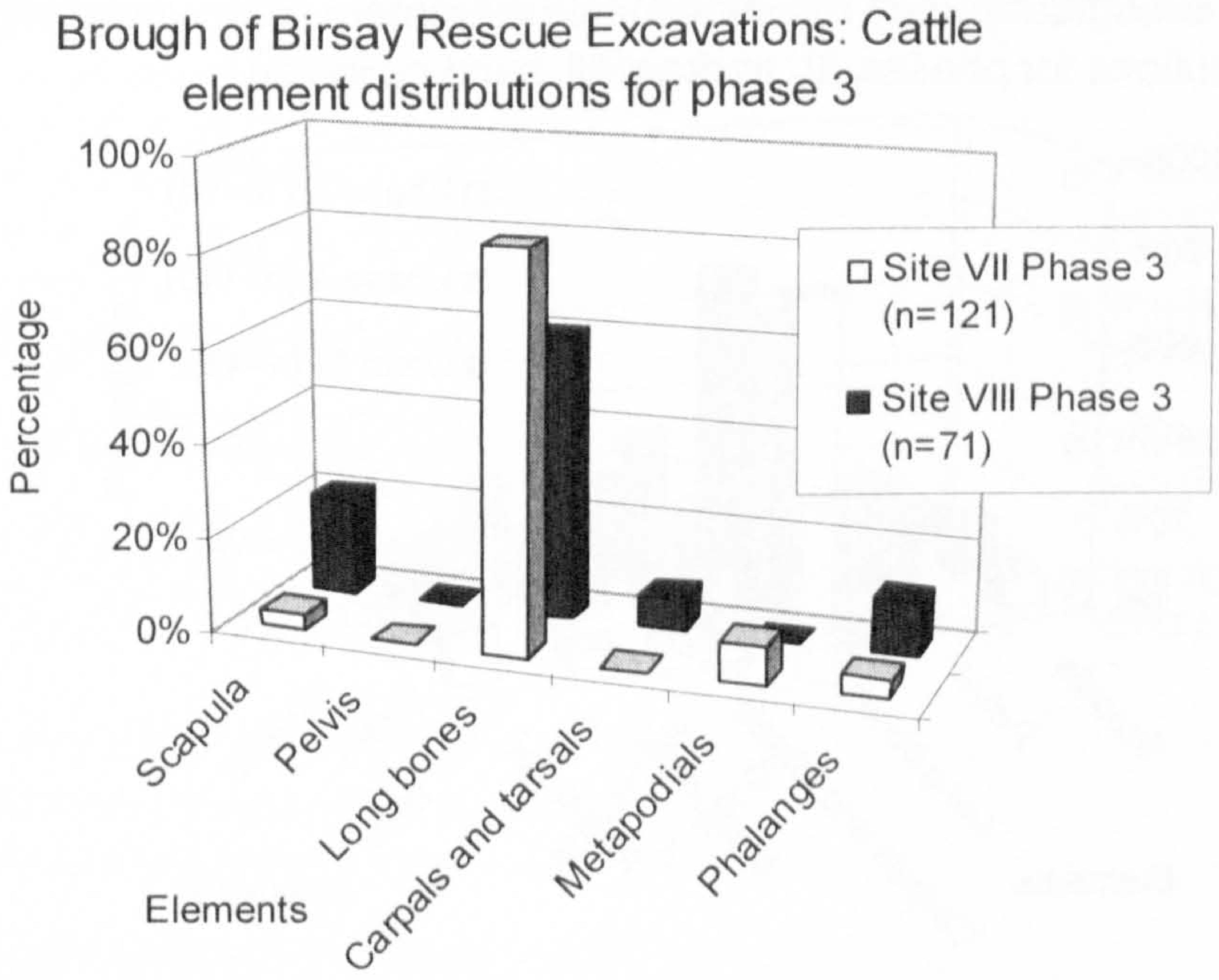


Figure 8.56: Cattle element proportions from the Brough of Birsay Rescue Excavations, phase 3 (from Sellar *et al.* 1986, Tables 12, 19, 26)

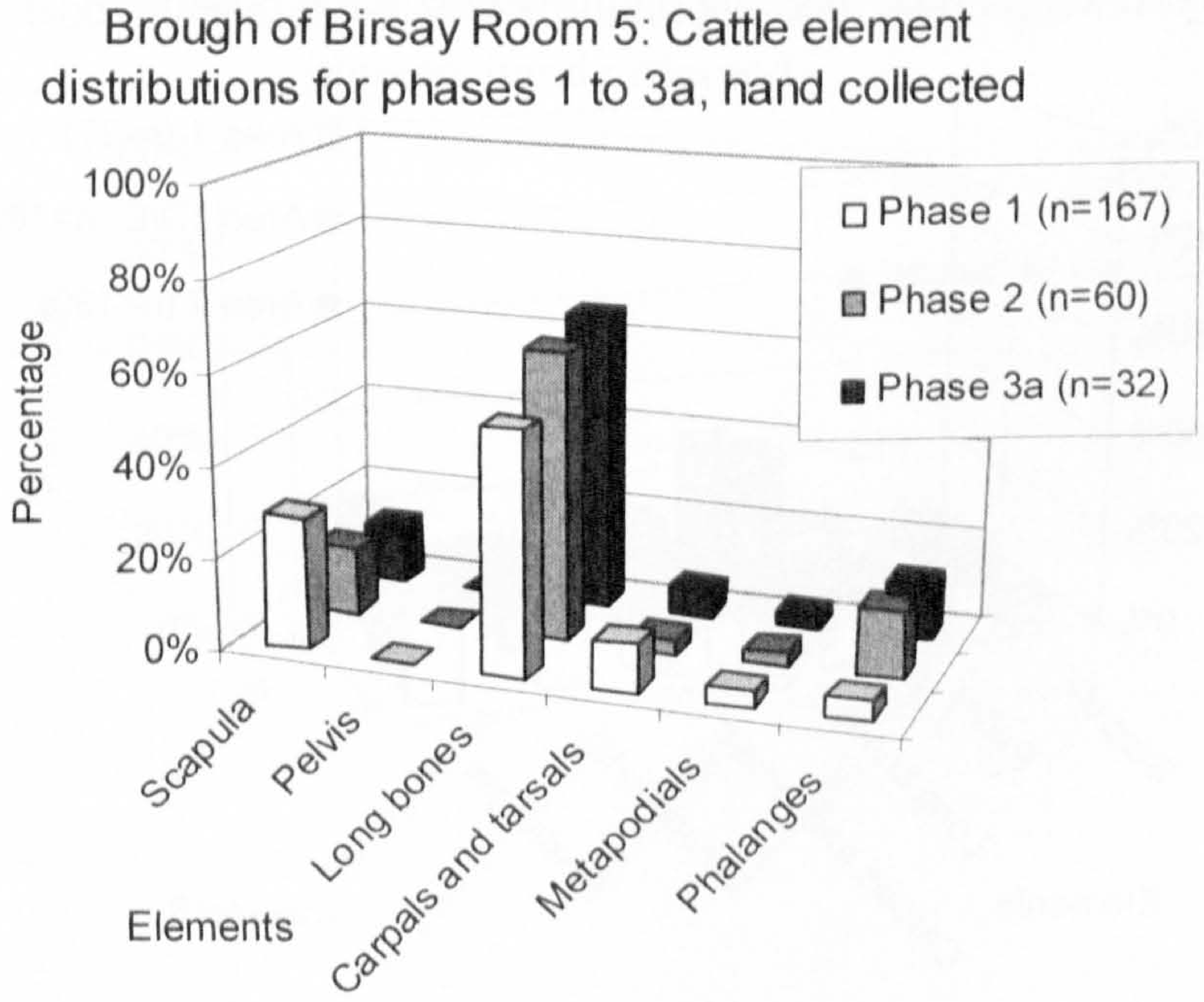


Figure 8.57: Cattle element proportions from the Brough of Birsay Room 5, phases 1 to 3a (from Sellar 1982, Table 3)

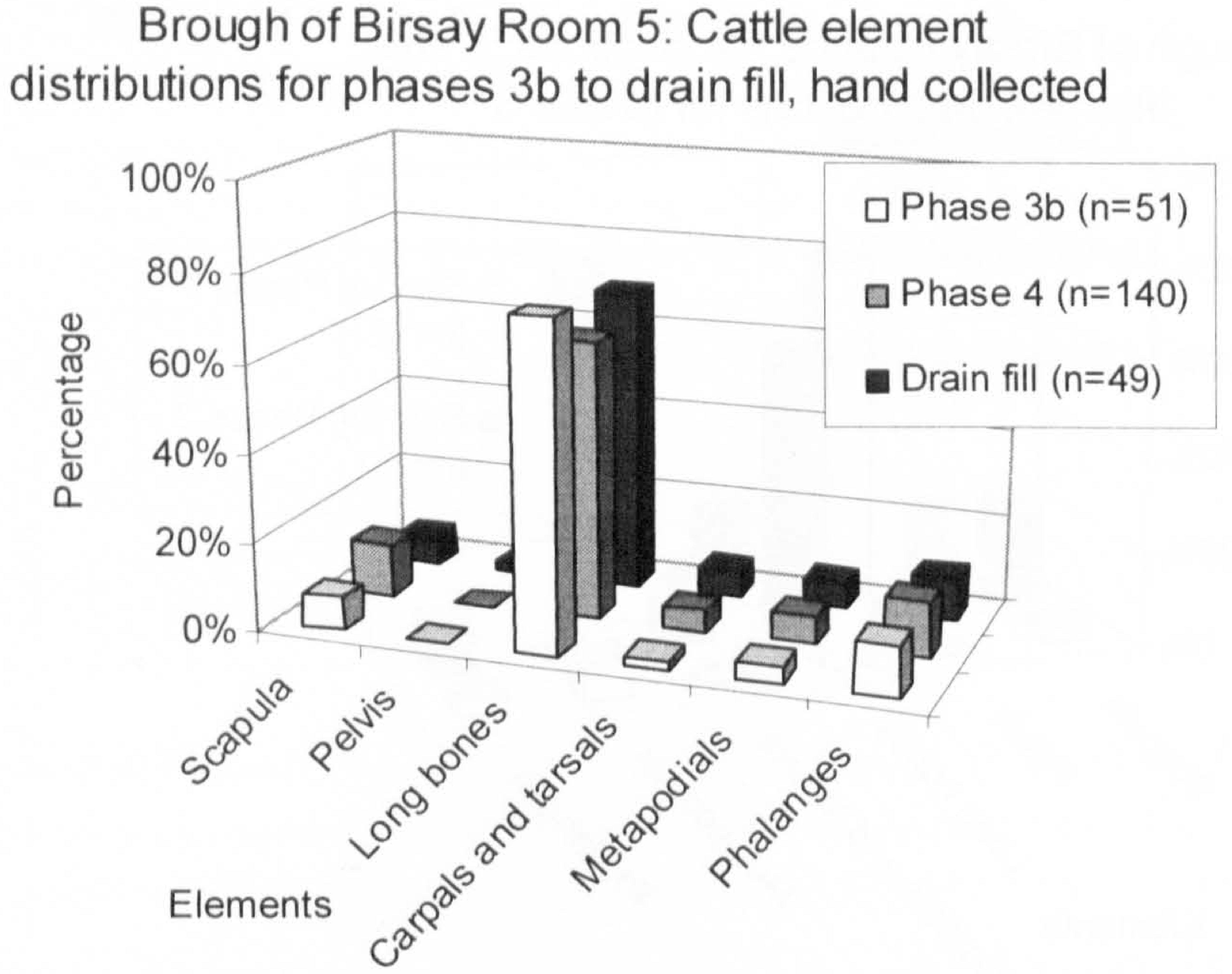


Figure 8.58: Cattle element proportions from the Brough of Birsay Room 5, phases 3b to drain fill (from Sellar 1982, Table 3)

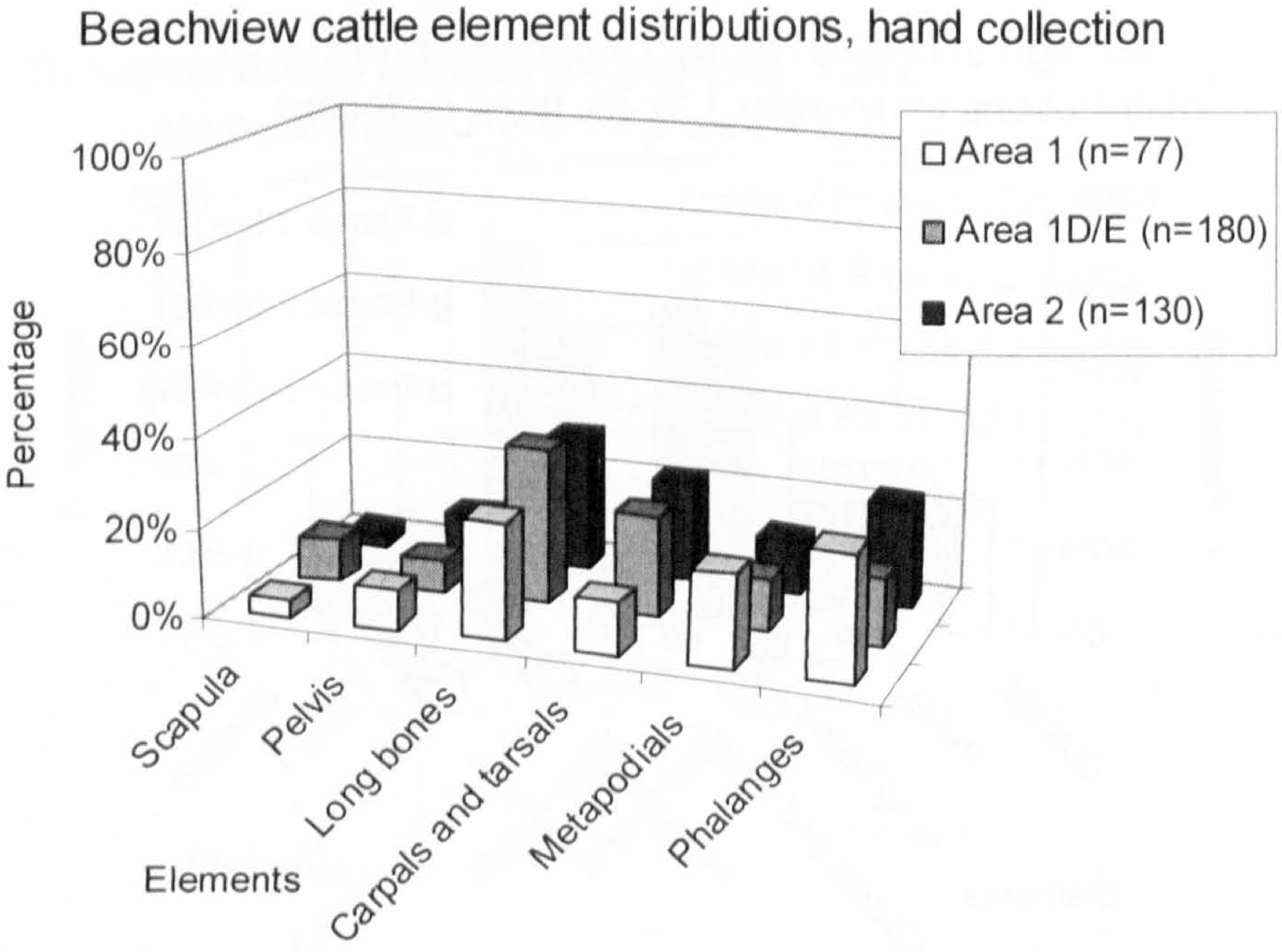


Figure 8.59: Cattle element proportions from Beachview, all phases (from Rackham 1996a, Table 18)

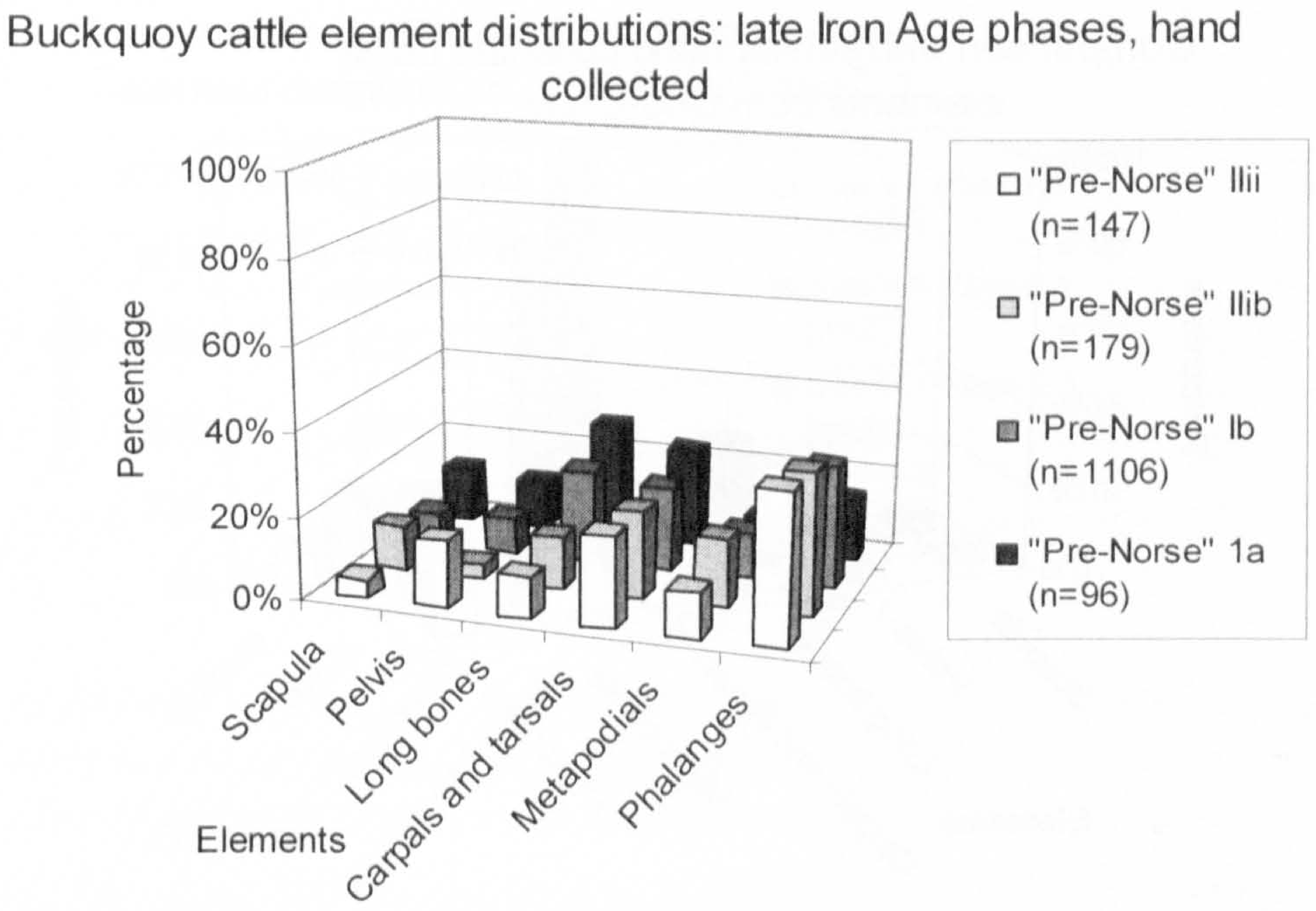


Figure 8.60: Cattle element proportions from Buckquoy, late Iron Age phases (Noddle archive)

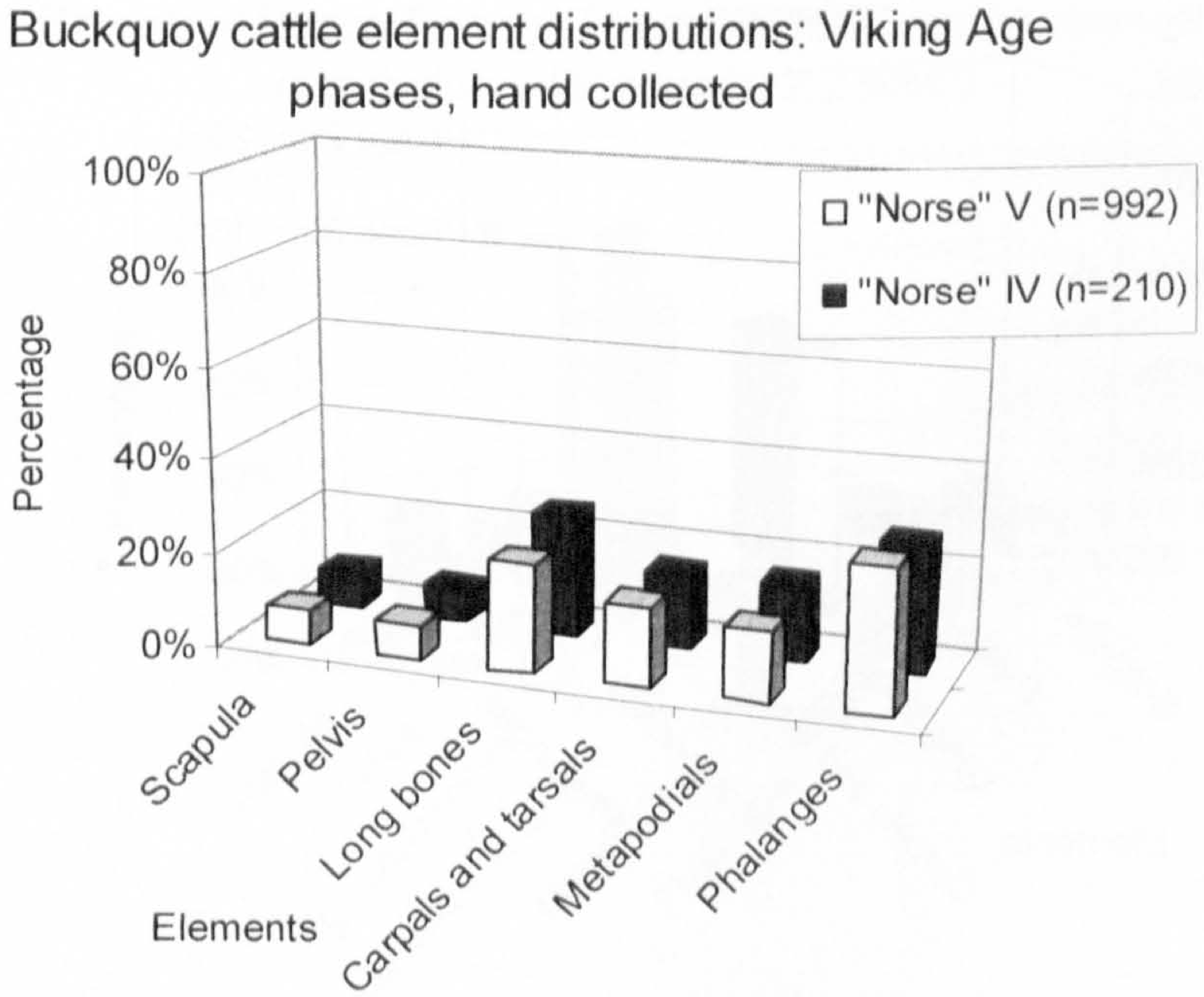


Figure 8.61: Cattle element proportions from Buckquoy, Viking Age phases (Noddle archive)

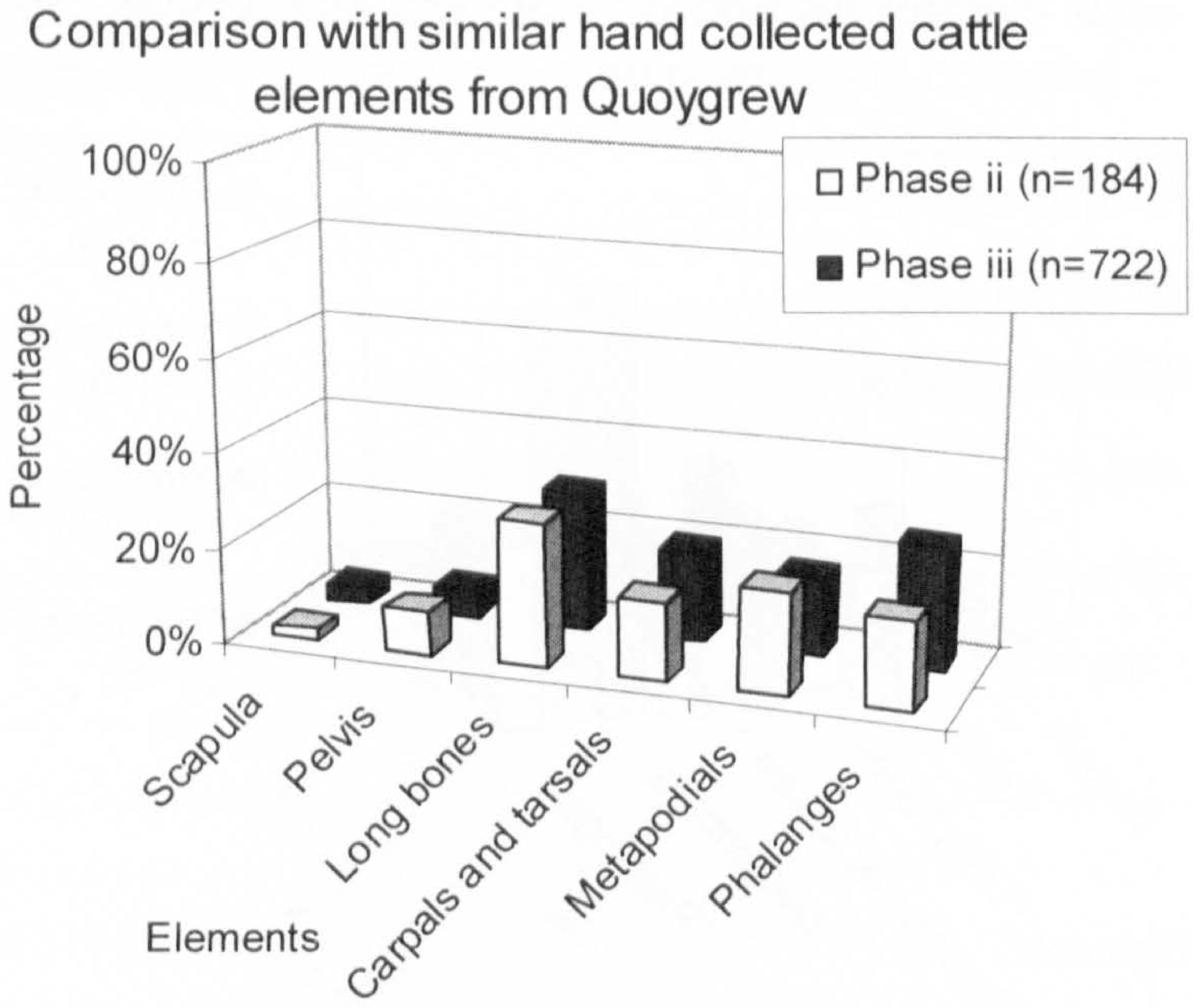


Figure 8.62: Comparison with cattle element proportions from Quoygrew

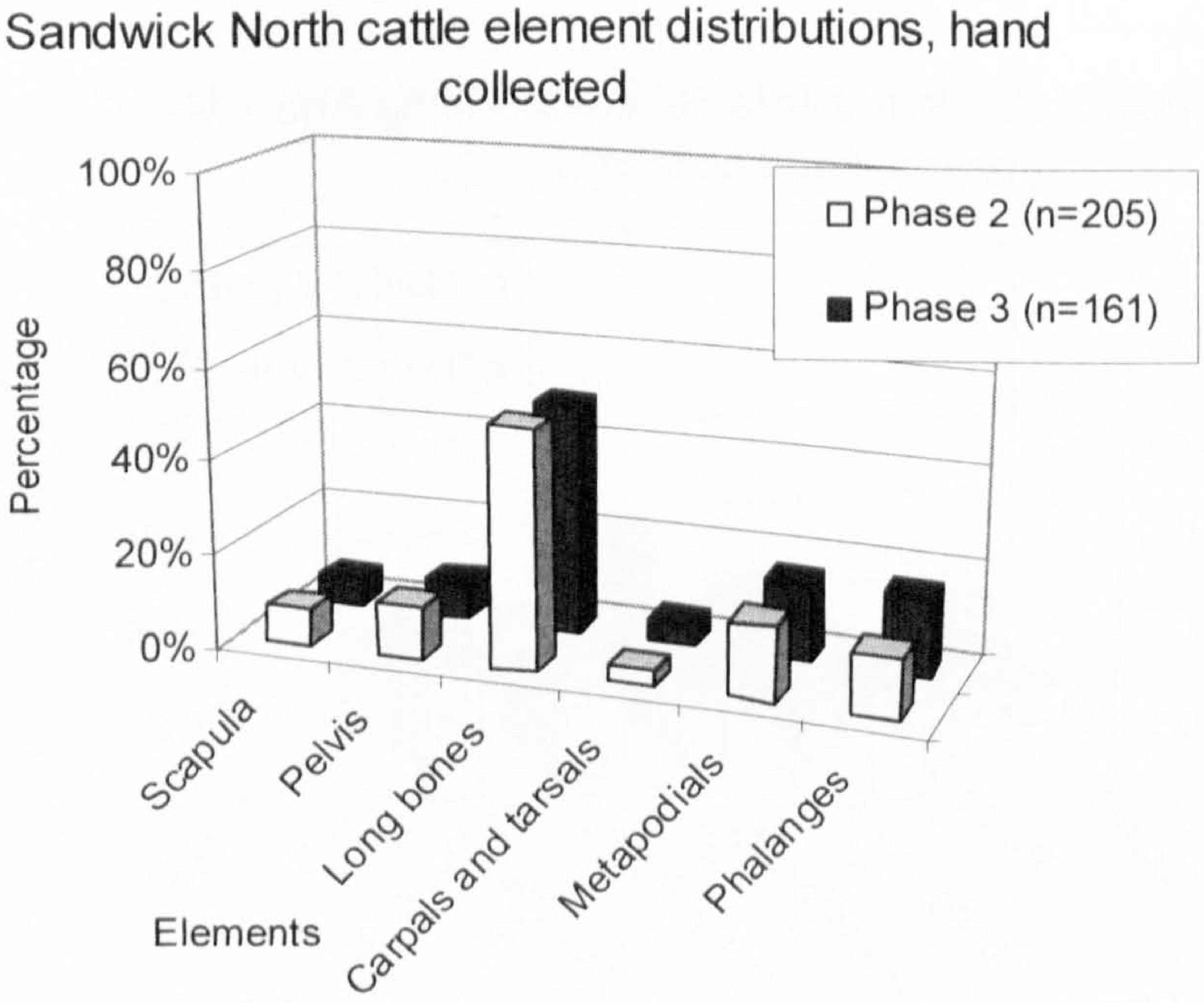


Figure 8.63: Comparisons with cattle element proportions from Sandwick North (Barrett and Oltmann 2000, Table 24)

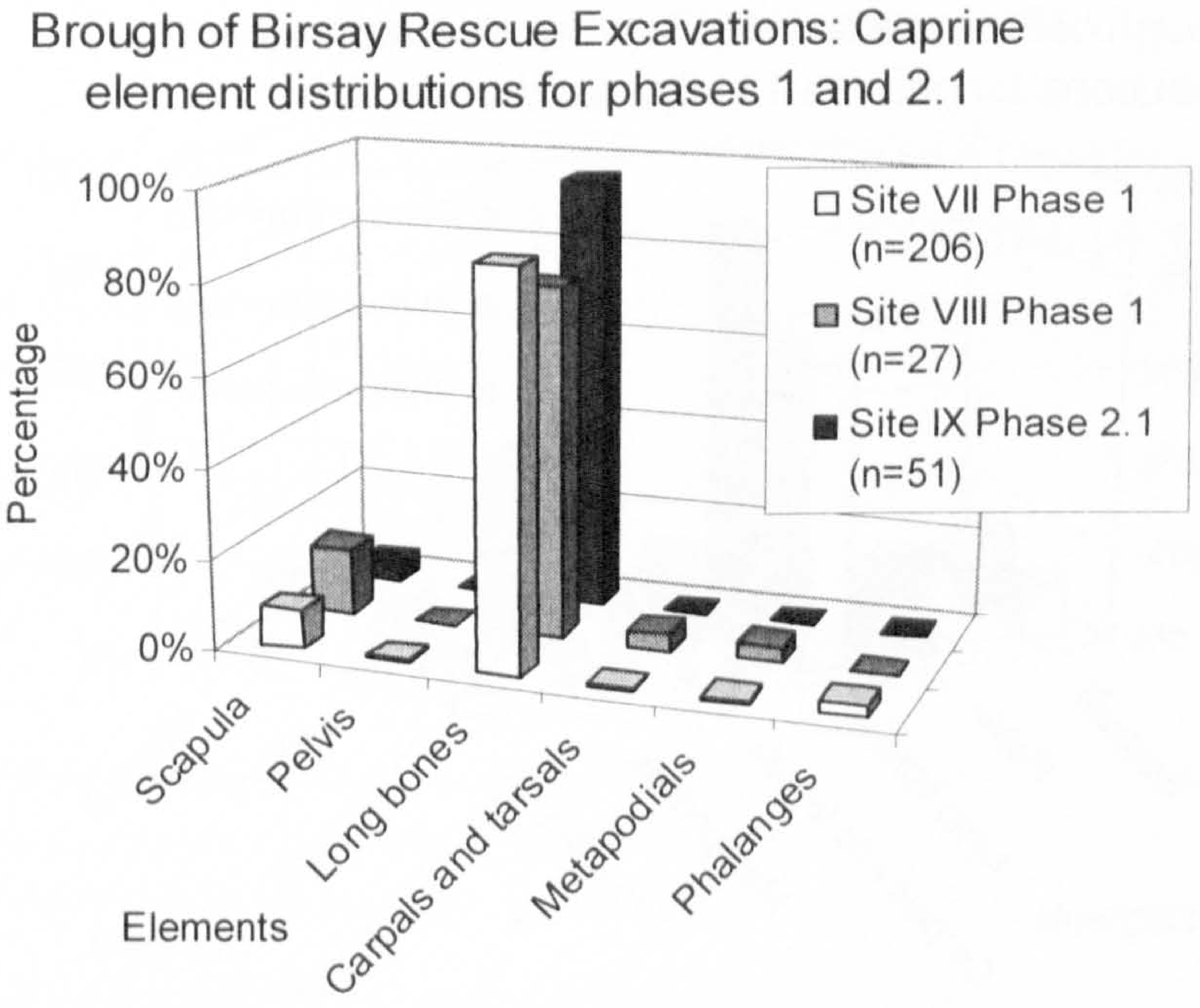


Figure 8.64: Caprine element proportions from the Brough of Birsay Rescue Excavations, phases 1 and 2.1 (from Sellar *et al.* 1986, Tables 13, 20, 27)

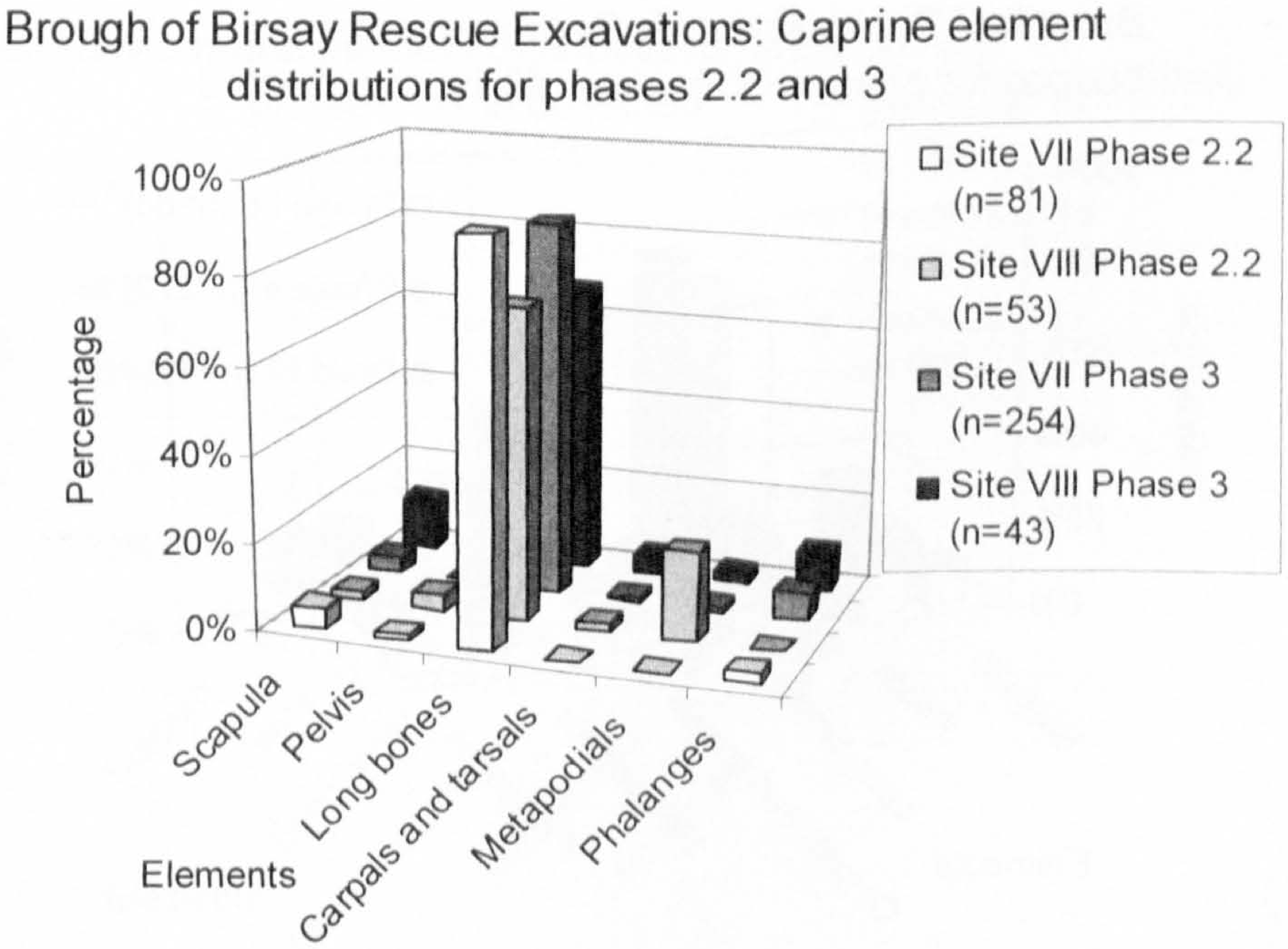


Figure 8.65: Caprine element proportions from the Brough of Birsay Rescue Excavations, phases 2.2 and 3 (from Sellar *et al.* 1986, Tables 13, 20, 27)

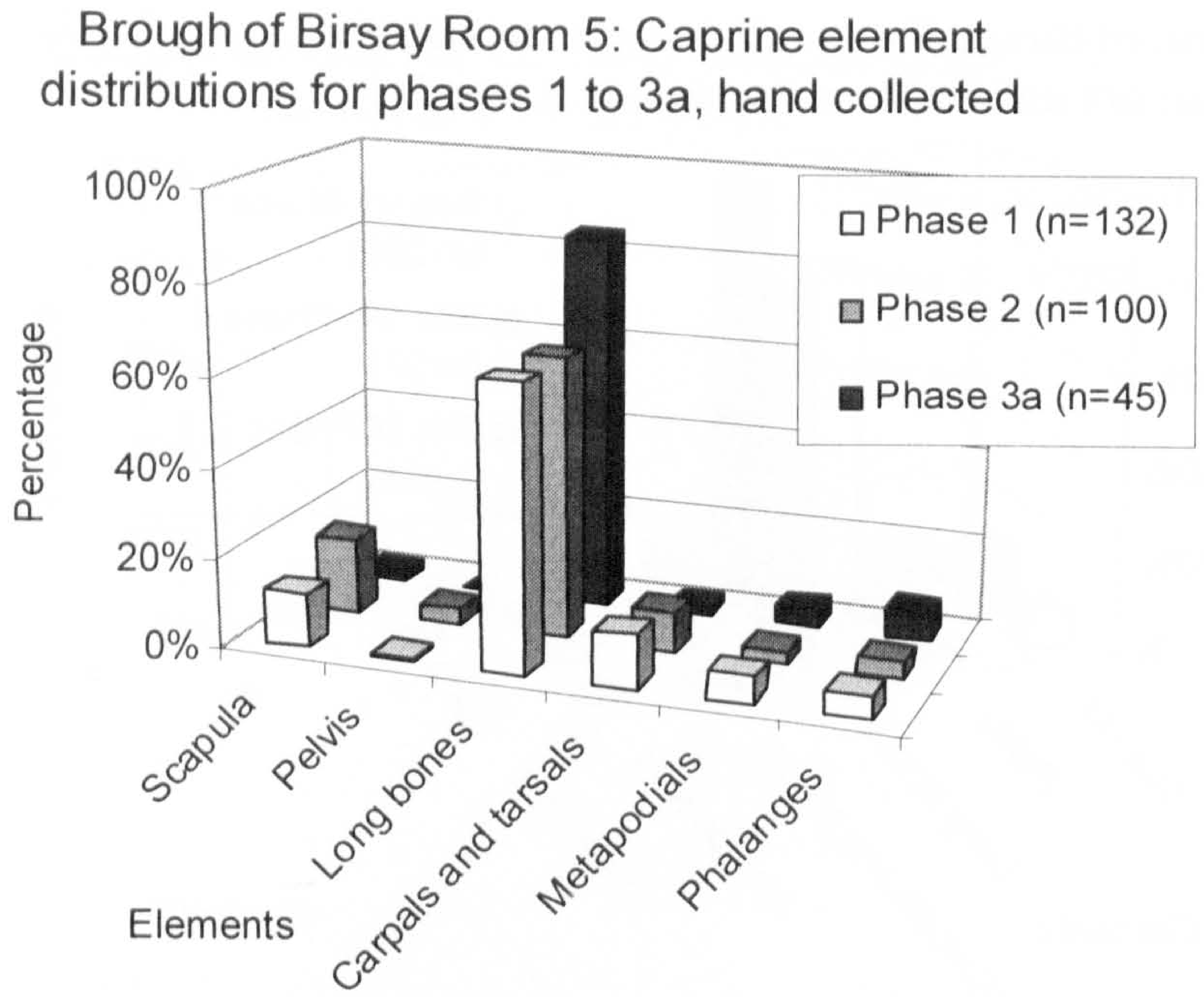


Figure 8.66: Caprine element proportions from the Brough of Birsay Room 5, phases 1 to 3a (from Sellar 1982, Table 4)

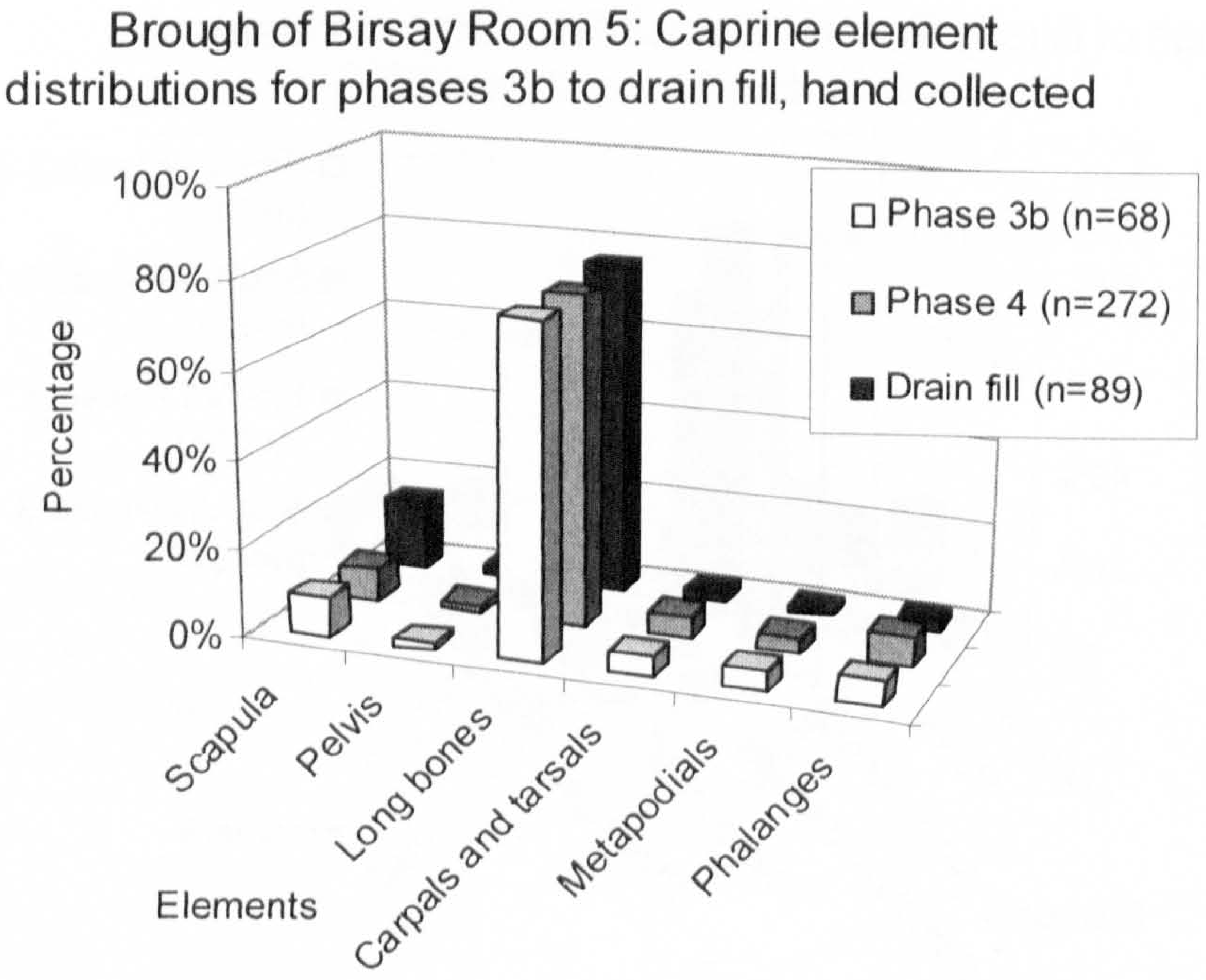


Figure 8.67: Caprine element proportions from the Brough of Birsay Room 5, phases 3b to drain fill (from Sellar 1982, Table 4)

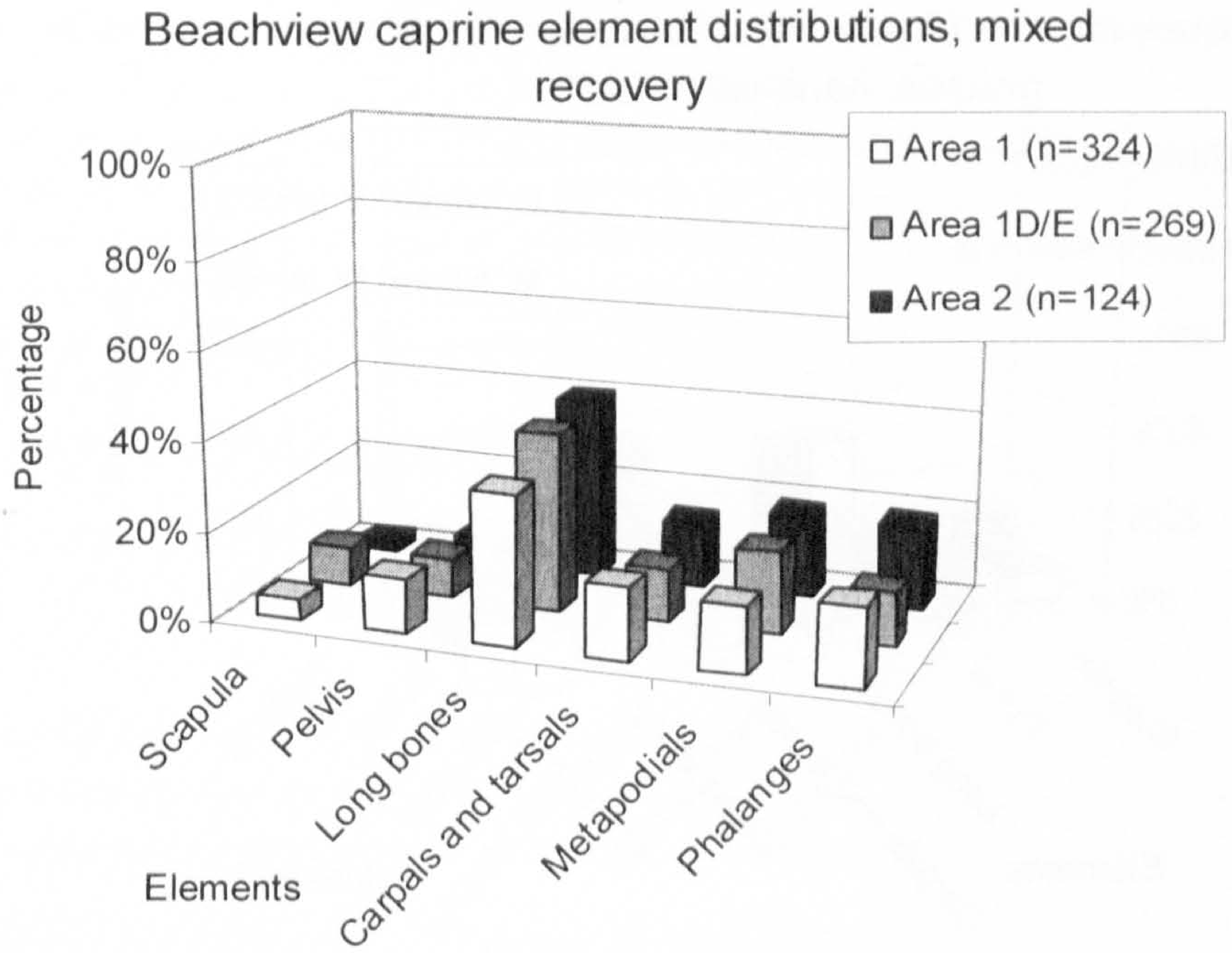


Figure 8.68: Caprine element proportions from Beachview, all phases (from Rackham 1996a, Table 20)

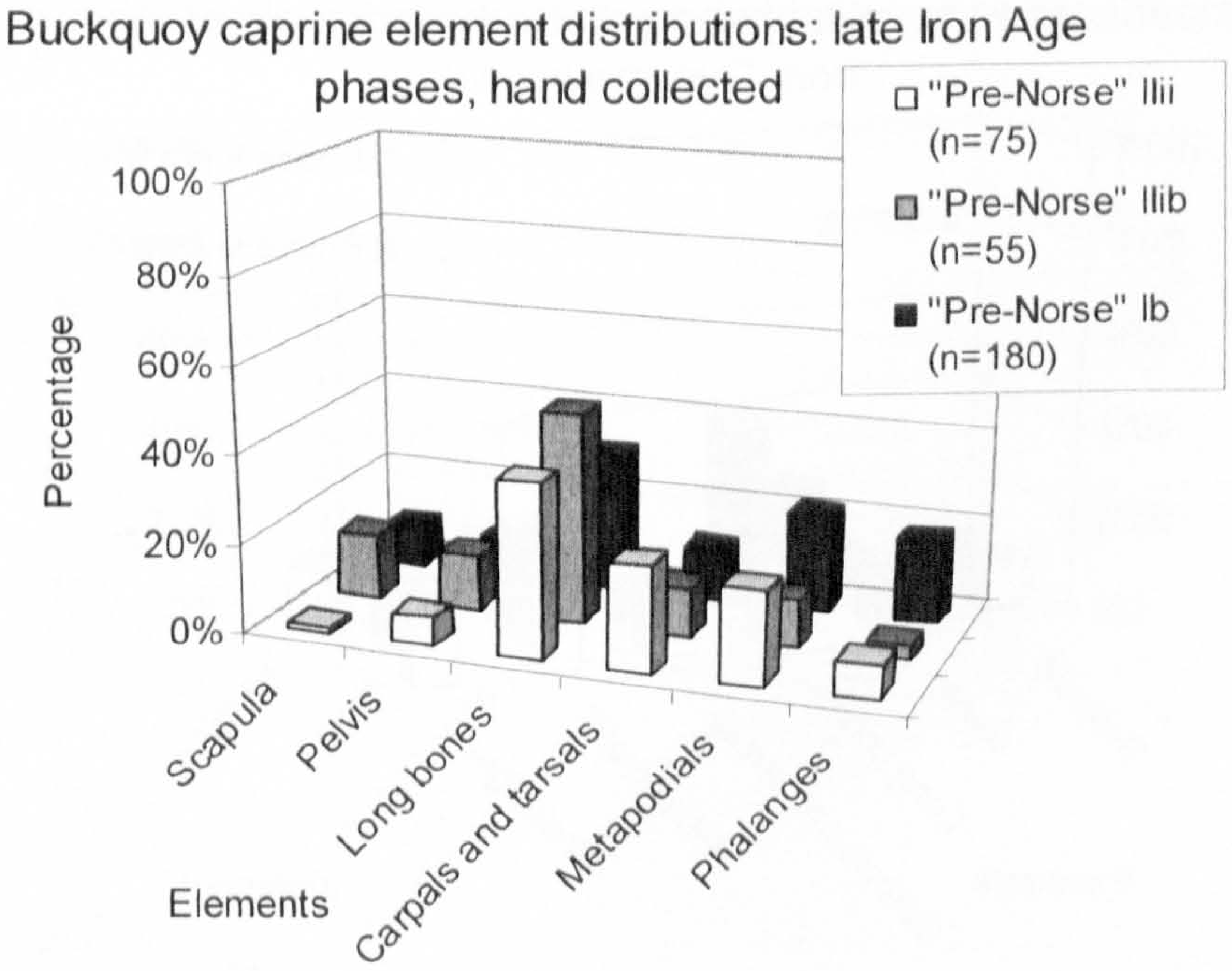


Figure 8.69: Caprine element proportions from Buckquoy, late Iron Age phases (Noddle archive)

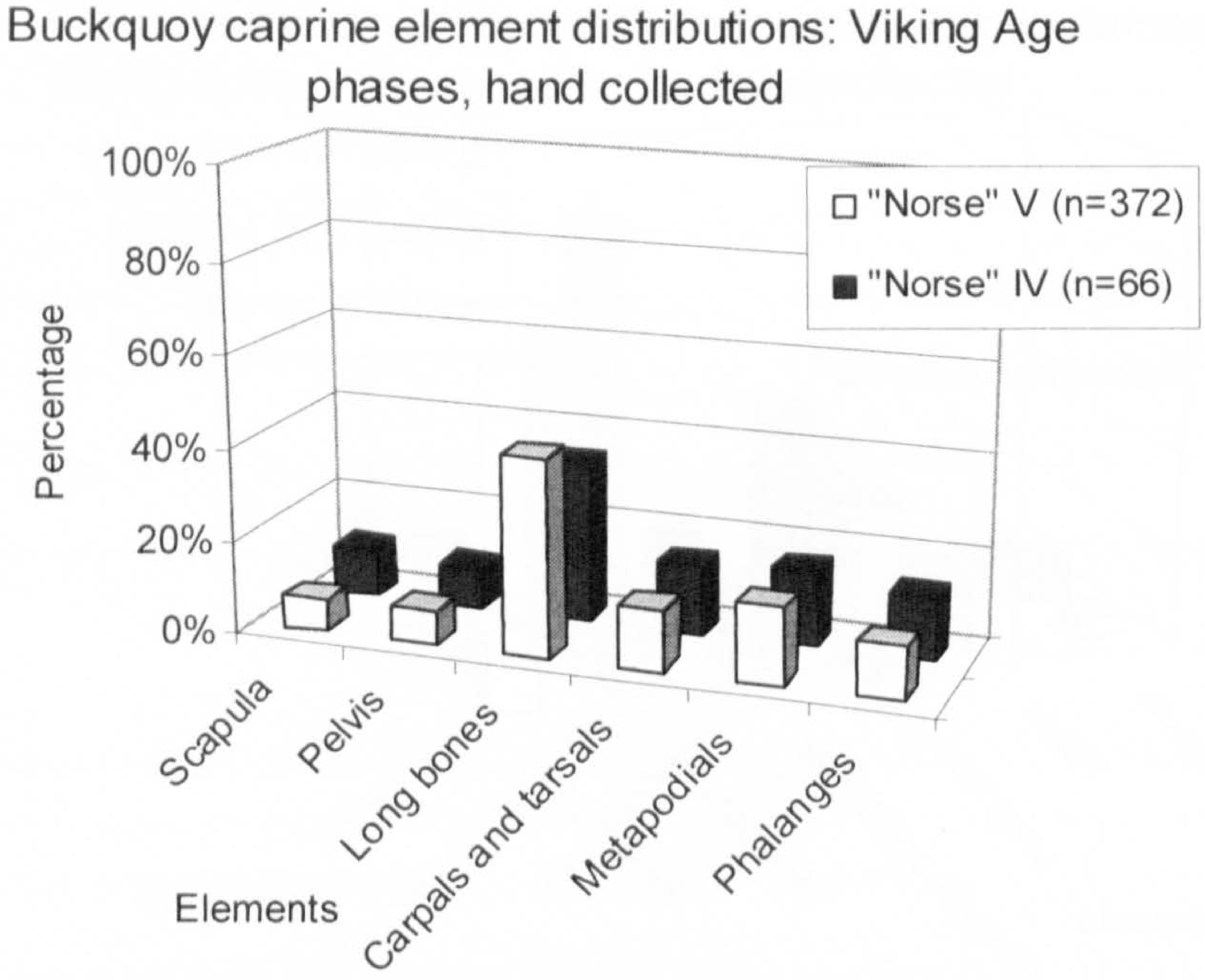


Figure 8.70: Caprine element proportions from Buckquoy, Viking Age phases (Noddle archive)

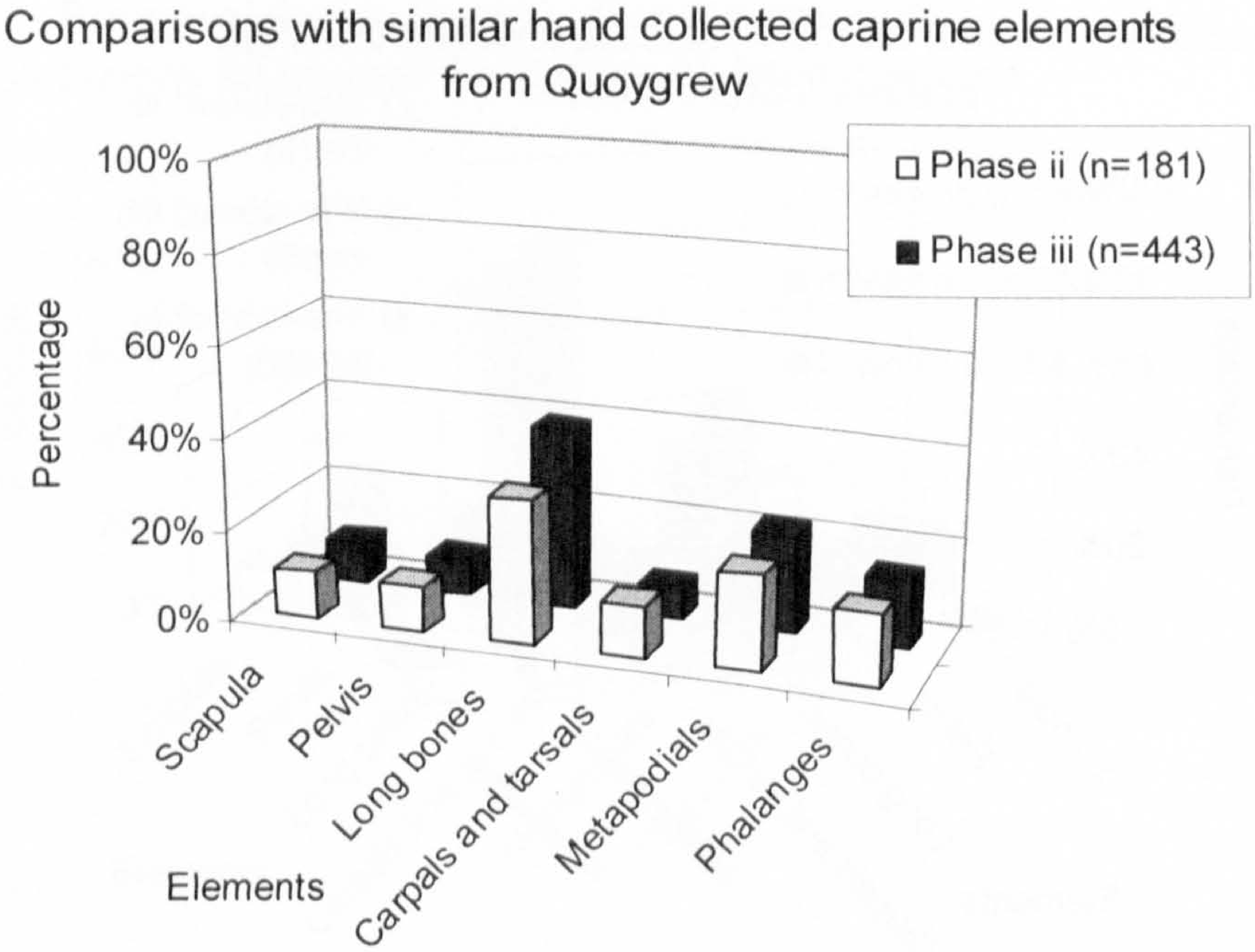


Figure 8.71: Comparison with hand collected caprine element proportions from Quoygrew

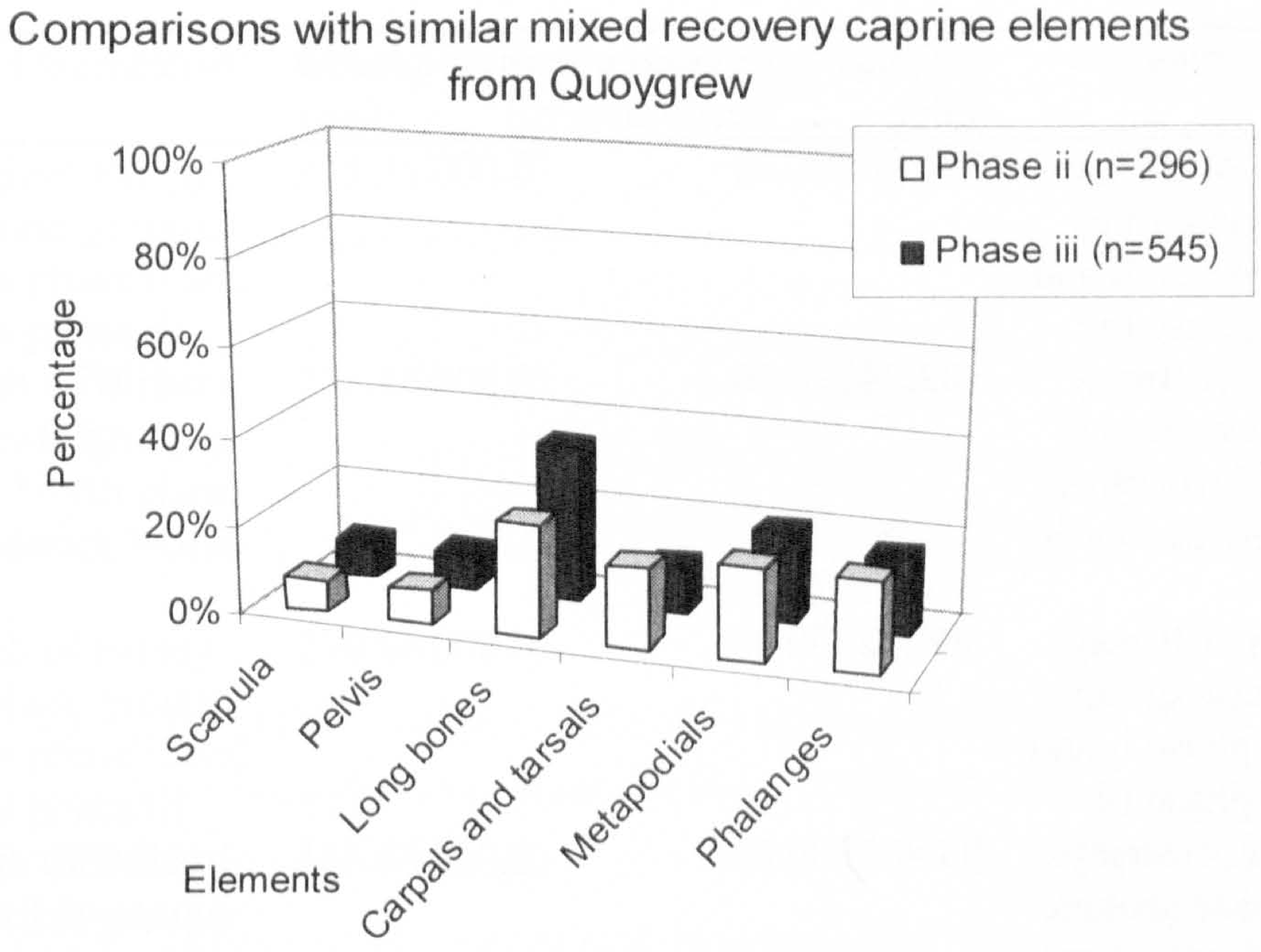


Figure 8.72: Comparisons with mixed recovery caprine element proportions from Quoygrew

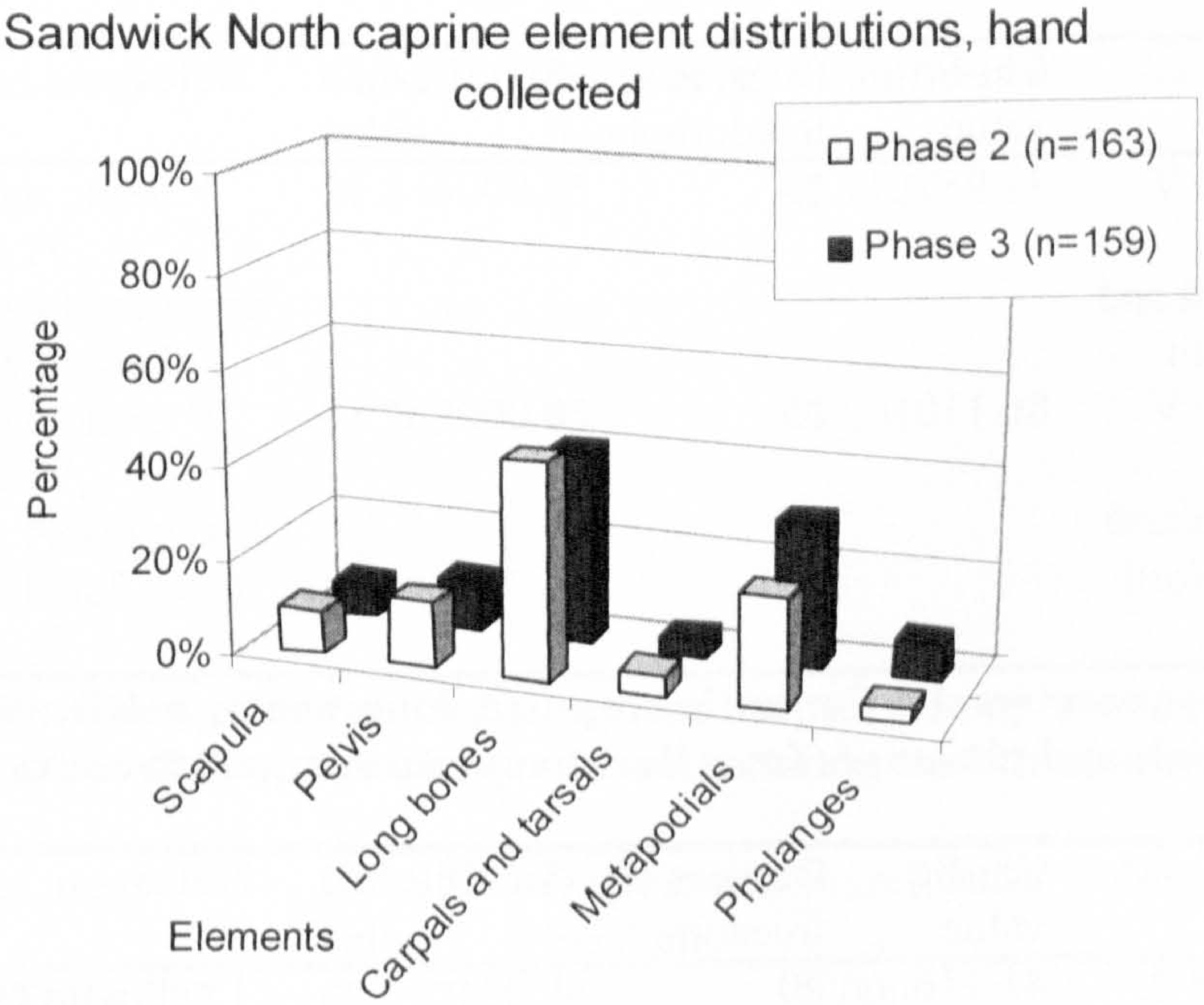


Figure 8.73: Comparisons with caprine element proportions from Sandwick North (Barrett and Oltmann 2000, Table 24)

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All Brough of Birsay Rescue phase groups, Quoygrew phase ii and Quoygrew phase iii	374.044	10	0.000	
All Brough of Birsay Rescue phase groups, Sandwick North phase 2 and Sandwick North phase 3	102.241	10	0.000	1 cell with expected count <5.0
All Brough of Birsay Room 5 phase groups, Quoygrew phase ii and Quoygrew phase iii	304.922	10	0.000	
All Brough of Birsay Room 5 phase groups, Sandwick North phase 2 and Sandwick North phase 3	93.400	10	0.000	1 cell with expected counts <5.0

Table 8.45: Chi-square results for cattle scapulae, long bones, carpals and tarsals, metapodials and phalanges from the Brough of Birsay and comparative sites

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Viking Age phase V and phase IV, Quoygrew phase ii and Quoygrew phase iii	31.957	15	0.000	
Viking Age phase V and phase IV, Sandwick North phase 2 and Sandwick North phase 3	86.110	15	0.000	

Table 8.46: Chi-square results for cattle scapulae, long bones, pelvis, carpals and tarsals, metapodials and phalanges from Buckquoy and comparative sites

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Areas 1, 1D/E and 2, Quoygrew phase ii and Quoygrew phase iii	41.116	20	0.004	1 cell with expected count <5.0
Areas 1, 1D/E and 2, Sandwick North phase 2 and Sandwick North phase 3	72.093	20	0.000	1 cell with expected count <5.0

Table 8.47: Chi-square results for cattle scapulae, long bones, pelvis, carpals and tarsals, metapodials and phalanges from Beachview and comparative sites

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
All Brough of Birsay Rescue phase groups, Quoygrew phase ii and Quoygrew phase iii	375.717	10	0.000	
All Brough of Birsay Rescue phase groups, Sandwick North phase 2 and Sandwick North phase 3	235.576	10	0.000	
All Brough of Birsay Room 5 phase groups, Quoygrew phase ii and Quoygrew phase iii	230.66	10	0.000	
All Brough of Birsay Room 5 phase groups, Sandwick North phase 2 and Sandwick North phase 3	166.895	10	0.000	3 cells with expected counts <5.0

Table 8.48: Chi-square results for caprine scapulae, long bones, carpals and tarsals, metapodials and phalanges from the Brough of Birsay and comparative sites

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Viking Age phase V and phase IV, Quoygrew phase ii and Quoygrew phase iii	21.846	15	0.112	
Viking Age phase V and phase IV, Sandwick North phase 2 and Sandwick North phase 3	33.262	15	0.004	

Table 8.49: Chi-square results for caprine scapulae, long bones, pelvis, carpals and tarsals, metapodials and phalanges from Buckquoy and comparative sites

Phases and areas tested	Chi-Sq value	Degrees of freedom	Significance	Notes
Areas 1, 1D/E and 2, Quoygrew phase ii and Quoygrew phase iii (mixed recovery)	48.937	20	0.000	

Table 8.50: Chi-square results for caprine scapulae, long bones, pelvis, carpals and tarsals, metapodials and phalanges from Beachview and comparative sites

8.4.4 Mammal biometry

The dataset of measurements for the Northern Isles consists of several hundred recorded values for cattle and sheep, and less than a hundred for pigs, horses, dogs and cats. However, given the number of possible measurements that could be taken (mostly following von den Driesch (1976)), and the range of phase groups and sites, it was difficult to compare measurements at either the intra-site or the inter-site level. Additionally, considerable quantities of bone from neonatal and young animals exists in the Northern Isles assemblages (see section 8.4.2), none of which could be measured.

As briefly mentioned in the introduction in Chapter One, metrical changes in livestock at Pool correspond with the late Iron Age to Viking Age transition (Cussans in press). This study will be described in detail below, and attempts will be made to assess the entire biometrical dataset for similar changes throughout the Northern Isles. This may illuminate the changes at this important transitional period, one of the key themes of this thesis. However, any biometrical investigation must first consider the many causes of variation, which can include age, sex, 'breed' and overall health and nutrition (e.g. Payne and Bull 1988).

The measurement of fully fused elements should produce a dataset based entirely on adult individuals, but it was not always known if both epiphyses of a long bone were fused when measured. The high degree of fragmentation at Quoygrew meant that it was not usually possible to measure the early-fusing epiphysis if the state of the late-fusing epiphysis was unknown. It is not known what practices were followed by other zooarchaeologists. The issue of post-fusion growth of some routinely measured elements is another factor that could influence the dataset. Davis discovered that sheep scapulae, humeri and radii display some post-fusion growth, and the astragalus is another element that continues to grow in width for some time while appearing to be fully grown and of adult size and texture (Davis 2000, 384, 386). These conclusions may be applicable to cattle as well, and unfortunately, the astragalus is one of the more commonly measured elements in the Northern Isles.

Sex profiles of livestock could influence metrical variation, but because of the high degree of adult bone fragmentation throughout the Northern Isles, the sex of very few bones could be determined. The presence of castrates within the assemblages is another unknown factor; castration in sheep delays the age of fusion by about one year, compared to intact males and females, which in turn influences the measurements of castrates (Davis 2000, 386-87). The sexual dimorphism naturally present between males and females is therefore complicated by the likely presence of castrates, and likely would cause a range of sizes to be present regardless of other factors, including 'breed' or health and nutrition. It is extremely unlikely that any biometrical study of the Northern Isles material could identify sex and castrates, simply because the dataset is insufficiently large.

The influence of 'breed' on livestock measurements may be considerable in present day improved species, but the use of this term for late Iron Age, Viking Age and medieval animals in the Northern Isles is questionable. However, any potential introduction of new phenotypes during the settlement of the Northern Isles may be recognisable through biometrical study, and their identification is a primary aim of any metrical analysis. Livestock were introduced to Iceland, Greenland and the Faroes during Norse colonisation, but the Northern Isles were already inhabited and already contained livestock. Recent cattle DNA analysis in Ireland indicated cattle found in the Viking settlement in Dublin were more closely related to breeds from the British Isles than those from Scandinavia (Edwards *et al.* 2003), but there has not yet been any biomolecular research on livestock introductions in the Northern Isles. If a significant change in measurements occurred at the beginning of the Viking Age, it may be indicative of new stock arriving, but equally, it could indicate an improved or changed animal husbandry regime. The small size of the metrical dataset make it unlikely that this question will be answered, but a preliminary consideration will be attempted.

Caprine measurements were successfully used at Pool to illustrate temporal changes. There, increased sizes and a changing shape index of metatarsals in the Viking Age – medieval period was interpreted as the introduction of new stock into the area by the incoming Norse people (Cussans in press). In particular, plots of shape indices on caprine metatarsals proved a successful method to illustrate chronological change (Cussans in press, Figures 3, 4). Using Cussans' method, Figure 8.74 explores the metatarsal greatest length plotted against the distal breadth for all available data in the Northern Isles, and Figure 8.75 investigates the metatarsal greatest length plotted against the shape index of distal breadth expressed as a percentage of greatest length. Although chronological changes were observed at Pool using this method, when those data are compared to all available measurements, there is no one spatial or chronological pattern; no clusters are observed. If the data from Pool (Cussans in press, Fig. 4; raw data were not available and have thus not been reproduced) were superimposed on Figure 8.75, the points from phase 8 would represent a discrete group, slightly peripheral to all others – but as this group has a sample size of three, this may represent random variation. Further application of multivariate methods may illuminate patterning not readily visible, but this was beyond the scope of this thesis. Instead, a traditional log ratio-based approach was applied to the basic cattle and caprine metrical datasets. This aimed to assess chronological changes, because there was insufficient data to examine spatial variation.

Log ratios were calculated for the most commonly occurring measurements, using Davis' standard sheep measurements (Davis 1996) and the formula $\log_{10}$(measurement/standard). No such standard exists for cattle, but instead of using the mean of the existing dataset (as used elsewhere, e.g. Johnstone and Albarella 2002), the mean values were drawn from the entire cattle metrical archive contained in ABMAP (Westcott 2003). Caprine measurements were also combined into groups of statistically similar measurements, following Davis (1996). This method was also applied to the primary analysis of the Quoygrew caprine measurements, in Chapter Six. Most phase groups had to be grouped together at the site level, but broad chronological boundaries were maintained, including Iron Age, Viking Age, Viking Age to medieval and medieval.

The measurements from four cattle elements have been displayed as log ratio diagrams: metacarpals (Figure 8.76), metatarsals (Figure 8.77), astragali (Figure 8.78) and first phalanges (Figure 8.79). These four elements represented the majority of all cattle measurements. Some chronological change is visible, particularly between the Viking Age and medieval periods. Sizes increased at Quoygrew (astragalus, metacarpal, metatarsal) and Buckquoy (first phalanx), but decreased at Sandwick North (metacarpal), Buckquoy (metacarpal, metatarsal), Skaill (astragalus, metacarpal) and Quoygrew (first phalanx). Sample sizes were too low to apply statistical tests to confirm the significance of any patterning. The astragalus was included despite the problems of post-fusion growth, as mentioned above, because this was one of the most frequently occurring measurable elements. However, the width measurement is affected the most, but these patterns are still visible in the other measurements. There was no overall size increase or decrease at the late Iron Age to Viking Age transitional period, but only the material from Buckquoy could be assessed for change. Measurements generally decreased at the Viking Age to medieval transition, but some measurements increased at Quoygrew, indicating there was no overall pattern applicable to the Northern Isles. Furthermore, because elements from the same site displayed both increases and decreases in size, it is difficult to draw any conclusions. The first phalanx is the most numerous of the measurable elements, but its interpretation is made difficult by the possible variation between fore and hind limbs, as well as sex profiles.

The caprine measurements have been presented as histograms, using Davis' method (Davis 1996). Similar measurements have been grouped together to increase the sample size, including astragalus and calcaneum values (Figure 8.80), metapodial widths (Figure 8.81), metapodial depths (Figure 8.82) and tibia values (Figure 8.83). All other measurements were too infrequent to include. As observed for the cattle, some chronological changes were noted. Measurements decreased over time at Sandwick North (metapodial widths and depths) and Quoygrew (metapodial depths), but some sites and measurements indicated no chronological changes took place. This was difficult to investigate given the overall lack of measurements.

Withers height measurements could be calculated for a small number of bones, but was made difficult by the lack of formulae for partial, rather than complete specimens (von den Driesch and Boessneck 1974). Only three cattle withers heights were calculated, all within the range of 102 to 106cm from Earl's Bu medieval, Skaill medieval and Buckquoy Iron Age. About 50 withers heights were calculated for caprines from a wide range of sites, almost all within the range of 50 to 60cm; these ranges were found throughout all sites, without any spatial or temporal patterning. This was contrary to Pool, where sheep were found to be significantly smaller in the Viking Age to medieval periods than in the late Iron Age to Viking Age phases (Bond *et al.* Forthcoming, 34). Additionally, about 20 caprine live weights were calculated from four sites, following Bond *et al.* (Forthcoming, 33). These ranged from 31 to 36kg, with an outlier at 39kg. Again, there was no spatial and temporal patterning. These weights are comparable to the modern 'primitive' Shetland breed, which averages 45kg live weights for rams and 35kg for ewes (Adalsteinsson 2000), but the archaeological weights are greater than the modern North Ronaldsay (at 30 to 35kg for rams and 25kg for ewes (Anon. nd.)). This may reflect natural selection pressures on the North Ronaldsay breed over the previous centuries, and their predominantly seaweed-based diet, which may have contributed to their smaller sizes.

To summarise, there were some indications that cattle and sheep decreased in size at the Viking Age to medieval transitional period, but this was not observed using all measurements or all phase groups and was difficult to conclude with certainty. This may reflect the general British and European trend towards decreasing sizes of livestock in the medieval period (e.g. Armitage 1982a, 53; Armitage 1983, 92; Bokonyi 1995, 42-43). Insufficient data from the late Iron Age period made it difficult to investigate potential changes around the beginning of the Viking Age. The decrease in size into the medieval period could indicate changing animal husbandry regimes, decreasing nutrition, or a gradual and natural adaptation to the environmental conditions of the Northern Isles. The high proportions of young animals in the Northern Isles severely limited the dataset. Despite promising results from Pool, there does not appear to be a chronological or spatial pattern across the Northern Isles when using shape indices.

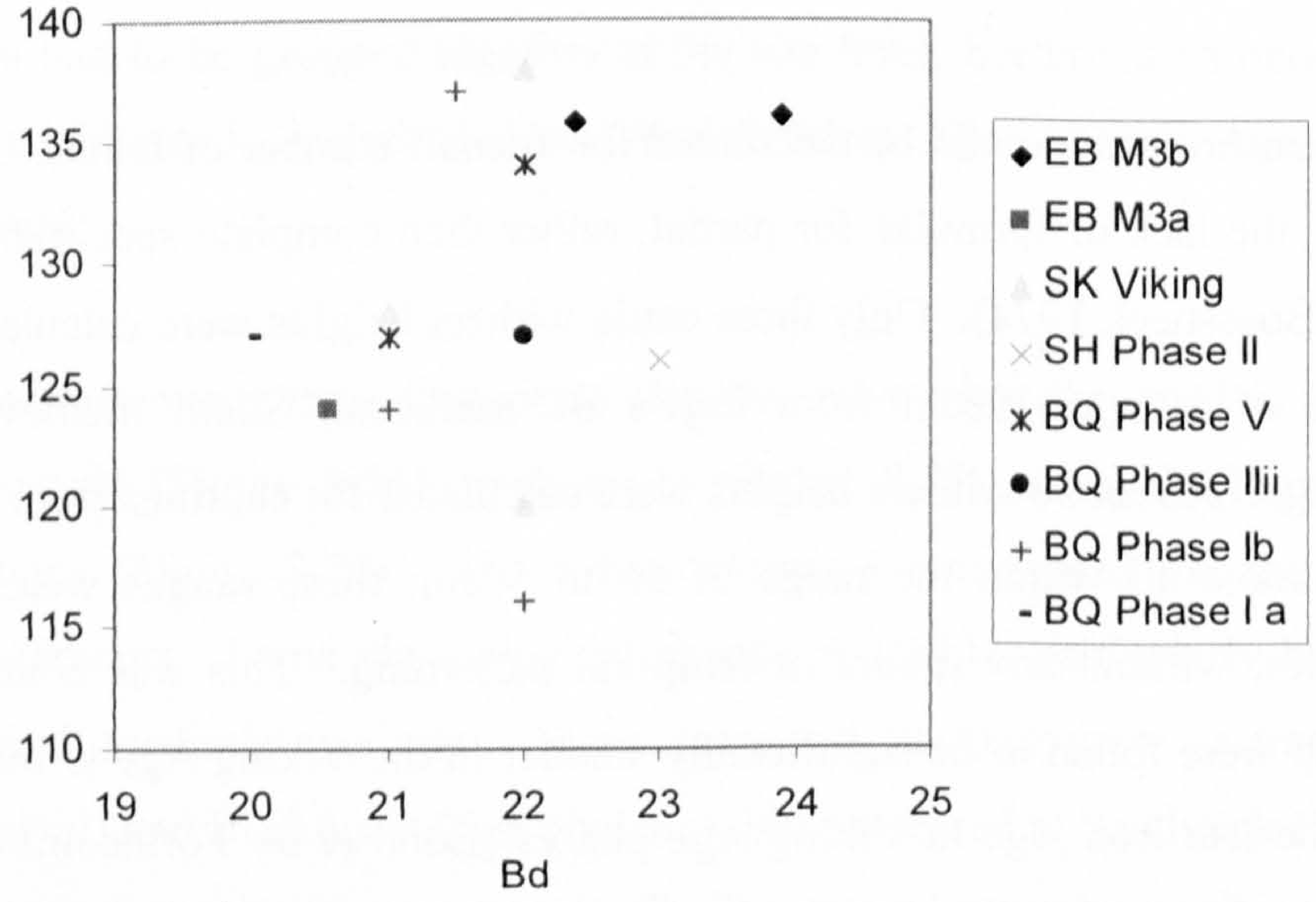


Figure 8.74: Caprine metatarsal measurements, length plotted against distal breadth

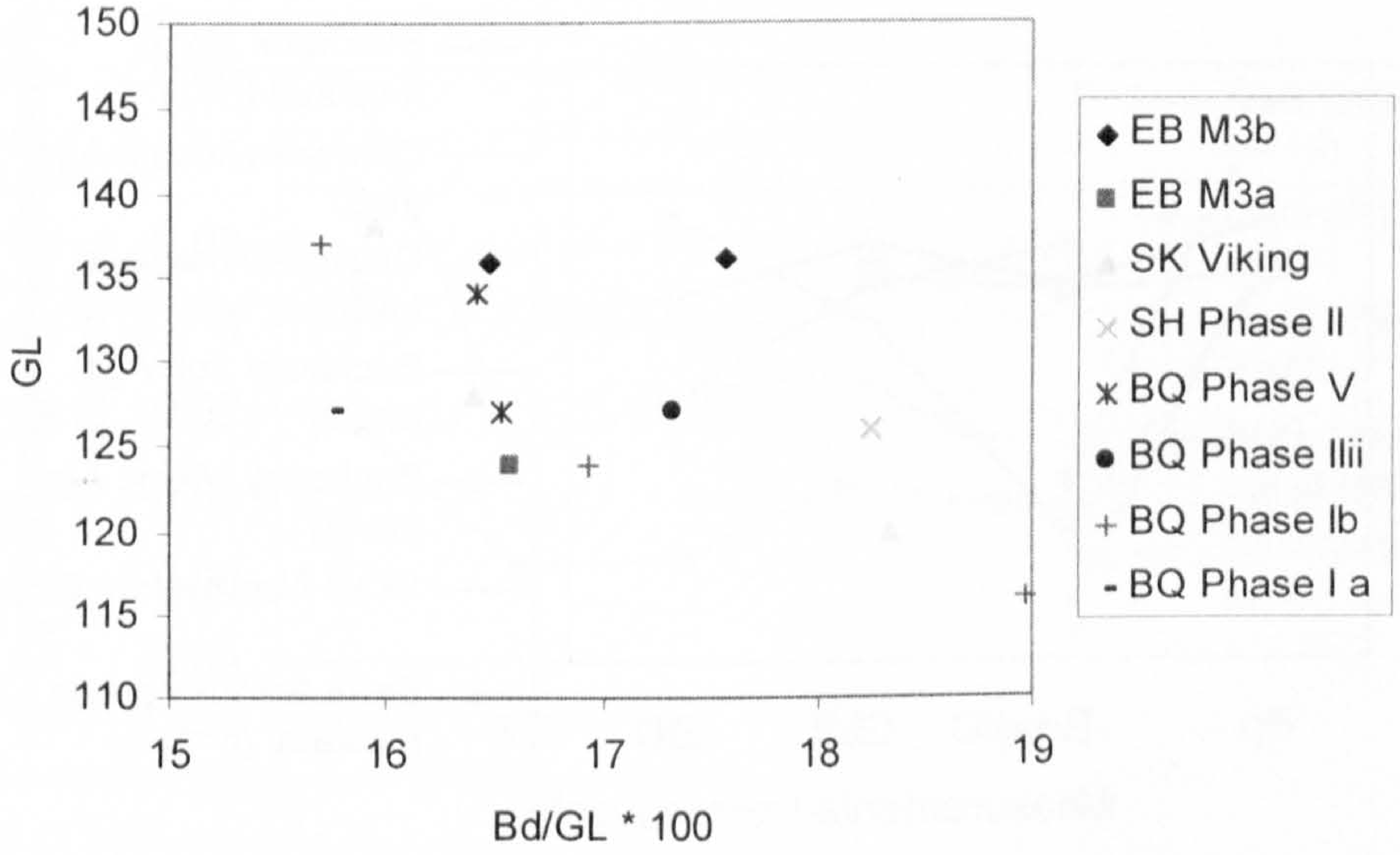


Figure 8.75: Caprine metatarsal measurements: length plotted against shape

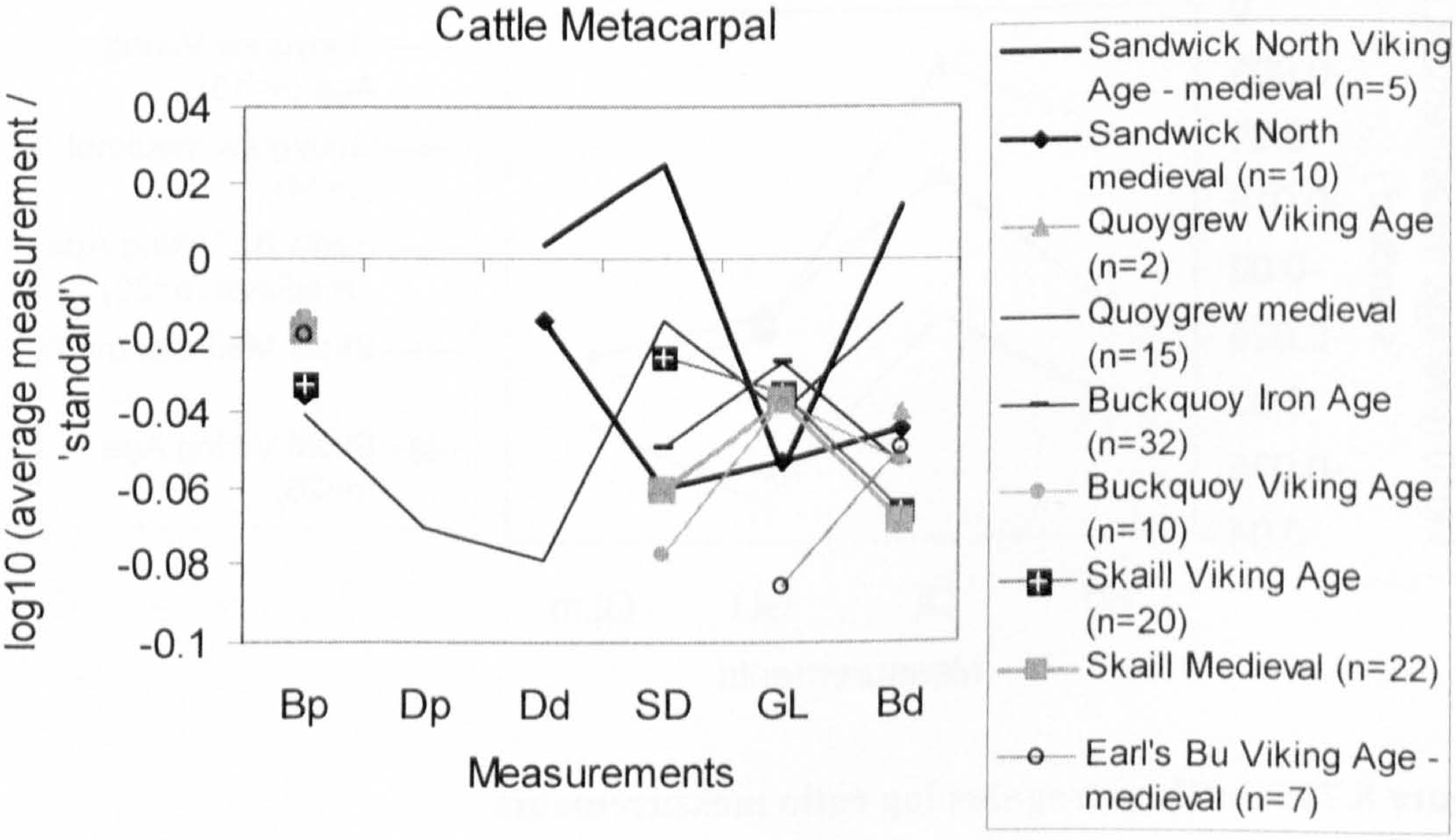


Figure 8.76: Cattle metacarpal log ratio measurements

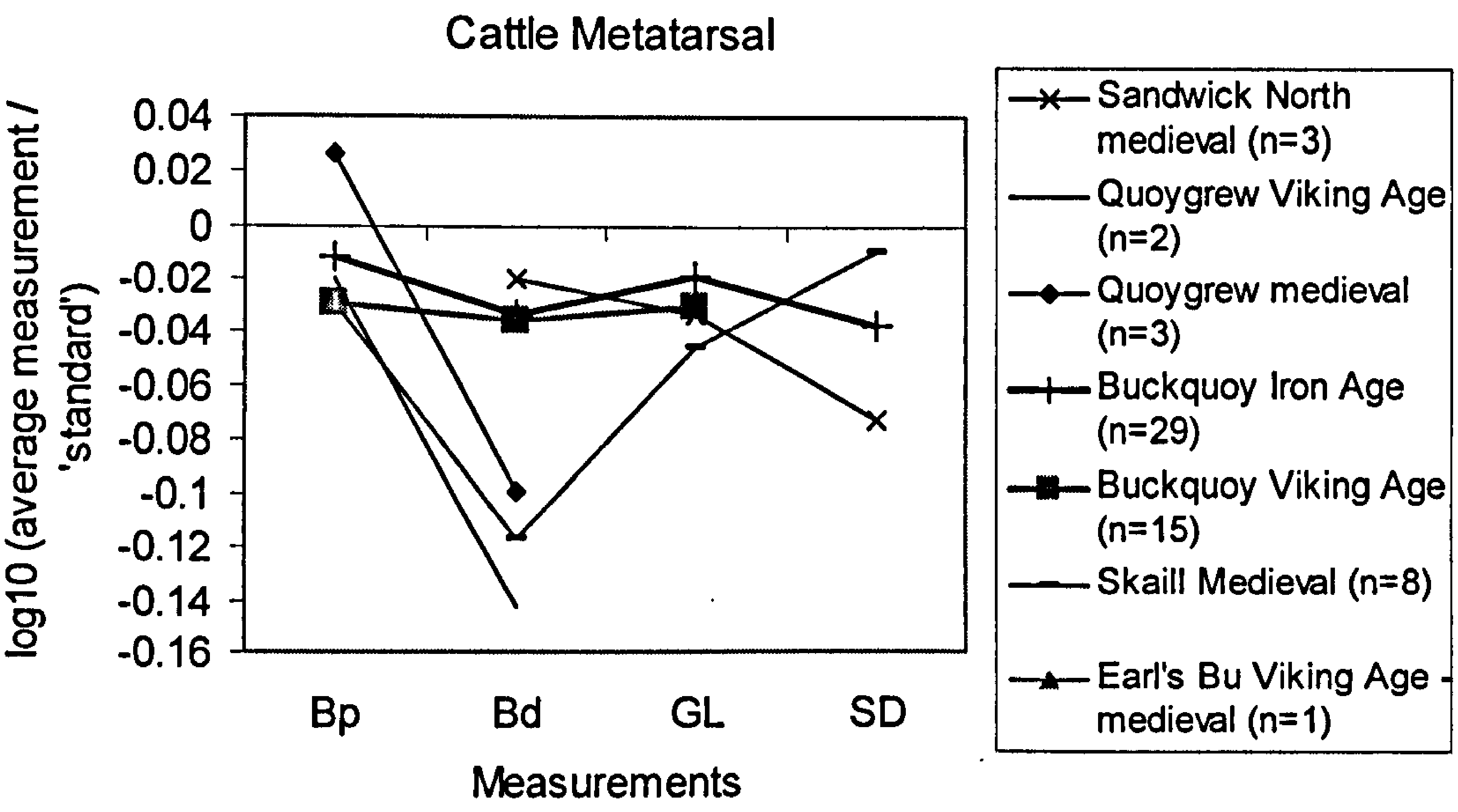


Figure 8.77: Cattle metatarsal log ratio measurements

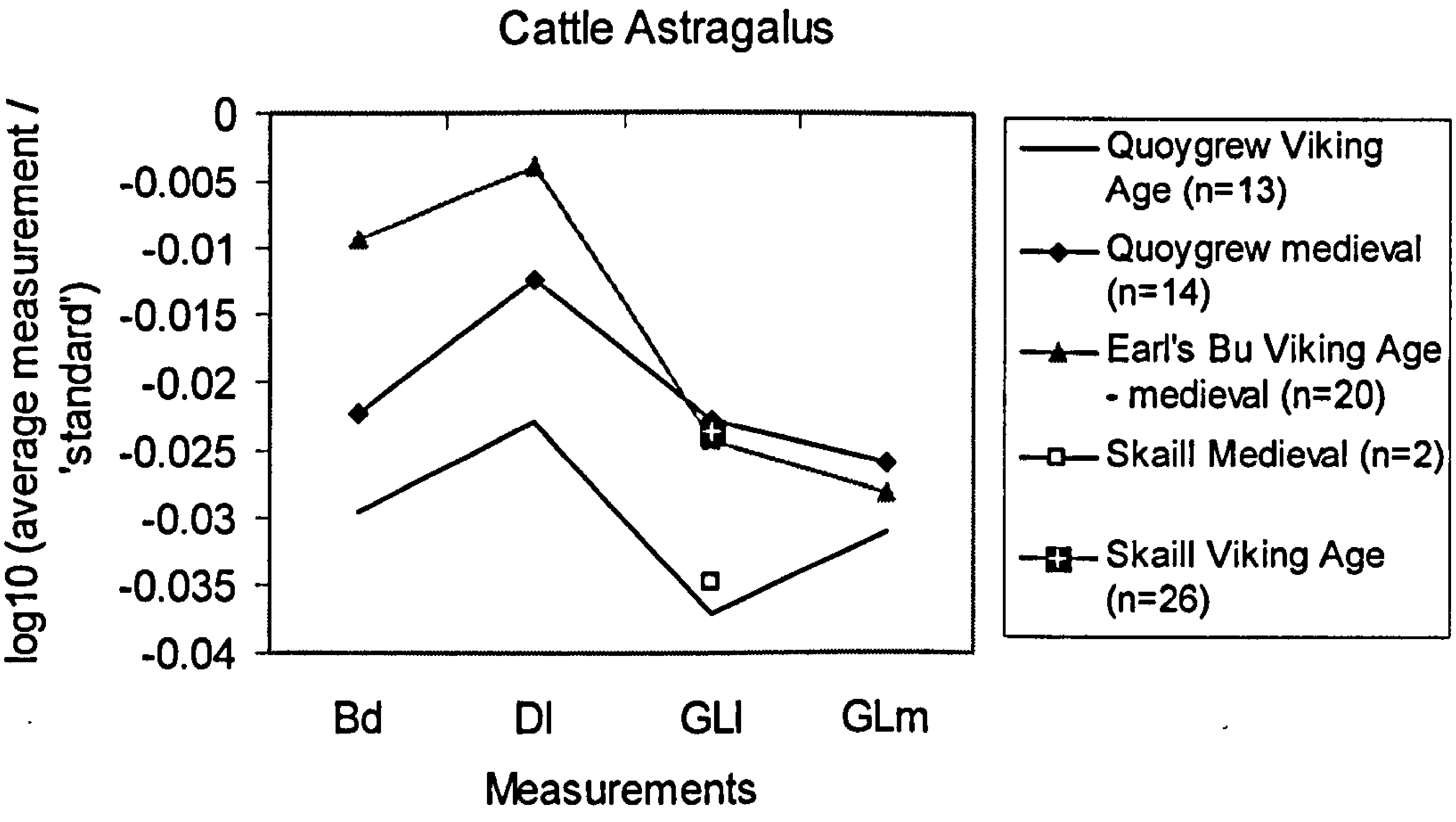


Figure 8.78: Cattle astragalus log ratio measurements

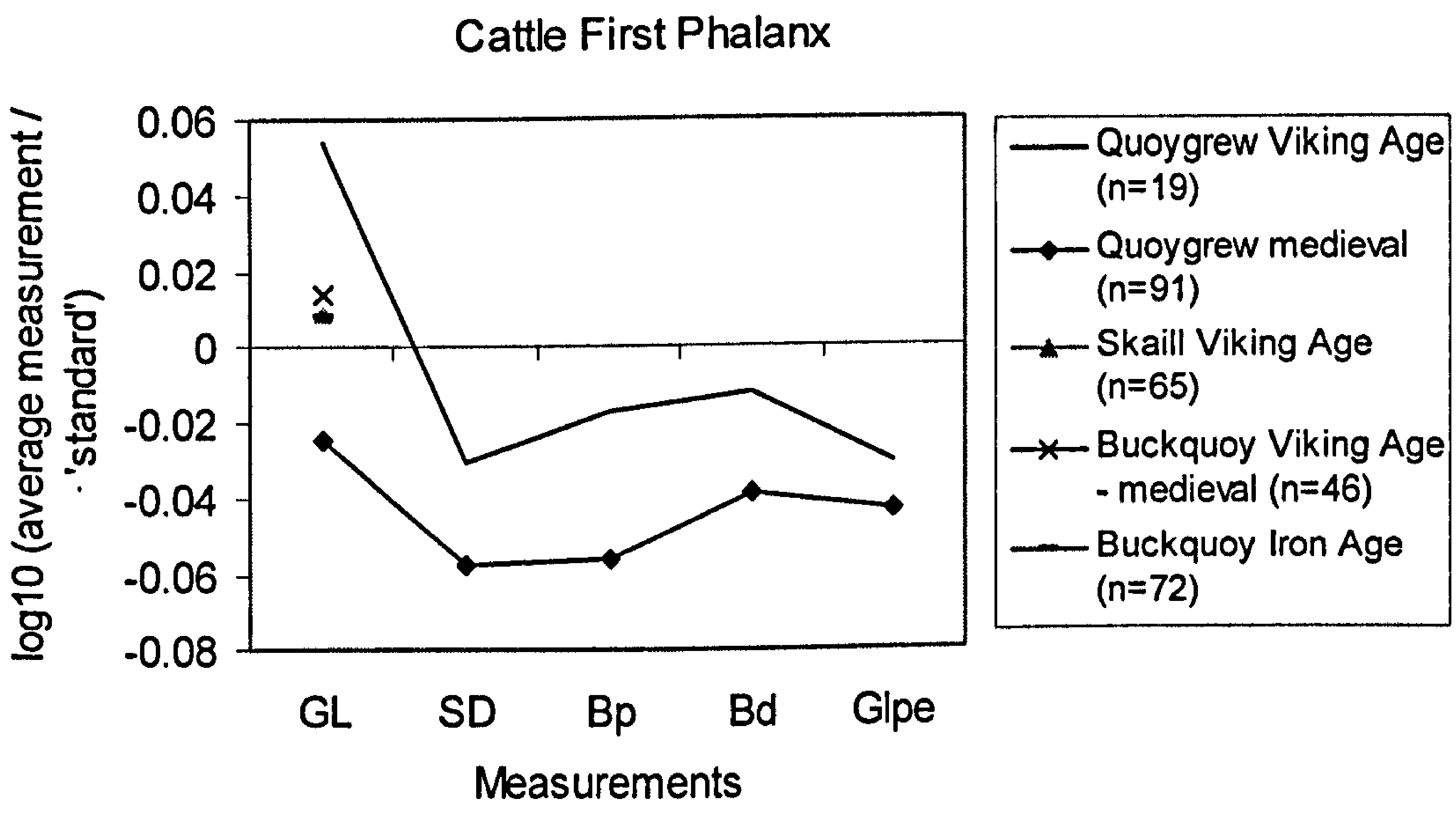


Figure 8.79: Cattle first phalanx log ratio measurements

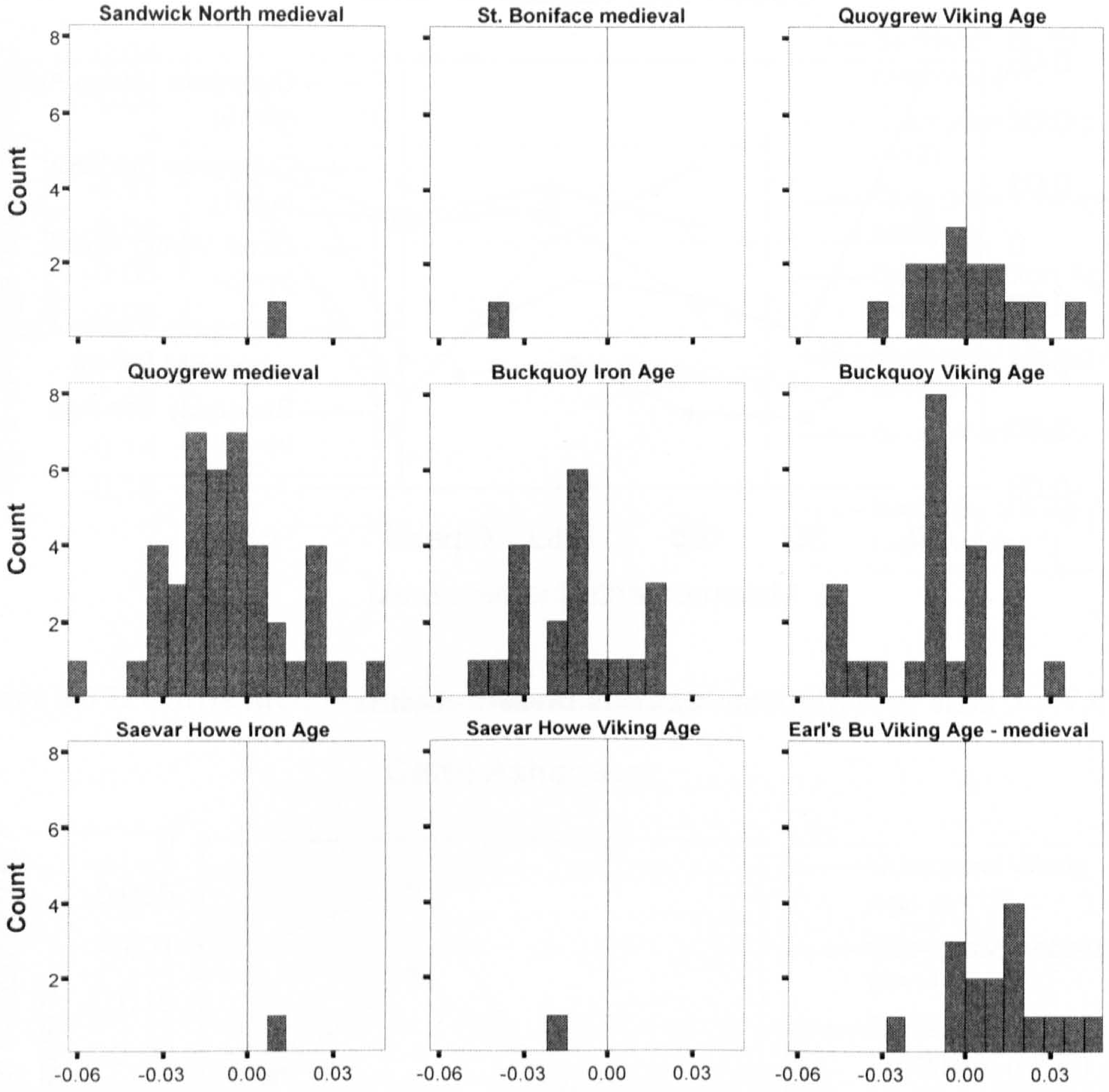


Figure 8.80: Caprine log ratios, based on astragalus GL, Bd and Dl, and calcaneum GL and using Davis' standard

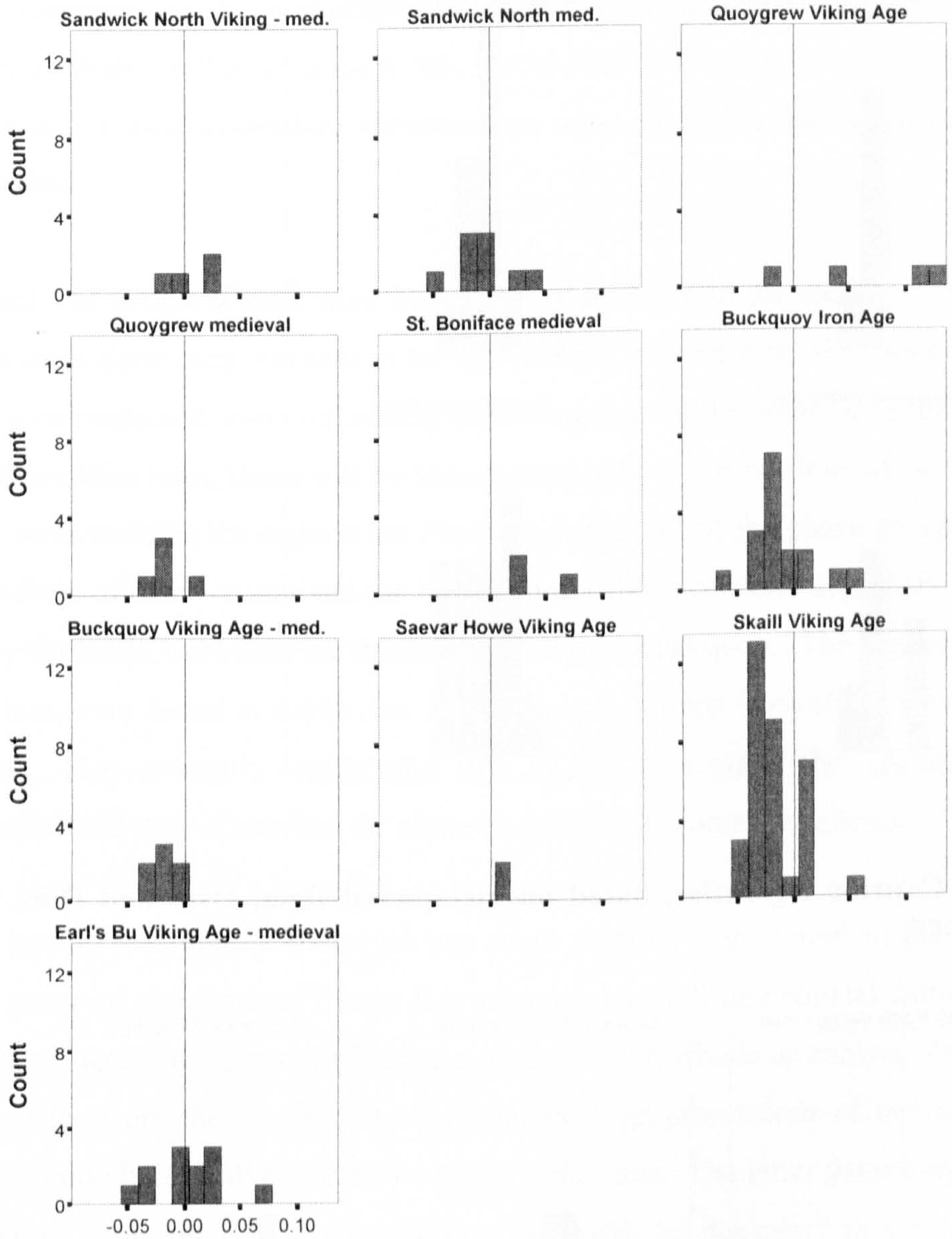


Figure 8.81: Caprine log ratios, based on metapodial BFp, BFd and SD, using Davis' standard

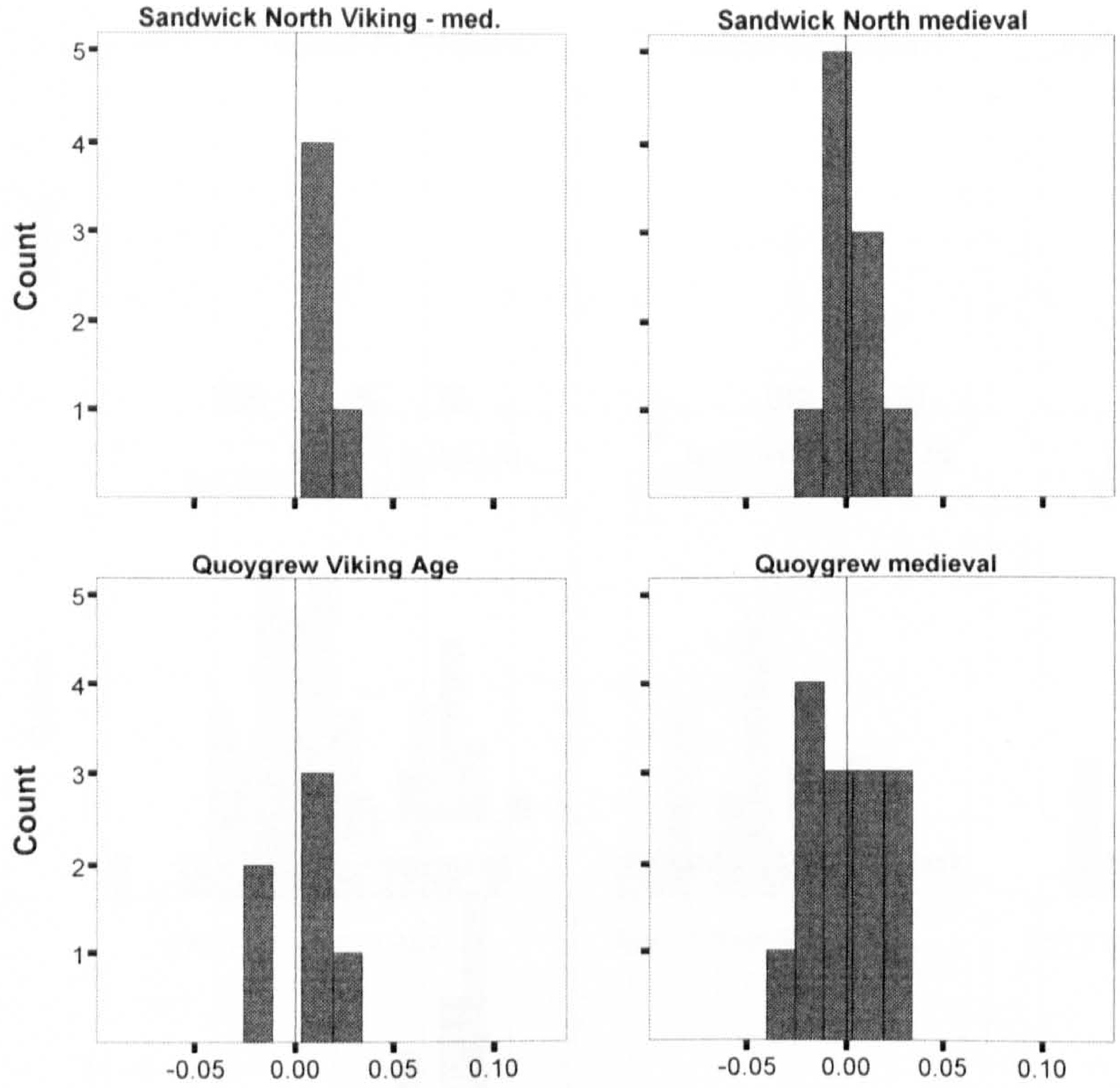


Figure 8.82: Caprine log ratios, based on metapodial Dem, Dvm and Dim, using Davis' standard

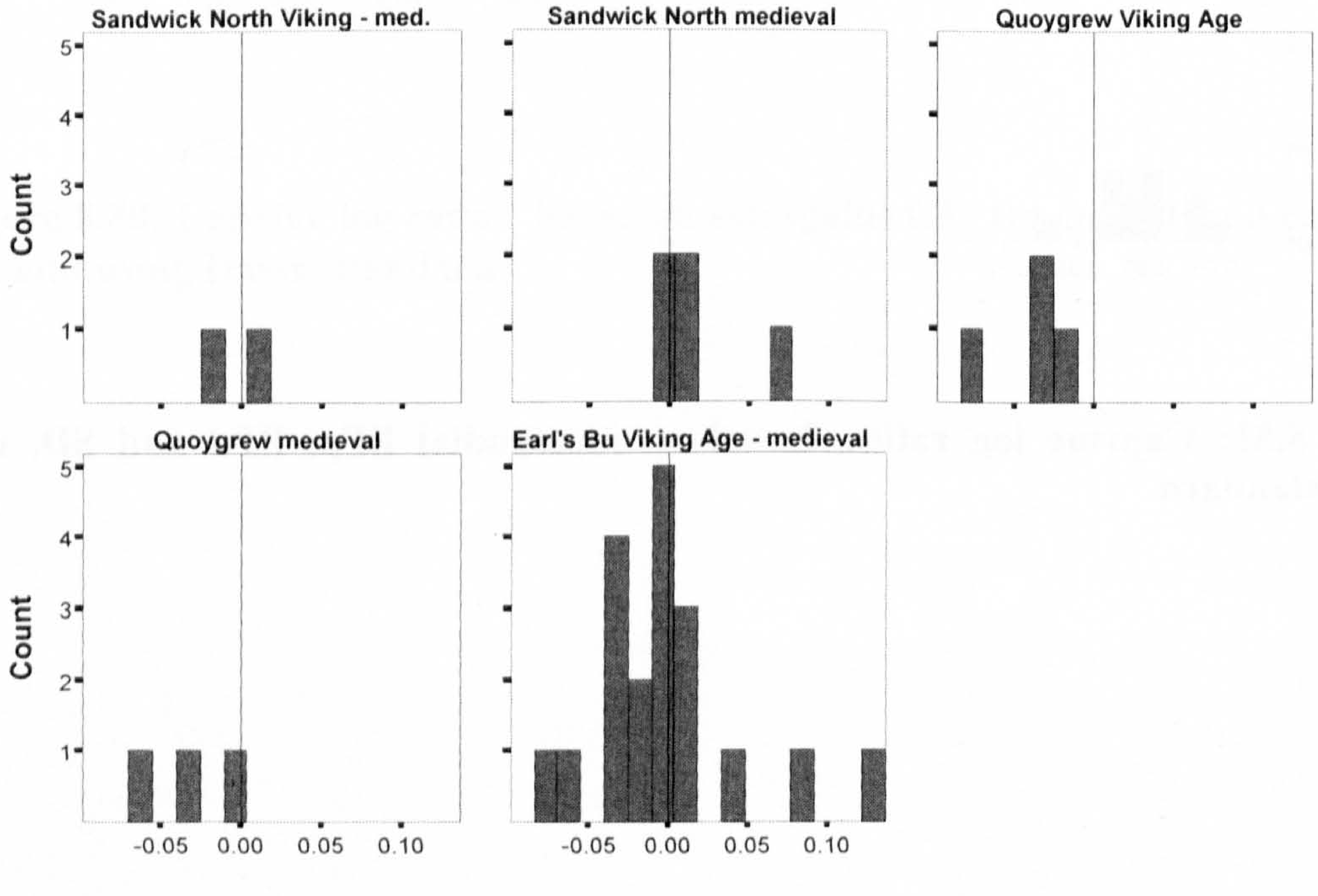


Figure 8.83: Caprine log ratios, based on tibia SD, Bd and Dd, using Davis' standard

8.4.5 Mammal bone summary

Any summary of the mammal bone patterning should consider the taphonomic and recovery biases influencing each site, but as with the fish intra- and inter-site summary, this was not always possible. Nevertheless, some chronological and spatial patterns were identified.

Spatial and temporal patterning was observed not only in the species composition of the three main domestics, but also in the age profiles for each site. The sites from the Birsay Bay area contained some interesting patterning that marks them out as unique among the Northern Isles sites; these will be summarised below. Proportions of cattle, caprines and pigs were variable throughout the Northern Isles. All of the phase groups at Freswick – regardless of date – contained the highest proportions of cattle anywhere in the Northern Isles, but cattle were also the dominant species at Buckquoy. The highest proportions of caprines were found at Earl's Bu, at some phase groups from Beachview and at Saevar Howe. Pigs generally represented 10% or less throughout the Northern Isles, but at Brough Road they accounted for almost a third of all domestic species.

The ageing information indicated two main patterns were found in the Northern Isles. The group of sites around Birsay Bay contained very little neonatal cattle, and very low levels of neonatal caprines, regardless of recovery methods or analyst. In contrast, most other sites from the Northern Isles contained high proportions of neonatal cattle, even approaching half of all cattle, by count, at some sites. The latter pattern may be related to dairying, as introduced in Chapter One, and will be discussed in Chapter Nine. The former pattern, that of little or no neonatal bone in the Birsay Bay area, is harder to explain, but appears not to be related to recovery or preservation biases. The ages of pigs are also different at some sites in the Birsay Bay area, although this could reflect a preservation bias. Sites on the Brough itself tended to contain much older, fully adult pigs, while a wide range of ages have been found at most other sites, particularly at the Brough Road where pigs of all ages were found in unusually high quantities. The final phase group at Saevar Howe, of 8th to 10th century date, also contains higher than average proportions of pigs of a variety of ages. Some of the variation around the Birsay Bay area might be attributable to recovery biases, given that a variety of recovery methods were used. Inter-analyst variability is unlikely to explain these patterns, given that the almost complete absence of neonatal material was separately identified by a number of zooarchaeologists. Preservation was noted as very good at the Brough Road, but it appears to have been relatively poor on the Brough itself (Rackham 1996b, 258); this might explain the lack of neonatal material on the Brough, but does not explain its near absence at the Brough Road. It therefore appears to be a real pattern, and one solely found in the Birsay Bay area.

The relative representation of different elements could not be evaluated for most phase groups and sites. However, element proportions were available from some of the sites in the Birsay Bay area, as well as for Sandwick North and Quoygrew. Unusual proportions of cattle and caprine elements were found at both excavations on the Brough of Birsay, which may indicate meat was brought to the Brough ready butchered. However, these unusual element proportions could also partly reflect the poor preservation on the Brough as well as inter-analyst variability. Element proportions from Buckquoy indicated some cattle meat may have been exported, and waste elements may also have been over-represented at Saevar Howe although primary data were not available to test this. No unusual proportions were observed at Beachview. These patterns will be interpreted in further detail in Chapter Nine, when site function and status will be considered.

The biometrical dataset from the Northern Isles was investigated, but sample sizes for most elements were small because of the high proportions of unmeasurable young animals. Some measurements indicated a decrease in cattle and caprine sizes from the Viking Age into the medieval period, but not all sites or elements displayed this decrease, and some exhibited the opposite. Shape indices showed no chronological or temporal patterns.

8.5 The birds

Unlike the fish and mammals, the birds identified from the Northern Isles comprised a wide range of species without any particular species or species groupings being predominant. The birds are also very much a tertiary resource compared to fish and mammals, as illustrated by their low contribution to midden densities (see 8.2.2) and inter-class comparisons (8.2.1). As such, any analysis of spatial and temporal patterning is difficult: it is not possible to concentrate on only a few species, and compared to fish and mammals, there are few identifications. In total, just over 3,500 bird bones were identified from the Northern Isles, which averages at only 26 identified bones per phase group. This problem was exacerbated by the lack of full quantification at some sites. There was also a lack of element quantification at most sites, even those with good NISP data, thus making it impossible to investigate patterning of element distributions.

Correspondence analysis was again chosen as a method of data exploration, but with rather lower thresholds. For the mixed and sieved dataset, which had to be combined to increase the sample size, phase groups were included if they contained at least 20 identified bones. Furthermore, the number of species included was restricted to birds with at least 15 identified bones. CA plots are illustrated in Figure 8.84, and these represent a considerable portion of the variation in the dataset (axis three inertia is 0.45, axis four is 0.43). The first two axes could not be used, because these were heavily biased by the high proportions of rock dove and rock/stock dove identifications at Earl's Bu (representing 45% of identified species) and the Brough of Deerness (35%), masking any other patterning. Only the 10 species that contributed the most to the CA plots in Figure 8.84 are labelled, but the others are included in the table of contributions in Table 8.51. The results indicate some phase groups are more closely associated with some species than others, and there is a relatively low intra-site level of variation. Robert's Haven phase 1 area A (11th to 13th century) is closely associated with Manx shearwaters, which account for 41% of all identified bone in that phase group. Brough Road area 2, phase C1 (9th to 11th century) is closely associated with both Manx shearwaters (28%) and mallard (22%). Some of the phase groups from Freswick are closely associated with fowl, including NCA area 4 (early 11th to early 14th century), representing 32.9% of all identified bone in that phase group, CCA area 7 (?late Iron Age to medieval), representing 12.7% and CCA area 8 (6th to 14th century), representing 41.9%. This explains some of the low intra-site variation. Freswick NCA area 4 is also strongly correlated to the great black-backed/ glaucous gull (27.5%). The two phase groups from Pool are similar, and both are correlated with gannet (the interface late Iron Age to Viking Age phase 7 contains 10.8%, while the Viking Age to mid 11th century phase 8 contains 39.4%). The single phase group from Earl's Bu is strongly correlated with rock dove, as already mentioned, while the two phase groups from Quoygrew have slightly elevated levels of passerines (representing 21.2% of the identifications from phase 2). Phase 2 is also correlated with gannets, again representing 21.2% of all identifications. Correlations between other phase groups and certain species are difficult to determine using the CA plots, but these can be augmented with percentage NISP data (Appendix Table 5.4).

The low level of intra-site variation could reflect preservation, recovery and methodological differences between sites, particularly given the combination of recovery methods represented here. However, it is also possible that local species were exploited throughout the occupation of each site, and that local habitats have dictated which species were present.

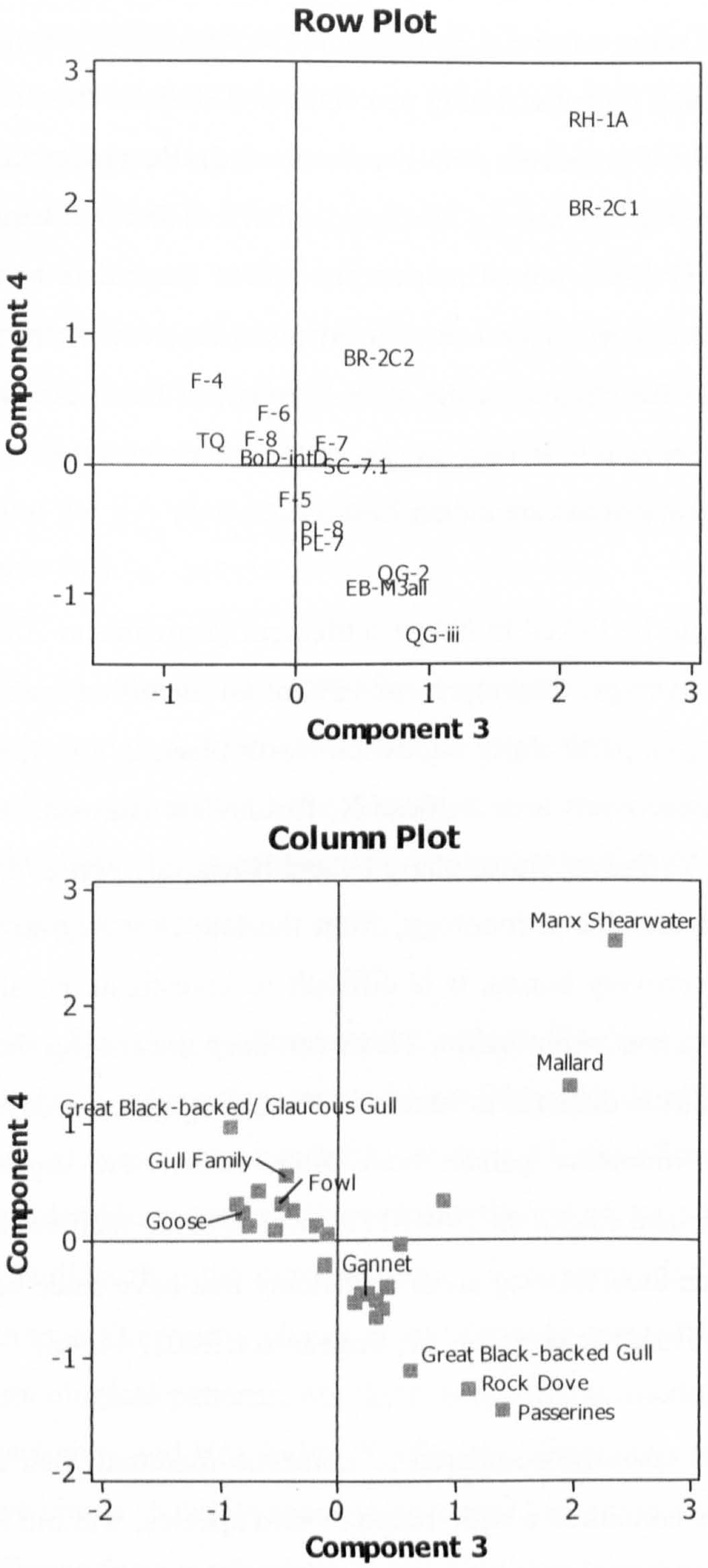
Figure 8.85 displays the row and column CA plots for the bird bone from sites with hand collection, where there were at least 25 bones identified for each phase group, and where each species is represented by at least 15 identifications. These plots still account for considerable variation (axis one inertia is 0.44, axis two is 0.28), but are less influenced by outliers than the previous plots. Intra-site variation was considerable for most sites, although Quoygrew phases ii and iii were located in close proximity. There were no chronological patterns, but there is a slight clustering of phase groups from Buckquoy, Beachview and Beachview Studio: the Birsay Bay sites. This could suggest these sites have similar habitats near by, or it could imply that the assemblages from this area were different from most others in the Northern Isles for socio-economic reasons. Although the latter may be true for the mammal and fish assemblages from the Birsay Bay area (see Chapter Nine), the bird evidence probably suggests natural variation.

Proportions of domestic fowl were generally low, indicating a reliance on wild species, but there is a slight suggestion that they become more common in the medieval period. However, this relies on using information from sites with very low NISP (see Appendix

Table 5.4). Domestic geese may have been kept, but are difficult to distinguish from wild greylags. As illustrated by some of the CA plots, some sites were strongly associated with rock or stock doves and pigeons. Using percentage NISP data, these sites comprise Earl's Bu phase group M3 (45% sieved, 40% hand collected), Beachview area 2 phase W (65% sieved), Beachview 1D/E phase Y (27% hand collected) and the Brough of Deerness Chapel Interior phase D (35% mixed recovery). All of these date to the medieval period, and may represent opportunistic use of local resources, which are not disposed of in other phase groups at Beachview, while at the Brough of Deerness, they may represent non-anthropogenic deposits. It may be possible that rock doves were deliberately kept at sites with high proportions, including Earl's Bu.

Proportions of gannets have proven to be linked to Norse settlement (Serjeantson 2001), as discussed in Chapter Seven. On average, they represent 12% of all identified species, but some sites have higher percentages, particularly Sandwick North phase 2, Quoygrew 2, Pool 8, Brough Road area 1D, Beachview area 2 phase X, Beachview Burnside area 1D/E phase U, Studio area 1 phase Y, Saevar Howe phase II, and Buckquoy phases I, II, IV and V. These sites span a considerable chronology, from the late Iron Age to the medieval periods, and because of recovery biases, it is difficult to investigate possible links between deep sea fishing and gannet exploitation. However, deep sea fishing likely took place at most of these sites (but is difficult to assess at Buckquoy given recovery biases), and the presence of one immature gannet bone from Beachview suggests exploitation of nesting sites (Allison and Rackham 1996, 172), which could include Sule Stack, although there may have been local nesting areas on Orkney that have since been disused (Groundwater 1974, 56-57; Booth *et al.* 1984, 13; Serjeantson 2001, 44, 48).

To summarise, birds were a minor resource compared to domestic mammal, fish and wild mammals. Most phase groups contained a wide range of bird species, without any emphasis on particular species, indicating exploitation of a number of different habitats. Domestic fowl and potentially domestic geese were found, but in small proportions at most sites, although they were slightly more common at several phase groups at Freswick than at any others. Rock doves were unusually common at Earl's Bu, possibly linked to that site's unusual status, but this will be discussed further in Chapter Nine.

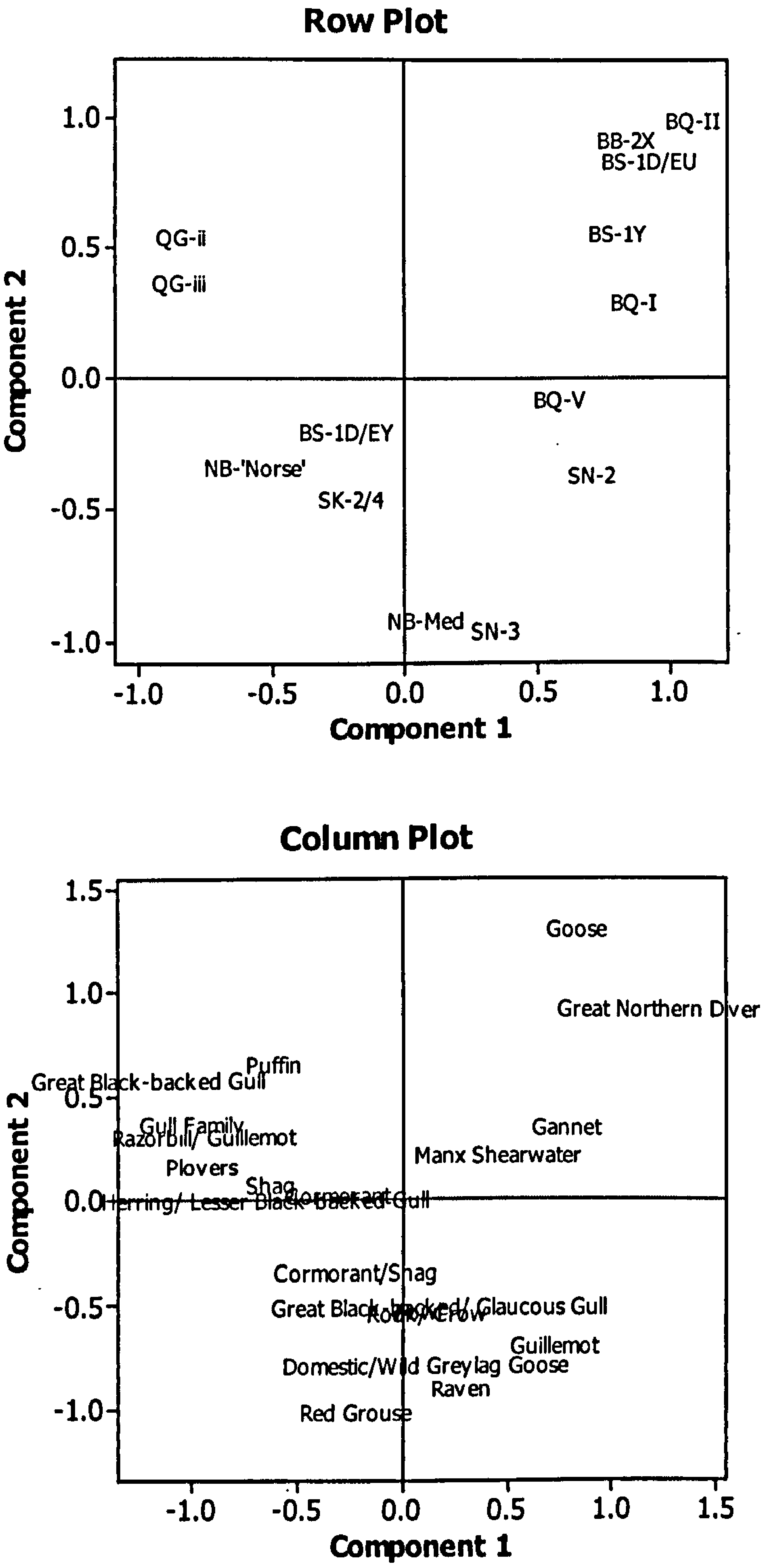


SC: Scalloway
QG: Quoygrew
TQ: Tuquoy
PL: Pool
BR: Brough Road
BoD: Brough of Deerness
EB: Earl's Bu
F: Freswick
RH: Robert's Haven

Figure 8.84: CA plots of major bird species (those with at least 15 identifications) for sites with mixed or sieved recovery and NISP≥20

Columns:				Component 3			Component 4		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Manx Shearwater	0.899	0.027	0.097	2.341	0.411	0.329	2.541	0.485	0.407
Gannet	0.320	0.097	0.032	0.236	0.045	0.012	-0.450	0.165	0.046
Cormorant	0.375	0.069	0.016	0.190	0.041	0.006	-0.454	0.233	0.033
Shag	0.339	0.106	0.012	-0.117	0.034	0.003	-0.217	0.117	0.012
Swan, Goose And Duck Family	0.338	0.019	0.010	-0.764	0.309	0.025	0.123	0.008	0.001
Goose	0.348	0.050	0.030	-0.816	0.306	0.074	0.227	0.024	0.006
Greylag Goose/ Bean Goose	0.291	0.031	0.021	0.318	0.040	0.007	-0.652	0.170	0.031
Mallard	0.459	0.013	0.042	1.964	0.316	0.109	1.307	0.140	0.051
Fowl	0.710	0.165	0.033	-0.493	0.325	0.089	0.302	0.122	0.035
Wader	0.178	0.010	0.006	-0.551	0.156	0.007	0.080	0.003	0.000
Snipe	0.087	0.008	0.023	0.888	0.076	0.015	0.318	0.010	0.002
Gull Family	0.249	0.055	0.032	-0.454	0.096	0.025	0.536	0.134	0.037
Herring/ Lesser Black-Backed Gull	0.515	0.027	0.007	0.321	0.103	0.006	-0.511	0.263	0.016
Great Black-Backed/ Glaucous Gull	0.267	0.033	0.063	-0.936	0.124	0.064	0.959	0.131	0.071
Great Black-Backed Gull	0.702	0.017	0.013	0.610	0.137	0.014	-1.102	0.446	0.048
Kittiwake	0.145	0.028	0.037	0.377	0.029	0.009	-0.585	0.069	0.022
Razorbill/ Guillemot	0.089	0.017	0.020	0.409	0.037	0.006	-0.400	0.035	0.006
Razorbill	0.147	0.032	0.006	-0.201	0.056	0.003	0.117	0.019	0.001
Guillemot	0.358	0.038	0.007	-0.398	0.233	0.013	0.242	0.086	0.005
Puffin	0.092	0.055	0.046	0.515	0.085	0.032	-0.048	0.001	0.000
Little Auk	0.998	0.013	0.104	-0.097	0.000	0.000	0.048	0.000	0.000
Dove/ Pigeon Subfamily	0.393	0.008	0.005	-0.872	0.337	0.014	0.291	0.038	0.002
Rock/Stock Dove	0.997	0.011	0.113	-0.101	0.000	0.000	0.051	0.000	0.000
Rock Dove	0.990	0.014	0.144	1.106	0.033	0.039	-1.276	0.044	0.054
Passerines	0.338	0.019	0.068	1.398	0.146	0.082	-1.450	0.157	0.092
Small Passerines	0.460	0.013	0.005	-0.691	0.324	0.014	0.406	0.112	0.005
Raven	0.399	0.024	0.007	0.131	0.016	0.001	-0.525	0.262	0.016

Table 8.51: Contributions for CA plot Figure 8.84



SN: Sandwick North
QG: Quoygrew
BB: Beachview
BS: Beachview Studio
BQ: Buckquoy
SK: Skaill
NB: Newark Bay

Figure 8.85: CA plots of major bird species (those with at least 15 identifications) for sites with hand collection and NISP≥25

Columns:				Component 1			Component 2		
Species	Quality	Mass	Inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia	Co-ordinate	Contrib. to row inertia	Contrib. of row to axis inertia
Great Northern Diver	0.304	0.018	0.092	1.232	0.196	0.061	0.915	0.108	0.052
Manx Shearwater	0.179	0.026	0.024	0.456	0.149	0.012	0.205	0.030	0.004
Gannet	0.903	0.195	0.107	0.791	0.761	0.275	0.343	0.143	0.081
Cormorant/Shag	0.138	0.025	0.020	-0.216	0.039	0.003	-0.344	0.099	0.010
Cormorant	0.295	0.045	0.009	-0.300	0.294	0.009	0.013	0.001	0.000
Shag	0.666	0.109	0.042	-0.616	0.658	0.093	0.067	0.008	0.002
Goose	0.420	0.034	0.132	0.840	0.123	0.055	1.306	0.297	0.207
Domestic/Wild Greylag Goose	0.418	0.044	0.044	0.114	0.009	0.001	-0.788	0.409	0.096
Red Grouse	0.429	0.025	0.041	-0.220	0.019	0.003	-1.008	0.409	0.089
Fowl	0.246	0.090	0.071	0.085	0.006	0.001	-0.532	0.240	0.089
Plovers	0.545	0.020	0.022	-0.948	0.529	0.040	0.163	0.016	0.002
Gull Family	0.678	0.025	0.027	-0.987	0.595	0.055	0.367	0.082	0.012
Herring/ Lesser Black-Backed	0.638	0.083	0.036	-0.648	0.638	0.078	-0.005	0.000	0.000
Great Black-Backed/ Glaucous	0.168	0.021	0.024	0.181	0.019	0.002	-0.504	0.149	0.019
Great Black-Backed Gull	0.836	0.028	0.040	-1.199	0.680	0.091	0.576	0.157	0.033
Razorbill/ Guillemot	0.666	0.049	0.047	-0.935	0.602	0.097	0.304	0.064	0.016
Guillemot	0.537	0.068	0.084	0.728	0.284	0.081	-0.688	0.253	0.113
Puffin	0.634	0.044	0.036	-0.606	0.297	0.036	0.646	0.337	0.064
Rook/ Crow	0.115	0.018	0.032	0.121	0.005	0.001	-0.543	0.109	0.018
Raven	0.281	0.033	0.069	0.283	0.026	0.006	-0.892	0.256	0.093

Table 8.52: Contributions for CA plot Figure 8.85

8.6 Summary

This chapter has explored the evidence for spatial and temporal patterning and has summarised the basic trends observed in the data. Having identified the various patterns in the data, and summarised them, the following chapter will now try to provide explanations, with an emphasis on the primary themes of this thesis. These were outlined in Chapter One, and include chronological patterning, focussing on evidence of economic intensification (particularly the Fish Event Horizon and dairying), as well as the introduction and extirpation of species. Conclusions will also be drawn regarding the spatial patterning explored in this chapter, linked to variations in site type, function and status. These include the variations observed between Earl's Bu and all other sites, particularly with regard to evidence of the fish trade. The unusual patterning observed at the Birsay Bay area will also be discussed, with an emphasis on different mortality profiles and a possible trade in meat within this area.

Chapter Nine: Conclusions

This thesis has aimed to explore the zooarchaeological record of the Northern Isles of Scotland, from the Viking Age to the medieval period, and has focussed on examining patterning at both the intra-site and inter-site levels. An attempt will now be made to interpret these patterns in terms of overall chronology, as well as site type, status and function, in order to address the key themes raised in Chapter One. These include:

- The extent and chronology of the intensification of fishing, firstly from the late Iron Age to the Viking Age, and secondly during the Fish Event Horizon of the late Viking Age and early medieval period
- Evidence of fish trade in the Northern Isles, examining both chronological trends (linked to the Fish Event Horizon) and spatial variation linked to site status
- The interpretation of increasing deposition of neonatal cattle bone over time, linked to an intensification in dairying
- Evidence of species introductions, extirpations or reintroductions, as linked to chronological change

By considering these themes, this chapter also aims to place the primary assemblages from Quoygrew and Earl's Bu into their context, using the entire comparative zooarchaeological dataset from the Northern Isles. The chapter is divided into two sections, one discussing predominately temporal patterning, and the second primarily discussing spatial patterning. There is a natural degree of overlap between these, which will be addressed by cross referencing between sections.

9.1 Temporal patterning

This thesis has focussed on the zooarchaeological material from the Viking Age and medieval periods. Some assemblages from the late Iron Age have been considered, where there is continuity of settlement through the transitional late Iron Age to the Viking Age. The assessment of temporal patterning is very traditional in zooarchaeological analysis, and has already been applied during the publication of most of the reports surveyed. A number of temporal themes have thus been identified by previous research. These were introduced in Chapter One, and include: the introduction and extirpation of species in the Northern Isles, the potential reintroduction of livestock during the Norse colonisation of the Northern Isles, and the economic intensification during the Viking Age and medieval periods. Two important facets of economic intensification include the evidence for increased dairying (Bigelow 1992, 10; Bond 1998, 85; Bond 2003, 108), and open water fishing from the late Iron Age to the Viking Age, and then from the Viking Age to the medieval periods, otherwise known as the Fish Event Horizon (Barrett *et al.* 1999; Barrett *et al.* 2004a).

9.1.1 Extirpation and (re)introduction of species

The study of any introductions or extirpations in the Northern Isles is a relatively simple analytical procedure, although it is always difficult to treat the absence of evidence as an indication of a real absence of a particular species. The most important case during the Viking Age and medieval periods was the steady decline of red deer, to the extent that the species is no longer found in the Northern Isles.

Red deer are known archaeologically from Shetland, Orkney and Caithness. These may or may not have reached Orkney naturally prior to its separation from the mainland, but they must have been deliberately introduced by humans to Shetland (McCormick and Buckland 2003, 87). Red deer bones were recovered in low quantities from several of the Northern Isles sites, from the late Iron Age, Viking Age and the medieval periods (see Appendix Five for quantifications and percentages), but are no longer found today. The date of this extirpation is difficult to ascertain with certainty, but few were found in the final phases of any one site, particularly those that extended into the medieval period.

Evidence from Howe, on Mainland, provides an additional dataset with which to explore the decline of this species. Howe was not included in this study because it only dated to the Iron Age, without any Viking Age or medieval deposits, but it provides evidence for the decline of red deer prior to the Norse arrival. In the early Iron Age, red deer represented over a third of all identified mammal bone, but by the mid Iron Age, this had decreased to under 20%. This declined further, the species then representing only 4% of identified mammals by the late Iron Age, a proportion only slightly higher than was found at various Viking Age sites (Ballin Smith 1994, 120; Smith 1994, 145).

Red deer bone or antler was present during the Viking Age at Jarlshof (Platt 1956), but none was found at Sandwick or Sandwick North, indicating possibly that there were no populations on Unst. None was found at Scalloway either, suggesting they were a marginal resource in Shetland, possibly extirpated by the end of the Viking Age.

Only two identifications were found at Quoygrew, dating to the late 8th to 10th centuries. This suggests few were found on Westray in the Viking Age, and by the medieval period, there does not appear to have been a viable population, at least on this island.

On Mainland, only one identification was found at Earl's Bu, in the earliest midden dating to the late 9th to mid 12th centuries (Mainland 1993; Mainland 1994; Mainland nd.b). This would suggest that in Orphir, there were no populations remaining by the medieval period. This is further enhanced by historical evidence. *Orkneyinga Saga* describes the Earls of Orkney going to Caithness to hunt red deer or reindeer, which would imply they were no longer available in Orkney by the beginning of the 13th century (Pálsson and Edwards 1978, 209; Clutton-Brock 1988, 28; Graham-Campbell and Batey 1998, 46). This would suggest that hunting could not be undertaken in Orkney, and given that Earl's Bu was an earl's residence, the effective absence of any red deer from the site would suggest the absence of local populations given the practice of aristocratic hunting. The few other examples on Mainland were from the Brough Road, dating from the 7th to 13th centuries and from Viking Age levels at Buckquoy (Noddle 1976-77; Rackham 1989). Trace quantities were also found at Beachview dating to the early 11th to late 13th centuries (Rackham 1996a), but this indicated a decline from the earlier proportions at the Brough Road. Single instances were also found at 9th to 11th century Skaill and medieval Newark Bay (Noddle 1997; Harland 2001b), indicating at least some survival into the medieval period in the Deerness Peninsula (a name probably derived from the Old Norse Dýrnes, meaning 'animal ness' and thus not directly correlated to red deer (Morris and Emery 1986, 306)). Red deer may have survived as a population in the medieval period on Mainland, but perhaps at much lower densities than in the late Iron Age.

Quantities of red deer were found at Pool on Sanday, dating to the late Iron Age to Viking Age interface, and slightly lower proportions were found in the phases dating to the Viking Age to mid 11th century. Bond identified a decline in red deer numbers through the Iron Age to the Iron Age and Viking Age transitional period at Pool (Bond *et al.* Forthcoming, 5). The elements present were suggestive of entire populations on

Sanday, as well as Mainland (given the evidence from Howe), but ones that declined into the medieval period. Red deer were found in several of the phase groups at Freswick, and were not extirpated from Caithness because they are still found there.

To summarise, red deer were found at low levels in the Viking Age, but declined into the medieval period with trace quantities found in Deerness and the Birsay Bay area, as well as at Pool. The historical evidence suggests that by the 13th century there were no populations left to hunt in Orkney. This extirpation was probably caused by increasing human population, hunting, and/or competition for resources needed for humans.

The Norse undoubtedly introduced livestock into the settlements of the Faroe Islands, Iceland and Greenland, given that they were likely uninhabited or barely inhabited at the time of colonisation, but the presence of indigenous people and livestock in the Northern Isles complicates this transitional period. The biometrical dataset for the Northern Isles was analysed in an attempt to identify changes at the late Iron Age to Viking Age interface. This has been successfully applied to material of this date at Pool, suggesting that cattle remained a similar size but caprines changed shape. However, when this method was applied to the entire dataset, no overall patterning was observed. Traditional log-ratio methods were also applied to the cattle and caprine datasets, and although slight changes were noted, the results were ultimately inconclusive. Even if indigenous livestock were being used, the arrival of the Norse was likely associated with agricultural intensification, as will be discussed below. This in turn could influence the size of livestock, even if using indigenous animals, making this issue a complex and difficult problem to attempt to answer. An alternative approach is to consider bioarchaeological methods instead. Genetic work on cattle from the Dublin Viking settlement indicated they were more closely related to cattle from the British Isles than from Scandinavia (Edwards *et al.* 2003), indicating the Norse were willing to use local resources. Such an approach has potential in the Northern Isles as well, but has yet to be attempted.

At Pool, the proportions of horse increased from the late Iron Age to the Viking Age and medieval phases, implying a correlation with the arrival of the Norse (Bond *et al.* Forthcoming, 5). However, this appears likely only at the intra-site level, given the presence of horse at a number of Iron Age and earlier sites, including Buckquoy (Noddle 1976-77) and Saevar Howe (Rowley-Conwy 1983). Goats have similarly been associated with the Norse arrival in the Western Isles (Noddle 1994, 121; Smith and Mulville 2004, 55) and at Pool in Orkney (Bond *et al.* Forthcoming, 7), but their presence in the late Iron Age deposits at Buckquoy (Noddle 1976-77) and Howe (Smith 1994, 144) indicate they were already in the Northern Isles prior to the Viking Age.

In conclusion, finds of red deer declined through the Viking Age in both Orkney and Shetland, with some isolated finds in the medieval period in Orkney, but not in Shetland. The biometrical dataset was analysed for any changes that corresponded to the arrival of the Norse, but although some variation was noted, the metrical results were inconclusive. Previous suggestions correlating the arrival of the Norse with both horses and goats appear unlikely, although further work may illuminate this issue. A number of changes to the fish species caught in the Northern Isles were also related to temporal patterning, but these shall be discussed below.

9.1.2 Economic intensification

The processes of economic intensification during the Viking Age and medieval periods is a recognised phenomenon in the Northern Isles, as discussed in Chapter One. It can potentially be observed in the zooarchaeological record in two ways: an increase in neonatal cattle that has been interpreted as an intensification in dairying, and secondly, an increase in open water fishing and the appearance of fish-rich middens containing large quantities of gadid (cod family) fish. Both of these aspects will also be discussed later in this chapter, when spatial variation is summarised, but this section will focus on chronology.

The large proportions of neonatal cattle found throughout the Northern Isles have been interpreted in two ways, as introduced in Chapter One, and before any conclusions can be drawn regarding the importance of this material, these potentially conflicting explanations need to be considered. One approach suggests that neonatal cattle were deliberately killed to allow human access to milk, thus maximising the potential milk yield for the creation of dairy produce (Bigelow 1992; McCormick 1998a; Mulville 1999, 271; Bond 2002; Bond 2003; Craig *et al.* 2004; Smith and Mulville 2004, 59; Mulville *et al.* 2005; Bond *et al.* Forthcoming). The other approach suggests the harsh winters, lack of fodder and marginal position of the Northern Isles resulted in large numbers of natural, neonatal deaths of cattle (McCormick 1998a; Bond *et al.*

Forthcoming, 10, 14). It is likely that milking was not as straightforward as today, in that either the calf needed to be present, or the cow needed some stimulation before the milk let down reflex occurred (Legge 2005, 12). However, Irish and Scottish historical sources indicate a number of methods were possible to encourage milk production without the calf (McCormick 1992, 202-03). Killing neonatal calves would therefore be a method of ensuring maximum milk availability for human use. The alternative explanation does not fit the evidence as well as the dairying solution. Ethnographic and biological studies indicate natural mortality profiles of cattle and sheep produce significantly fewer neonates than were found in the Northern and Western Isles (Mulville *et al.* 2005, 174), indicating the pattern suggests real and deliberate culling of neonatal cattle, although accidental losses would be expected and no doubt contribute to a moderate degree. There is also the added role of human manipulation of livestock reproduction. Experience of winter and spring fodder availability would probably allow a known number of animals to be successfully over-wintered, and if there was no desire to kill neonatal cattle, then surely the number of pregnancies could be restricted to fit with the quantities of fodder available. This in turn would limit the number of unintentional deaths.

The question of winter fodder availability can be approached using bioarchaeological methods. Isotope studies can indicate if cattle ate an entirely terrestrial, diet, or whether their diets needed to be supplemented with seaweeds, fish oils and fish bones. Ethnohistoric evidence suggested the latter foods were sometimes needed in more recent centuries. Seaweed formed a known component of the diet of Neolithic sheep (Balasse *et al.* 2005), modern North Ronaldsay sheep, and a possible component of the Iron Age to medieval caprine diet at Newark Bay; marine protein also formed a component of pig diet at Newark Bay, and perhaps to a minor degree at Quoygrew (based on one pig skull dated to 779-981) (Barrett 2005, 269; Richards *et al.* 2006, 124-25). However, cattle isotopes from Newark Bay indicated a complete absence of any marine foods from the diet (Richards *et al.* 2006, 124-25)*. This may indicate marine resources were not needed to supplement winter fodder. The presence of considerable quantities of cereals at Pool, and corresponding evidence for an increase in agricultural production during the

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* Stable isotope analysis of a cow pelvis from Quoygrew, dating to 1027-1267, originally indicated some marine protein consumption (Barrett 2005), but reanalysis has now shown this not be the case (M Richards pers. comm.)

medieval period (Barrett *et al.* 2000a, 20; Simpson *et al.* 2005), would suggest agricultural surpluses were present (Bond *et al.* Forthcoming, 10). The analysis of human remains from the 8th to 14th century cemetery at Newark Bay confirms this, indicating that "overall nutritional resources would appear to have been plentiful" (Molleson 2005, 114). Using this evidence, it appears that unintentional deaths of neonatal cattle may have been present, but are unlikely to be the explanation for the large quantities found.

Looking now at the zooarchaeological evidence itself, many of the sites in the Northern Isles contained substantial quantities of neonatal cattle. The exception to this was a number of sites in the Birsay Bay area, but these will be discussed separately below, when drawing conclusions regarding spatial rather than chronological patterning. The neonatal cattle are difficult to quantify absolutely, because ageing can be determined by a number of different methods, and neonatal bone may not survive as well as adult bone. Nevertheless, the presence of young cattle was considerable at many sites. Evidence from Pool suggested the proportions of neonatal bone increased through time, indicating an intensification in dairying (Bond 1998, 85; Bond 2003, 108). This was first apparent at the late Iron Age to Viking Age transition, but a second and later increase dated to the Viking Age to mid 11th century. Some other sites that could have provided chronological evidence regarding this intensification were inconclusive because of ambiguity in recording methods, quantification or taphonomic patterning, while full age profiles are not yet available for Earl's Bu or Tuquoy. Evidence from Sandwick suggests an intensification in neonatal cattle occurred in the 12th century, but as discussed in the introduction, these results are preliminary and are based upon a small sample size. At Quoygrew, the proportions of neonatal cattle increased through time within the farm mound. Neonatal bone represented about one third of all cattle in phase ii, dating to the late 8th to late 10th centuries, but by phase iii, dating to the early 11th to mid 13th centuries, the proportion had increased to about half of all cattle. This mirrors the proportions found at Pool, suggesting that this is probably not an isolated phenomenon: the increasing proportions of neonatal cattle at the end of the Viking Age and beginning of the medieval period probably indicates that dairy produce became more important at this time.

Meat was undoubtedly still being consumed, though was probably secondary in importance to dairy produce. A dairying economy may be expected to contain a predominantly female adult population, but adult bones were often butchered and broken, and thus the sex could very rarely be determined by traditional methods. Future bioarchaeological techniques may illuminate this problem, including genetic methods of determining the sex of adult cattle (S McGrory, pers. comm.).

Ethnohistorical sources suggest dairy products played an important role in the Norse economy. The intensification of dairying towards the end of the Viking Age or within the medieval period may be linked to the use of dairy products as payment for taxes and rent (Thomson 2001, 208-09). Dairy produce, particularly in the form of cheeses and butter, are an easily portable, storable product, high in calories and useful for periods when fresh milk and other produce is not available (Challinor 2004; Legge 2005, 12-13).

The proportions of cattle within the mammal assemblage varied during the Viking Age and medieval periods, but there was no direct correlation between an increase in cattle compared to caprines and pigs, and an increase in neonatal cattle. Cattle and caprines were recovered in approximately similar proportions at most sites, barring a few that will be discussed in the context of spatial variation below. Even at sites with direct evidence for dairying intensification, caprines were still an important resource, and one that appears unaffected by the focus on cattle dairy produce. It is likely that milk from caprines was also used, albeit not necessarily as intensively as cow's milk. Fenton suggests sheep's milk was used, rarely, until the mid 18th century in the Northern Isles (1978, 454), but ethnographic sources from Iceland indicate it was used into the early 20th century, and into the 17th century in the Faroes (Bergsaker 1978, 86). Ethnographic evidence for primitive Norwegian and Icelandic sheep indicates that, when ewes were milked once or twice a day, the lambs were not slaughtered as competitors to human consumption of milk, but were instead stopped from suckling for a set amount of time (Bergsaker 1978, 87-88). Small bits could be placed in the lamb's mouth and tied to the head; these were known as a 'kevel', of Old Norse derivation, and are known from at least the 18th century in the Faroes (Baldwin 1978, 117). A find from Jarlshof possible functioned in this manner (Hamilton 1956, 95; also Challinor 2004, 164). If true, this would leave no distinguishing mortality profiles in the zooarchaeological record, and there are no high levels of neonatal mortality among the caprines to compare to the cattle.

Further ethnohistoric evidence suggests that sheep's milk could be turned into butter or cheese, but the butter was of poor quality and only suitable for industrial or agricultural function (Challinor 2004, 167). However, this may have been a suitable product with which to pay rents and taxes (Challinor 2004, 165), and therefore the role of caprine dairy produce in the economy of the Northern Isles should not be underestimated. Because ethnohistoric evidence indicates sheep milk could be exploited without killing neonatal lambs, it is likely sheep populations were used for a variety of primary and secondary products, including wool and meat, without any one focus, but the good quality dairy produce derived from cattle became increasingly important over time, probably for both direct human consumption and payments of taxes and rents from at least the later medieval period.

The existing North Ronaldsay and Soay rare breed sheep are related to the primitive Shetlandic and Icelandic sheep (Berry 2000, 135), implying an association with the Norse, albeit one unconfirmed by traditional biometrical analyses. These were not shorn, but were 'rooed' or plucked, which helped separate out the woollier fleece from the less desirable hairs (Berry 2000, 137; Greenfield 2005, 15). Contra Noddle's suggestion that the wool was of little use (Noddle 1976-77), evidence for wool processing has come from parasites in the 10th century waterlogged pit at Tuquoy (Owen 2005, 207). Furthermore, the ubiquitous presence of spindle whorls (Graham-Campbell and Batey 1998, 213) indicates that wool production was likely an important part of the economy. This is further evidence to suggest caprines were used for a variety of purposes (Mainland and Halstead 2005).

The second aspect of economic intensification that has a chronological basis is the increase in open water fishing that occurred in the Viking Age and medieval periods, with an emphasis on the Fish Event Horizon around the end of the first millennium AD. As discussed in Chapter One, there were probably a number of stages to this intensification process. Although much of this chronology has been proposed based on previous research, Quoygrew and Earl's Bu add important new datasets with which to test past hypotheses – in terms of both time and space (the latter of which will be discussed in greater detail below).

The arrival of the Norse marked the first change in the range and quantity of fish species caught. It was possible to examine the late Iron Age to Viking Age transitional period at a few sites, including Pool, Buckquoy and Saevar Howe. There, the proportions of cod increased and saithe decreased at this transitional period, and the proportions of gadids recovered also increased, indicating a more intensive focus on this one family of fish. Fish species again changed between the Viking Age and the early medieval period. At that chronological transition, there was a second increase in the proportions of cod caught, while saithe correspondingly decreased. However, in the later medieval period, proportions of cod decreased again, with saithe becoming more common. Changes occurred not only within the fish assemblages, but also within the entire animal bone assemblages. Fish became increasingly important over time, compared to mammal and birds. There was insufficient data to examine the transitional period from the late Iron Age to the Viking Age, but increases in the proportion of fish were visible from the end of the Viking Age and the beginning of the medieval period, from c. 1000. This was particularly apparent at the areas classed as "fish middens", but was also observed at middens that continued to contain mammal and bird. The specialised fish middens tend to date from the beginning of the medieval period onwards, from about 1000. Fish middens will be discussed in detail below, when considering spatial variation, but their presence has chronological ramifications. Terrestrial resources were still used, but became secondary in importance to fish. Towards the end of the medieval period, two sites displayed an increase in the proportion of mammal bone, but most sites lacked the chronological resolution to examine this issue in any detail.

The sizes of fish caught during the late Iron Age, Viking Age and medieval periods were also subject to change. Firstly, large gadids indicative of open water fishing were found in the late Iron Age, but only on a small scale. Two sizes of cod were recovered from Viking Age and very early medieval sites. These were primarily between 400 and 700mm in length, with smaller quantities of older (longer) cod caught. From the 11th to the 13-14th centuries the size distributions of cod change. Again, two sizes were caught, but most were between 800-1000mm in length, with smaller quantities of the shorter, younger cod caught. This transition approximately corresponds with the intensification of fishing that occurred about 1000, but not all sites have adequate chronological resolutions to test this. Gannet exploitation increases in the 9th and 10th centuries, and is probably correlated with the increasing intensification of deep sea fishing (Serjeantson

2001, 48). Most sites, regardless of date, contain large quantities of saithe that could have been caught from coastal waters. There is a slight tendency for saithe from the earlier (i.e. Viking Age) phases to be larger than the later phases, but this was not observed at all sites and was difficult to test. Saithe sizes will be revisited below, when considering spatial patterning. Haddock were found at only a small number of sites, and thus do not warrant inclusion in this general assessment of chronological change. However, their presence has important status correlations, and they will be discussed in greater detail below when conclusions are drawn regarding spatial analysis in the Northern Isles.

The initial increase in deep sea fishing coincides with the arrival of the Norse at the start of the Viking Age. They imported food preferences from Scandinavia, as well as boat technology and a thorough knowledge of the sea (Barrett *et al.* 2001). The later Fish Event Horizon of c. 1000 can be explained by examining the larger European cultural and economic trends of the time. Christianity was re-introduced to the Northern Isles in the 10th century (Barrett 2003a), involving new dietary restrictions involving both horses and fish. Restrictions on hippophagy are difficult to trace, given that horse products were consumed as dog food in Scottish medieval towns (Smith 1998, 876), but there is no direct evidence in the Northern Isles. Fish became a necessary part of the diet during fasting, but more importantly, dried, tradable fish became a highly desired product throughout Europe. Evidence for the production of dried cod family fish had been found in the Northern Isles prior to this study, but important contributions have been made. Considerable quantities of prepared haddock and cod were imported into Earl's Bu in phases dating to the 10-12th century, while at Quoygrew, most fish were caught and consumed locally, but a small proportion of cod was likely prepared and exported between the mid 11th and late 13th century. A few other sites displayed similar evidence for the production and export of dried large gadids, dating from the 11th to the 14th centuries in Shetland, Orkney and Caithness; this corresponds to the date of the Fish Event Horizon, and suggests that dried fish were produced at a number of locations in the Northern Isles. Earl's Bu may have functioned as a distribution centre, receiving large quantities of prepared fish (as well as locally caught fish), consuming some of it, and possibly exporting some to as yet unknown locations. The final stages of this process are difficult to investigate using traditional zooarchaeological methods, but new bioarchaeological techniques may be able to trace the origin and movement of fish from the North Atlantic region into Europe and Britain (Barrett 2006a).

Isotopic analysis of human remains in the Northern Isles confirms the patterning observed in the zooarchaeological record. Little marine protein was consumed in the late Iron Age (Barrett and Richards 2004, 264), but in contrast, from the Viking Age onwards, high levels of marine protein were found in the diet of Orcadian men, and, to a lesser degree, women (Barrett and Richards 2004, 264; Richards *et al.* 2006, 128, 129). There is a secondary intensification in fish consumption visible between c. 1000 and 1200-1300, after which marine protein drops to the levels recorded during the Viking Age (Barrett and Richards 2004, Figure 3).

Towards the end of the medieval period small saithe became more common, mammal bone increased, and there is less evidence of any fish trade. This period was explored historically by Thomson, who stated that "[e]ven before the Black Death ravaged the islands in 1349, the economy was probably on a downward course... with a declining population, worsening climate and a depressed economy" (2001, 169). The historical sources for the plague are limited, but corresponding archaeological evidence suggests a decline in the quantity of cultivated land about this time, possibly linked to the decrease in population and worsening climate (Thomson 2001, 187; Barrett and Richards 2004, 265; see Schei and Moberg (2003, 31-32) for a similar pattern in the Faroe Islands). The Northern Isles began to orient themselves politically towards Scotland and away from Scandinavia (Thomson 2001, 189-205), a process that may have altered the economic foundation of the isles and led to a reduced maritime focus. Together with the reduced population, this may have resulted in a decline in deep sea fishing, which was a high risk activity. Fishing for small saithe from the shore or from near the coast was an activity with lower associated risks, but one that reaped fewer rewards. However, small saithe provided both food for immediate consumption, as well as livers that could be rendered for oil that could be traded or used for lighting (Fenton 1978, 527; Nicholson 2005), and small saithe could be smoked and dried for later consumption (Fenton 1978, 528-29). Large accumulations of ash were found at St. Boniface, in close association with fish bone, and were interpreted as the remains of fuel used to render small saithe (Lowe 1998, 208). These fish had a much lower commercial value than the large gadids, and were often "regarded as a hunger-food, filling the gap when other sources failed" (Fenton

1978, 528). It is hoped that future work on the later medieval deposits at Tuquoy, or at Quoygrew, will illuminate this little understood time period.

Having explored the overall chronological themes present in the Northern Isles, it is now possible to examine variation within these patterns, and correlate exceptional sites with status and function. Spatial differences in site types will be investigated, including the fish middens discussed above, while conclusions will be drawn regarding the role of Earl's Bu, an important site during the events of the Fish Event Horizon.

9.2 Spatial patterning

Having assessed the overall chronological changes that occurred in the zooarchaeological record in the Viking Age and medieval periods, it is now possible to examine spatial variation within that overall patterning. A number of intra- and inter-site themes need to be considered. These include associations between zooarchaeological characteristics and site type, function and status (see Chapter One for a summary of specific site characteristics).

Conclusions regarding spatial patterning will be divided into two categories. Firstly, conclusions about site function will be presented, including differences between secular and 'religious' sites and between fish middens and other middens. Secondly, conclusions regarding site status will be discussed, incorporating the evidence from Earl's Bu and other high status sites, and comparing them to others, like Quoygrew, that had less evidence of high status. Special consideration will be given to the evidence from the Birsay Bay area, because several aspects of the zooarchaeology of the six relevant sites have proven different from all others in the Northern Isles, as discussed throughout Chapter Eight.

9.2.1 Variation in site function

Two aspects of site function can be investigated in detail. Firstly, the assemblages directly associated with religious structures can be compared to those from deposits associated with secular activity. Secondly, conclusions can be drawn regarding differences between the two main types of middens.

Two Christian chapel sites contained bone that was directly associated with religious structures, Newark Bay (Harland 2001b) and the Brough of Deerness (Morris and Emery 1986; Morris 1996b), both located in the Deerness peninsula in eastern Mainland. The faunal remains from both may have originated at nearby secular settlements, or may have been deposited by visitors to the sites. Animal bone was also found in association with graves at Newark Bay (Harland 2001b), though at low quantities and probably not as grave goods; these may have been present in the sediment prior to inhumation. Conclusions are difficult to draw from these sites because sample sizes were generally very small, and recovery was mostly by hand collection, thus limiting the potential observations that could be drawn from the fish assemblages. Some of the later material from the Brough of Deerness may have represented natural, non-anthropogenic accumulation as well (Rackham 1986, 348). Slightly inflated proportions of seals were found at Newark Bay, compared to other sites, which possibly indicated easy access to coastal resources, while unusually high proportions of caprines and some bird species in some phases at the Brough of Deerness were likely naturally occurring deaths. Otherwise, these small assemblages were comparable to most others.

At least one 'special' deposit of animal bone was identified during excavation of late Iron Age phases at Buckquoy (Brundle *et al.* 2003, 75), but this was not discussed in the zooarchaeological report or in any of the papers included in the Noddle Archive (Noddle 1976-77). Similar deposits are known from late Iron Age sites in the Western Isles, but they are otherwise unrecorded from the Northern Isles (e.g. Campbell 2000; see Chapter Two for further details). The single porpoise mandible found in association with the St. Ninian's Isle hoard in Shetland may have been buried at the very end of the late Iron Age, just prior to the Viking Age, and probably provides further evidence of the ritual importance of animals during this time.

Turning now to the conclusions that can be drawn regarding the different types of middens found in the Northern Isles, there was a considerable dataset available. As discussed in the previous section, fish middens contain high proportions of gadid fish, very little mammal and bird, and they date from the beginning of the medieval period from about or shortly after 1000. Other middens containing higher proportions of mammals and birds were still found during this time period, notably those at Earl's Bu, so an examination of the differences between these types is crucial to the understanding of the Fish Event Horizon and the economic changes of the medieval period.

Quoygrew is the most important site with regards to this spatial variation, because the upper phase of the farm mound – the inland multipurpose midden – is directly contemporary with the fish midden eroding from the shoreline, both dating from the mid 11th century to the late 13th century. Aside from slightly different proportions of mammal and bird (as summarised in Chapters Six and Seven), the two middens contained different species and sizes of fish (see Chapter Five). The fish midden contained approximately equal quantities of cod and saithe, with almost no other species recovered, but in the farm mound, about one third was saithe, slightly less than two thirds were cod, and trace quantities of a variety of species were found. The sizes of cod deposited in both middens were similar, with equal quantities of 500-600mm total length and c.1000mm total length cod deposited. However, the slight under representation of certain elements indicated some cod had been prepared and removed from the fish midden, leaving butchery waste behind. There was no evidence of this in the farm mound, indicating the fish midden represented specialised deposits of cod consumed locally as well as processing waste, while the cod from the farm mound were probably fished from the same areas of the sea and using the same methods, but were used solely for domestic consumption. Small saithe of 150-350mm were found in both middens, and using ethnographic accounts, it is possible to link these to certain ages of fish. The smallest and youngest saithe, which tended to be found in greater quantities in the farm mound, were probably fish in their first year of life, caught during the autumn or winter from the shore, while the slightly larger saithe found in both areas of the site were probably caught in slightly deeper water, though still close to the shore, in the later winter and spring months (Low 1813, 193-94). Low suggests that other species may have tasted better than these young saithe, but their sheer ubiquity and ease of capture through the winter made them "the treasure of the Orkneys" (1813, 167-230).

The spatial variation observed at Quoygrew, between the two different types of midden, can be used to answer one of the questions posed in the introductory chapter. The appearance of fish middens associated with the Fish Event Horizon could have been the result of differential refuse disposal practices in the late Viking Age and early medieval periods, wherein the inhabitants deposited fish bone in one area and mammal in another.

However, the intensification of fish bone deposition was visible within the farm mound at Quoygrew, indicating the hypotheses regarding the Fish Event Horizon were correct: the economic intensification in fishing was not solely evident in medieval fish middens, but was apparent in general purpose, domestic midden material as well. This also confirms the pattern observed in the human stable isotope analyses, as discussed above.

It is difficult to find parallels for the intra-site spatial variation at Quoygrew, because few other sites contained a similar arrangement of middens. At St. Boniface, the excavations were restricted to the wave-cut bank, and the relatively low densities of material recovered there led the excavators to speculate that the main midden deposits probably were not excavated (Lowe 1998, 109). Intra-site variation could not therefore be investigated at that site. Bigelow identified two midden types at Sandwick, but they have yet to be fully published and cannot be explored in detail. There, a fish-rich midden dating to the 13th century contained substantial quantities of small saithe, but other middens at the same site were contemporary with this fish midden and yet contained much higher proportions of mammal bone, as well as large cod and saithe. Additional middens pre- and post-dated the fish midden, but contained quantities of mammal bone and large gadids. Further work should illuminate the chronological relationships between the various middens at this site. At Robert's Haven, a fish midden of the 11th to 13th centuries contained considerable quantities of large cod, but later middens at the same site contained higher proportions of domestic mammals and small saithe. This could reflect intra-site spatial variation, in addition to the general chronological trends described above. Small saithe became more common at a number of sites toward the end of the medieval period, but the spatial variation at Robert's Haven and Sandwick could be related to intra-site function and status differences. By analogy with Quoygrew, where fish processing waste was only found in one area, these could be explained by a separation of waste into commercial and domestic areas, albeit likely with some overlap.

9.2.2 Variation in site status

Spatial variation within the Northern Isles can also be attributed to differences in site status. As emphasised throughout this thesis, Earl's Bu is a high status site, while the other primary assemblage, from Quoygrew, is more likely to represent a normal settlement. Differences between them were apparent in the fish assemblages, detailed in Chapters Four and Five, and in the proportions of fish, mammal and bird, examined in

Chapter Eight. Evidence from other sites can be incorporated into the conclusions as well, because as detailed in Chapter One, high status associations were also found at St. Boniface, Tuquoy, the Brough of Birsay and Skaill.

At Earl's Bu, although there was an increasing intensification in the deposition of fish bone over time, mammal bone was found in considerably higher proportions than fish in the earlier Viking Age to early medieval phase groups, and in the late Viking Age and medieval phase groups, mammal and fish were found in approximately equal quantities by count. This is in contrast to all other sites where such data were available: fish dominate the zooarchaeological assemblages of the medieval period, once recovery and methodological biases have been taken into account. The high status Viking Age and medieval site of Tuquoy, Westray, has the potential to illuminate this patterning further, because the mammal assemblage is not yet available. When compared with the existing fish bone dataset, it will be interesting to compare the results with the patterning found at both Earl's Bu and all other sites in the Northern Isles.

The composition of fish species at Earl's Bu was also unique in the Northern Isles. Similar to all other sites, the fish were primarily from the gadid family, but substantial proportions of haddock were found, representing up to a third of all fish in the later phase groups. Haddock were a trace species at many other sites, including Quoygrew, but they were found in moderate quantities at some medieval phase groups at Pool, Sandwick North, Tuquoy and Freswick. Saithe were a commonly occurring species at many sites, sometimes outnumbering all other species, and yet at Earl's Bu they decreased from under 10% in the earliest phase groups to less than 2% by the final medieval phase group. Furthermore, these saithe were primarily large fish, caught from deep water habitats. The small, young saithe that dominated middens throughout the Northern Isles were not found at Earl's Bu, and nor was this the product of recovery biases. Ethnographic evidence from the 18th and 19th centuries indicates small saithe were available in the Orphir region and were the major fishery during the winter months (Liddel 1791-99, 399; Anderson 1845, 30), implying they were likely present but not exploited in the Viking Age and medieval periods. The correlation observed at Earl's Bu between low proportions of saithe and high proportions of haddock can also be extended to two of the four other sites that contained haddock in excess of trace levels, Pool and Sandwick North. These high proportions of haddock cannot be attributed to taphonomic biases, indicating these are real patterns. At Tuquoy, the final medieval or later phase contained unusually high proportions of both haddock and saithe, and was unlike any other material from the Northern Isles, suggesting it post dates the medieval period. At Freswick, elevated proportions of haddock were recovered from the medieval inland area 9, in association with poorly understood industrial deposits (Morris *et al.* 1995, 105-109), but these lacked a correspondingly low level of saithe. If haddock are a high status and desirable fish in the Viking Age and medieval periods, as concluded from their presence at Earl's Bu, then their absence from most middens containing small saithe makes sense, given the ethnographic evidence that small saithe were a low value, easily caught subsistence level food.

Earl's Bu is the only site in the Northern Isles with direct evidence for large quantities of cod and haddock arriving already prepared. Several sites contain butchery waste indicative of processing of cod, including Quoygrew, but these products were always exported. Earl's Bu appears to have been receiving prepared haddock from the earliest midden phase, dating to the Viking Age and early medieval period, and by the later phase groups, dating from the late Viking Age and medieval periods, considerable quantities of haddock and cod were arriving ready prepared. Currently, evidence for fish butchery waste from processing has been found at Quoygrew, St. Boniface, Robert's Haven, and possibly Sandwick, all dating to the medieval period. These sites may have supplied Earl's Bu, but the exact origin of these processed fish cannot yet be determined, particularly as there are so few sites with haddock evidence, but future zooarchaeological work in the Northern Isles may reveal other processing sites. The evidence at Earl's Bu indicates substantial proportions of prepared fish were consumed there, but Earl's Bu may have also functioned as an intermediary site in the distribution of prepared gadids elsewhere in Europe. The prepared fish may have been used to pay rents or taxes, or traded for other goods, processes exploited or facilitated by the elite earls of Orkney at their estates.

The mammal bone assemblage from Earl's Bu has already been noted as being proportionally much larger, when compared to the fish, than at any comparative site. Multivariate analyses performed in Chapter Eight have illuminated the nature of the domestic species found throughout the Northern Isles. Most sites, including Quoygrew, contained approximately similar quantities of cattle and caprines, and much lower proportions of pigs. Little chronological patterning of species composition was noted overall, although age profiles of cattle did alter over time corresponding to increasingly intensive dairying. At Earl's Bu, all phase groups of Viking Age and medieval date were associated with the highest proportions of caprines in the Northern Isles, usually representing about half of all hand collected mammal bone in each phase group, and much higher proportions from the sieved subset. A few phase groups from other sites also displayed high proportions of caprines, including some in the Birsay Bay area as will be discussed below, but none consistently contained such high proportions. Initial assessment of element proportions do not indicate any over- or under-representation of body parts, but this assessment will be clarified by the final report to be produced by Ingrid Mainland. These observations may indicate that Earl's Bu functioned as a specialised centre for a caprine-based economy, focussing on wool and meat production with little cattle-based dairying. Of course, dairy produce may have arrived at Earl's Bu from other sites, but little evidence of this can be found in the archaeological record. This is in direct contrast with evidence from other areas of the North Atlantic settled by Norse. In Greenland, high status sites had higher proportions of cattle, but sites with large quantities of caprines tended to be smaller and more marginal (McGovern 1985, 97-102). These two areas are not directly comparable, given the different environmental conditions and the presence of pre-existing economic systems based on domestic livestock in the Northern Isles. Definitive conclusions regarding the mammal assemblage at Earl's Bu will have to wait for the final report, but these interim results indicate this high status settlement can be defined by high proportions of caprines, as well as high quantities of cod and haddock, and low proportions of small saithe.

The bird bone assemblage from Earl's Bu is also different from most others in the Northern Isles, but the full dataset has yet to be published. However, interim reports suggest a high prevalence of rock or stock doves and pigeons found throughout all phase groups, representing just under half of all bird bone. A few other sites have single phases with similarly high levels, but none has consistently high proportions. This may represent opportunistic use of local resources, or could indicate doves and pigeons were kept at the site. An antiquarian account of the Orphir area describes wild pigeons living in caves located only a mile from the church at Earl's Bu (Anderson 1845, 14; confirmed by comparisons with modern maps). This is the most likely source of the Earl's Bu birds, thus representing a use of local resources. In conclusion, bird assemblages appear to be less correlated to status than the fish or mammal assemblages.

The evidence from the high status site of Tuquoy is difficult to interpret, partly because mammal data are not yet available. Some phases may be associated with structures of a lower status, because the high status hall was later reused and subdivided (Owen 2005, 200), but the site chronology is not yet fully linked to the zooarchaeological material. The existing fish and bird assemblages conform to the general patterns observed throughout the Northern Isles, but once the full chronology and mammal bone assemblages are available, this site will probably provide important additions to the conclusions regarding status variation. Skaill, Deerness, is another site with high status connotations, but the zooarchaeological assemblages were not sieved and lacked the spatial or chronological resolution needed to draw any conclusions.

The six sites in the Birsay Bay area are closely located in time and space, and thus provide an excellent opportunity to assess possible status related patterning. Historical sources indicate the Birsay area was an important political and religious centre from at least the mid 11th century, and excavations on the Brough of Birsay have revealed a wealth of archaeological material. The problems surrounding inter-analyst variability, differential preservation, and variation in recovery methods have been discussed at length in Chapter Eight, thus reducing the biases present in the assemblages and allowing them to be directly compared. Several trends were noted when comparing the Birsay material with that from other areas of the Northern Isles. The overall proportions of fish, mammals and birds matched those found at other areas, and displayed similar chronological patterning indicating an increase in the deposition of fish bone over time. Fish species also followed the general chronological trends. However, the mammal assemblages within the Birsay Area formed a markedly different pattern than those from the rest of the Northern Isles. Firstly, very few or no neonatal cattle were found. Secondly, there was evidence for the movement of meat around the Birsay Area, but all other sites indicated an absence of any meat import or export. Thirdly, the proportions of the three domestic mammals were unusual.

As already discussed, the large quantities of neonatal cattle found throughout the Northern Isles have been interpreted as evidence for a dairy-based economy. However, almost no neonatal cattle were found at any of the sites in Birsay Bay, despite factoring in preservation and recovery biases. This pattern probably has origins in the late Iron Age, given that deposits from early phases at Saevar Howe and Buckquoy have almost no neonatal cattle. Only one other phase group in the Northern Isles has similarly low levels, Freswick SCA, but this was more likely to be a taphonomic pattern. The reasons for this are difficult to interpret. Interim reports from Earl's Bu suggest a variety of ages were found there, including neonatal, thus making this correlation unlikely to reflect status. The excavated sites in Birsay Bay may have operated an alternative economic system, or the sites that have been found might have specialised in the production of meat and wool. Dairy produce itself is difficult to trace archaeologically, but if large quantities of dairy produce were paid as rents and taxes to the elite, then a high status area like Birsay Bay may have found it unnecessary to produce its own milk products. It is difficult to reconcile this observation with evidence from Earl's Bu, particularly given the absence of evidence for the import of preserved fish to the Birsay area, but it is possible that each of these high status areas specialised in different economic activities. However, this shall remain speculation until further work is carried out in the Birsay area and the Earl's Bu mammal bone report is finalised.

Mammal element distributions indicated some transport of meat likely occurred around the Birsay Bay area. Cattle butchered at Buckquoy in the Viking Age may have been taken as cuts of meat to the Brough. Saevar Howe may have provided meat as well, but this was difficult to investigate in detail. The element proportions of both cattle and caprines on the Brough indicate meat was likely imported throughout the occupation there. Two explanations for this are possible. One, the Brough was too small to contain adequate herds of livestock, which is possible, and two, the elite settlement on the Brough relied on provisions being imported from elsewhere. Future work on the Brough, with fully sieved deposits and explicit zooarchaeological methodologies, may allow these conclusions to be investigated in greater detail.

Two major phases of midden at Beachview contain very high proportions of caprines, similar only to those from Earl's Bu. These date from the late Viking Age and medieval periods, and are matched by additional minor phases, but others follow a more traditional pattern. These phases may be correlated to periods of intensive caprine-based activities, including wool production, and by analogy with Earl's Bu, may represent periods of wealth or status. Caprines were the dominant species at Saevar Howe from the late Iron Age until the end of the Viking Age, and they were also more common than usual on the Brough of Birsay itself, thus corroborating its high status associations.

To summarise, correlations between site status and zooarchaeological assemblage have permitted conclusions to be drawn regarding the spatial variation present in the Northern Isles. The high status settlement at Earl's Bu received substantial quantities of prepared gadid fish, and may have functioned as a link in the trade network that ultimately exported dried fish to elsewhere in Britain and Europe. The high quantities of caprines found at Earl's Bu may be indicative of a wool and meat based economic system, with less of an emphasis on the production of cattle dairy produce. Age profiles from the Birsay Bay area indicated an almost complete absence of evidence for dairying economies, suggesting these high status sites may have received dairy produce made elsewhere and paid as rent or tax, thus not requiring its production at these elite sites, or in the case of Earl's Bu, requiring much less intensive dairy production. The lack of evidence for the fish trade in Birsay Bay may indicate Earl's Bu specialised in the collection of prepared fish, but future work in the former area may alter these conclusions.

9.3 Further work

A variety of suggestions for further work have been mentioned in the above sections. Publications of the existing zooarchaeological datasets will greatly aid in the spatial and chronological conclusions that can be drawn. Further work will be undertaken at Quoygrew, and will add to the existing interesting comparisons that have been possible between the contemporary farm mound and fish midden.

Finally, bioarchaeological methods have great potential to illuminate some of the patterns discussed throughout this thesis. Ongoing isotopic analysis of both human and domestic mammal bone will allow conclusions to be drawn regarding dietary consumption of marine and terrestrial foodstuffs, and analysis of fish isotopes should have the potential to track processed gadids to consumption sites in Europe (Barrett 2006b).

9.4 Methodological reflections

At this stage in the thesis, it is possible to reflect on the choice of methods used for the collection and analysis of data, as well as on the wider methodological issues discussed in Chapter Two and used throughout. The emphasis on a spatial approach, in addition to temporal analysis, has proved successful as demonstrated by this chapter. Also, as cited in the introduction, many zooarchaeologists working in the Northern Isles wished they had been able to apply such an approach to their datasets, for good reason. The synthetic use of published and archival sources was an important aspect of the methodology from the beginning, and it is hoped this thesis has demonstrated the potential for re-evaluating past zooarchaeological work. It was initially hoped to make better use of context-level variation in the comparative dataset. However, at several sites this proved impractical because either it reduced the dataset to many individual units, each too small for analysis, or because these data were not available. However, at sites like Tuquoy, where context types were known but little other contextual data were available, the ability to restrict the dataset to solely midden material reduced the variation present and thus enabled a better understanding of the intra-site zooarchaeological patterning. Almost every site with a published or archival zooarchaeological report has contributed to the conclusions drawn in this thesis. There were problems of inter-analyst variation and recovery biases, but it must be stressed that these can be overcome with a careful reading of the original sources. This takes time, but as demonstrated, the results were worth the investment.

The methodology used for the primary recording and analysis of bone throughout this thesis has three facets, each of which has met with various degrees of success. The primary bone recording methodology was based on several extant methods, and has a long and proven track-record in zooarchaeological analysis. However, the addition of Outram's methods for assessing marrow and grease extraction proved extremely useful, and importantly, did not significantly increase the recording time. Any future bone work by the author shall automatically include Outram's methods, and they can be highly recommended to anyone working in the Northern Isles and elsewhere.

The two other facets of these primary methods in need of assessment are inferential and multivariate statistics. Inferential tests were applied to many of the quantifiable aspects of zooarchaeological data, and were easily calculated and interpreted using basic statistical software (see Appendix Two). They permitted any apparent patterning, observed by eye, to be tested for significance. These are relatively simple and are widely applicable to many aspects of archaeology, and are not restricted to zooarchaeological data. As such, based on the author's experience, they can be widely recommended for use. Although the same could be said of multivariate methods, their use and interpretation is not as straightforward as the author had hoped. Initially it was thought that multivariate methods could be used to explore all aspects of the primary and comparative datasets, but this ultimately proved unrealistic.

Correspondence analysis (CA) remains a useful technique for exploring complex datasets, but its use in zooarchaeology is limited by a few factors. The first of these is the data structure: counts of data, like NISP values, can be used for CA, but its use for element counts produced results that were without meaning. Secondly, inter-analyst variability produced most of the initial patterning observed using CA and thus had to be removed; this included variation in the use of categories like "large mammal", "medium mammal" or "gadid". Thirdly, CA proved less useful for inter-class analysis than for class-specific analysis. As has been shown throughout Chapter Eight, CA was crucial in identifying patterning within the fish dataset, or within the mammal dataset, but it was of much less value when these datasets were combined. This is largely a factor of differential recovery of each class, combined with inter-analyst variability. Finally, CA was useful for exploring intra-site patterning at Earl's Bu, where there were several major phases, but it was of little use at Quoygrew because there were only a few phases. Thus, much of the variation could be observed by eye and could be tested using simpler, inferential methods. CA is an important analytical technique in zooarchaeology, but it is best restricted to NISP data from a single class, and inter-analyst and recovery biases must be taken into account prior to interpretation.

In summary, the methods used in this thesis are widely applicable to zooarchaeological data. The reassessment of existing zooarchaeological records proved useful, despite variations in recording strategies between analysts. Simple inferential statistics were widely applied to determine whether observed patterning was actually significant, a technique that could easily be more widely applied in zooarchaeology. Multivariate methods, particularly correspondence analysis, proved useful, but only for class-level NISP count data.

9.5 Final conclusions

This study has demonstrated the value of a combined spatial and temporal approach to the zooarchaeological record of a region over a given time period. Several zooarchaeological reports from excavations in the Northern Isles over the last few decades discussed the importance of a spatial approach, when applied in conjunction with a chronological approach, but despite this realisation, very few zooarchaeologists had applied such a methodology to their datasets. However, where possible, this study has used zooarchaeological data from these comparative sites as well as two primary sites, separated into both spatial and chronological facets. This approach has successfully illuminated aspects of site status and function throughout the Northern Isles.

Economic intensification occurred throughout the Viking Age and medieval periods, and was particularly apparent in the early medieval period when dairying intensified and dried, cod family fish started to be exploited in considerable quantities throughout the Northern Isles. Prepared fish was likely produced at a number of sites, and traded or paid to Earl's Bu, the high status Viking Age and medieval site on Mainland. Another high status area in Mainland, Birsay Bay, contains an unusual absence of zooarchaeological evidence for dairy production, suggesting this area may have received dairy produce from other areas of the Northern Isles.

These conclusions are directly relevant to wider economic issues in medieval archaeology and history. Economic intensification is an important facet of the Viking Age to medieval transition in Northern Europe (Hodges 1989; Barrett *et al.* 2000a; Dyer 2002; Barrett *et al.* 2004a). The trade in prepared cod family fish is an important aspect of this economic transition and intensification, because it can be traced archaeologically and is linked to the rise in urbanism that signalled the commercial revolution at the end of the first millennium AD (cf. Enghoff 2000; Hufthammer 2003; Ervynck *et al.* 2004). Although this thesis focussed on one small island archipelago, the identification of patterning in the Northern Isles corroborates the large pan-European economic phenomenon.

Appendix One: Comparative material

1.1 Introduction

This appendix presents the comparative faunal assemblages from the Viking Age and medieval periods in the Northern Isles, building upon the brief introduction provided in Chapter One (see Figures 1.1, 1.2 and 1.3 in Chapter One for location maps). This appendix also assesses the ways in which spatial analysis has been applied to each assemblage. In most cases spatial analysis has been applied implicitly and incidentally when a chronologically based assessment of change has been considered. Some faunal analysts have used spatial data explicitly; for those few assemblages, the ways in which a spatially derived analysis has been applied will be critiqued. Each excavation is presented in chronological order, by date of excavation rather than publication. This will permit the use of spatial data in the Northern Isles to be compared to the general trends in spatial analysis used throughout all of archaeology and zooarchaeology (as discussed in Chapter Two). Actual descriptions of the archaeology will be kept to a minimum unless relevant to the discussion of faunal data. Further information is provided in the site reports or in Graham-Campbell and Batey (1998).

This appendix also emphasises the potential of each assemblage for additional spatial analysis. This will include a discussion of the various factors that contributed to the formation of each zooarchaeological assemblage, including context type variation, recovery methods, and importantly, site status and function. Many of the sites listed below will be useful for a wider study of spatial trends within the Northern Isles and Caithness, but as will be described, very few zooarchaeological reports included any inter-site spatial analysis when published. Only with a detailed understanding of the ways in which spatial analysis has been studied at the intra-site level, will it be possible to examine the inter-site spatial analysis of the Northern Isles and Caithness during the Viking Age and medieval periods. The final location of each assemblage is included here (Appendix Table 1.1), and although not all assemblages have survived, this provides a starting point for any zooarchaeologists wishing to reanalyse any of the material covered in this thesis.

Site	Current bone location
Jarlshof	Only select bones were analysed. Some or all of these are in the National Museum of Scotland, and have been looked at by Bigelow.
Skaill	Probably destroyed
Newark Bay	Some analysed by Noddle and probably destroyed. Some analysed by Harland last seen with DR Brothwell, but current location is unknown. Some at the Natural History Museum.
Buckquoy	Probably destroyed
Brough of Birsay Room 5	National Museum of Scotland
Brough of Deerness	Probably in the Orkney Museum, but may have been misplaced
Brough of Birsay Rescue Excavations	National Museum of Scotland
Birsay Bay Brough Road	Orkney Museum
Birsay Bay Burnside and Studio	Orkney Museum
Saevar Howe	National Museum of Scotland
Sandwick	Possibly still with Bigelow?
Freswick Links	National Museum of Scotland
Tuquoy	With Olwyn Owen at Historic Scotland
Pool	Most at the Orkney Museum, but some still at Bradford
Scalloway	Difficult to trace, but possibly with the Shetland Musuem or the National Museum of Scotland
St. Boniface	Orkney Museum
Robert's Haven	At York with JH Barrett
Sandwick North	Has been sent to Historic Scotland and may now be at the National Museum of Scotland or at the Shetland Museum
Earl's Bu	Fish bone with C Batey, mammal and bird with I Mainland, and will go to the Orkney Museum when complete
Quoygrew	At York with the author, and will go to the Orkney museum when complete

Appendix Table 1.1: Locations of bone assemblages, as of August 2006

1.2 Jarlshof, Shetland

Viking Age and medieval areas were excavated at Jarlshof, a substantial multi period site at the southern tip of Shetland that became the 'type-site' of early Viking Age settlement archaeology (Graham-Campbell and Batey 1998, 155). It was the first site to be excavated with modern – or at least non-antiquarian – methods, but these investigations took place before the great potential of environmental finds had been recognised. Not only was sampling not carried out, but hand collection of bone was extremely limited. One of the aims of the 1949 season was to investigate the Viking Age middens to establish a chronology for the settlement (Hamilton 1956, 97). However, it is likely the emphasis was on the finds from the middens, and not the environmental components. Three types of midden deposit were identified in subsequent excavation seasons, each with different compositions and structural associations. The first type was located near the Viking Age houses, within the enclosure area but separated from the houses by the paved or cobbled yard. Contents of this midden type included general occupational debris, peat ash and burnt stones, and animal bone (Hamilton 1956, 97-98). Similar material was also associated with the pre-Viking byre and small structure (Hamilton 1956, 98), though this degree of similarity may be questionable by the standards now applied to faunal material. The second type was the 'house midden', smaller than the general occupation debris middens at about 4.5 to 7.5m across. These contained peat ash, burnt stones and animal bone again, but lacked the general occupation debris of the larger middens. Two of these were found, each associated with an early Viking Age house, and located outside the walls of the enclosed yard or up against the gable ends of houses or their outbuildings (Hamilton 1956, 97-98). Later in the sequence of settlement, a 'communal midden' developed, probably used by a few houses together over several generations. This formed an area over $460m^2$. This was later restricted by the construction of a 10th century farmstead, causing the midden material to build up beside the path to the primary settlement (Hamilton 1956, 98).

The published zooarchaeological report was prepared by Miss Platt, but was written up based on her notes following her death. No quantitative results were presented, but a qualitative assessment included comments relating to species and age, making this report of little use despite the interesting spatial arrangement of middens presented in the report. Bigelow re-examined the Jarlshof faunal material held in the site archive and discovered it consisted of mainly complete bones, and was therefore obviously unrepresentative of the archaeological assemblage (Bigelow 1984, 34). Jarlshof can only be considered qualitatively, and despite its potential, it will not figure strongly in any discussions, a conclusion shared by Bigelow (1984, 113).

1.3 Skaill, Deerness

These considerable excavations on the east coast of the Deerness peninsula included a series of several overlying domestic structures dating from the late Iron Age to Viking Age interface to the medieval period. These provided much of the animal bone from this site, with other areas of possible Viking Age or medieval date contributing smaller assemblages. The areas, structure and middens that contained bone are summarised in Appendix Table 4.2, along with any problems associated with each part of the zooarchaeological record

A small amount of Norse walling was found at site 1, probably forming internal partitions to a medieval building of domestic function. The high quality of building materials and methods used led the excavator to suggest this structure may be the one mentioned in the Orkneyinga Saga as home to a nobleman (Edwards 1997, 80). A small quantity of midden probably – but not definitely – associated with this structure has survived, providing possible evidence of high status consumption.

Skaill has a spatial arrangement of structures that reflect domestic occupations in both the Pictish-Norse interface and Viking Age or Norse periods, as well as a Norse period high status domestic structure and a non-domestic building of questionable function. Despite the lack of dating, the spatial contrasts between the middens associated with these structures have the potential to illuminate status and functional differences. No sampling strategies were used, and nor was sieving applied, but despite these problems the hand collected mammal bone could be used to investigate this variation in status and function.

Site, structure and phase	Associated bone assemblage	Dates	Problems
Site 1, internal partitions to a building of domestic function, possibly high status	Midden near structure	One medieval artefact in structure, midden assumed to be contemporary but without dating evidence	Tenuous connection between high status structure and midden
		Edwards 1997, 80, 81	
Site 2, House 1, phase 1	Midden 3, located beside paved path just outside main entrance to house	Finds of native late Iron Age and Norse type ("cultural ambivalence"), architecture uncertain: therefore probably interface period of 8-9th c.	Midden 3 could be associated with the second phase of House 1, or Hous 2
	Edwards 1997, 72	Edwards 1997, 76, 77	Edwards 1997, 72
Site 2, House 3, phase 1	Midden 2, located beside a paved path near the main entrance	Architecture of Norse "conventional hall-house"; midden find of Norse style	Confused stratigraphy resulted in a questionable connection between House 3 and midden 2
	Edwards 1997, 74	Edwards 1997, 74	Edwards 1997, 74
Site 2, House 3, phase 2 (following internal rearrangements and alterations to House 3)	Midden 1, located to north of midden 2 and the house entrance	Finds of "quantity and quality" to be associated with House 3 and not later structures; midden finds of definite Norse style of 9-11th c	Originally associated with later structures 4 and 5 by Gelling
		Edwards 1997, 75	Edwards 1997, 75
Site 4, the 'bath house'	?Midden	Construction and artefacts are Norse style but only dating evidence is a *terminus ante quem* of 16th c.	Original bath house function determined by Gelling now questioned; could be a grain drying structure or a cook-house
		Edwards 1997, 78, 79	Edwards 1997, 80

Appendix Table 1.2: Skaill, zooarchaeological structural and chronological associations, and problems

The excavation and subsequent publication of this site spanned several decades and several problems, not least of all the death of Peter Gelling, the main excavator. The bone reports have been similarly troubled, with different specialists using their own versions of phasing. Barbara Noddle's bone report (1997) grouped all Viking Age and medieval deposits from sites 2, 3 and 4 together and classed 'Post-Viking' deposits from site 1 and 4 together (1997, 235), regardless of spatial origin from the range of structures described above. The high status medieval midden from site 1 could have been classed in either category. An unknown portion of the mammal assemblage from three middens was analysed by "Prof W. Potts", and probably integrated into Noddle's report, although consultation of the Noddle archive reveals that Potts' report probably did not represent the entire assemblage from those middens. Potts supposedly studied all mammal and fish bone from site 2, midden 1; site 2, 'lowest level' midden; and site 3. Assuming that when Potts refers to these he was referring to Buteaux's midden 1, midden 3 and the unnumbered midden associated with the high status structure on site 1, then his report provides a spatial separation for some of the midden deposits recovered from the Norse period, including an important separation of the higher-status deposits from more typical Norse domestic midden. However, the quantities discussed in Potts' report, at a total of 690 identified fragments, are substantially smaller than Noddle's Viking total of 6024 identified fragments (Noddle 1997, 237). Even when considering that Noddle's report would have included additional material from site 4, possibly site 1, and site 2 midden 2 (the main 'Norse' midden), the difference in quantities is substantial. An early draft of Noddle's report, found in the archive, indicates the largest assemblages originated in site 2, midden 1, and site 4, indicating Potts must have only analysed part of these assemblages; possibly Potts' report was not even integrated with Noddle's report. The advantage of Potts' report is that he maintained the spatial separation between each midden, including quantified element distributions.

Nicholson's fish report does not included any phasing, but all fish "appear to have originated in Norse-period middens on site 2" (1997, 245). Other excavation units may have included fish but they may have been subsequently lost (Nicholson 1997, 245). Noddle and Nicholson's data can be used to represent the Viking and medieval deposits as a whole, and Potts' report can therefore be used to investigate some of the intra-site variation present at Skaill, with the caveat that Potts probably only investigated a portion of the assemblage from sites 2 and 3 that may or may not be replicated in Noddle's report. The 'Viking' bird assemblage referred to "all levels on site 2 together, possibly, with the Norse levels on site 4" (Allison 1997, 247), making it difficult to compare with the mammal material.

In conclusion, the Skaill animal bone assemblages could have had great potential to investigate spatial, functional, status and chronological differences within a Viking-Norse settlement. Realistically, only a small part of this variation can be studied, but the discovery of the Potts report does allow extra variation between midden types to be investigated. Skaill can be compared to other hand collected assemblages, but the conclusions drawn from this site will always remain limited due to the many problems surrounding it.

1.4 Newark Bay, Deerness

Newark Bay, in Deerness, East Mainland, is a multi-period site consisting of two souterrains, a chapel and burial ground and a later 16th or 17th century laird's house. The site was investigated by Don Brothwell during a general programme of rescue excavations in the area (Brothwell 1977, 182). Approximately 250 individual human skeletons were excavated to prevent further erosion and loss. Excavations beneath the 10th century chapel revealed two so-called 'mycoform structures', or souterrains (Brothwell 1977). Further comments regarding the human remains from the site have been published (Brothwell *et al.* 1986; Barrett *et al.* 2000b; Molleson 2005; Richards *et al.* 2006) and the excavation report is in preparation.

The majority of the bird bone assemblage was analysed and published, quantified by species as 'Norse' or Post-Norse (Brothwell *et al.* 1981), but the mammal and fish assemblages have been problematic. Some or all faunal material from the first season of excavation at Newark Bay was sent for analysis to Barbara Noddle (DR Brothwell, pers. comm.). Some of this information is contained in her little-known 1979 publication, although as this contained several errors, the conclusions must be questioned. Miss Noddle was sent the complete assemblage including wild mammals, fish and possibly birds, but she makes no mention of them and it is likely they were never returned to the collection. An unpublished and incomplete report was found in the Noddle archives relating to the material she analysed, but, being only in draft format, this again contained calculation errors. It has been possible to reconstruct some of her results, but the spatial resolution is poor: species and elements are presented by phase only, including 'Norse', 'Post-Norse', 16-18th century, and post 18th century (Harland 2001b, 63). These data correlate with the summary provided in Noddle's 1979 publication (Table 2), but in that publication the Post-Norse and 16th-18th century phases were combined to form one 17th century phase.

The remainder of the Newark Bay assemblage was then analysed by the present author for her undergraduate thesis; what remained of the assemblage at that point was 809 fragments, a smaller assemblage than Noddle's approximately 2000 bones. However, contextual and spatial information were available: contexts included souterrain fills that could date from the late Iron Age, bone associated with a child burial, medieval and early 'Post-Norse' faunal material associated with burials, medieval and later chapel wall base material, medieval floor deposits, fill below a 17th century drain, and post-1500 deposits from the 'North side' of the chapel (unknown if exterior or interior). A further deposit labelled 'The Norse Horses' was of unknown date and origin (Harland 2001b, Fig. 1). No sampling or sieving was undertaken, though the presence of small sesamoids, carpals, tarsals and phalanges indicates some diligence in hand recovery (Harland 2001b, 12)

The largest contexts, those with over 300 fragments each, were the medieval and early 'Post-Norse' burial level, and the medieval floor deposits (Harland 2001b, Fig. 14). The former might represent midden material, into which graves were placed. Graves from other Orcadian sites of the period were known to be cut into midden, as seen at the area 1 of the Brough Road excavations (Morris 1989, 109-113). Speculation as to the nature of this context must await publication. The medieval floor deposits are assumed to be domestic in nature, and are not from the chapel. Noddle's draft report indicated the largest phases (those with over 300 fragments) were 'Norse' and 16-18th century (Harland 2001b, 64). These might be comparable with the contexts analysed by the author, but their contextual associations are unknown.

Some implicit consideration of contextual variation was included in the author's report. The 'Norse' deposits associated with the burials were more likely to represent all elements from the domestic species than were the later domestic medieval deposits, which only included elements of low meat value (Harland 2001b, 39, 42). The high proportion of non-domestic species in the Norse deposits suggested that Newark Bay was different from most domestic Norse assemblages. At the time the author speculated that "[p]ossibly the site was used sporadically by small numbers of people, who could land easily at the beach, and fish or hunt seals and birds easily from the site, but who also butchered and consumed domestic mammals" (Harland 2001b, 41); this contrasted with contemporary sites that were of definite secular function. The medieval deposits associated with the laird's house comprised a species and element range more consistent with published data.

The chapel may have been associated with a domestic or monastic settlement now lost, or the bone material could have resulted from the activities of pilgrims to the chapel. The association between small private chapels and settlements is known from 'Bu' sites, estates owned by the Earldom that included farmsteads and chapels like that at Earl's Bu, Orphir (Graham-Campbell and Batey 1998, 191-92). Chapels like the ones at Newark Bay and the Brough of Deerness have been found throughout the Northern Isles, most being for small, private use (Morris 1996b, 197). The evidence for Newark Bay is tenuous, but the associations between settlement and chapel explain some aspects of this unusual bone assemblage.

Integrating Noddle's draft report, her published summary data and the author's own raw data, while considering that some additional bone material may have been lost during the intervening decades (DR Brothwell, pers. comm.), was not easy. Noddle's summary data appears to be based on her draft report, although the many errors present mean a low confidence level must be applied to her work. Noddle's draft data can be used for comparison, with the caveat that her Norse deposits *may be* associated with the chapel and therefore *may be* non-secular, while her 16-18th century phase is *probably* associated with the domestic laird's house. Noddle's 'Post-Norse' phase (identified NISP of 176) is of completely unknown origin and is best ignored. The material identified by the author has a more secure contextual basis, and can be used with more confidence, although only to compare with other hand collected assemblages. The value of this site is its Norse deposits and their association with the chapel and comparability to other sites with religious associations, such as the Brough of Deerness chapel material.

1.5 Buckquoy, Mainland

Buckquoy was the first of many sites in the Birsay Bay area to be investigated using modern excavation techniques and its importance lies in its evidence for the late Iron Age to Viking Age transition. Three phases of Norse-style architecture included a byre, a threshing barn and a domestic house (Ritchie 1976-77, 189), associated with finds of native Pictish style (Ritchie 1976-77, 192). What was once thought to be a clear differentiation in building structure from 7th and early 8th century cellular (Pictish) to early 9th to late 10th century rectilinear (Norse) (Ritchie 1993, 26) has been recently questioned in light of evidence that Pictish structures could take either form, but following a recent re-evaluation, consensus is that "[d]espite the lack of diagnostic Scandinavian artefacts, the houses of the later three phases at Buckquoy still seem to fit best into a Norse context" (Brundle *et al.* 2003, 96).

The first Norse structure, in phase III, was a "combined byre and barn" that was later used as a dumping ground for midden from phase IV, the possible threshing barn (Ritchie 1976-77, 185-86). The other phases must have included some midden material as almost all of the bones were recovered from "waste middens" according to the bone report (Noddle 1976-77, 201), yet barring the phase IV midden "there were no distinct midden horizons, and food debris ... appeared to have been scattered at random over the site" (Ritchie 1976-77, 191). The presence of at least one ritualistic deposit from pre-Viking Age levels has now been discussed in print (Brundle *et al.* 2003, 95), leading to some question over the type of deposits originally quantified.

The bone report from Buckquoy (Noddle 1976-77) contains several inconsistencies between data tables, and following investigation of archive material by the author, some data were reassigned to other phases or were re-quantified. Noddle attributed differences between phases as the result of chronological subsistence changes, with some level of variation due to behavioural practices (including midden removal) and taphonomic differences, including the rate of accumulation of midden affecting its preservation (Noddle 1976-77, 201). Noddle states that "it is not possible to distinguish between changes in midden context due to 'input', and those due to subsequent events" (1976-77, 203), thus recognising that changes in human activity patterns, together with taphonomic alterations, may make it difficult for us to critically assess the many factors that contributed to a midden's formation and its internal variation. The spatial variation found between the byre/barn, the threshing barn, and the later domestic structure may provide an additional factor in the variation at Buckquoy.

Using the statistic of number of bone fragments per single MNI, some difference was noted over time (that is, between the early byre/barn, middle period threshing barn, and later dwelling house) between cattle and the smaller domestic species that was possibly attributed to changes in butchery practices or cooking practices (Noddle 1976-77, 202-03). Element representations are provided by phase, which will allow this hypothesis to be investigated further, but the suggestion that fragment size may change through time cannot be tested because no fragment sizes were provided. This change could be influenced by proximity to the dwelling house and cooking areas.

The Buckquoy assemblage, after reassessment using archive material, provides a relatively comprehensive late Iron Age to Viking Age hand collected mammal and bird assemblage, with data relating to species, element and age. The fish assemblage was only presented as MNI by phase, which makes any consideration of potential changes impossibly to determine. The lack of contextual data is problematic: although probably entirely midden, a later publication has indicated the presence of ritual animal bone deposits from the earlier, pre-Viking Age levels. Given the general lack of ritual deposits from the Viking Age and medieval periods, we could consider that the entire assemblage from this period derives from domestic middens. Limited intra-site analysis is possible between the Norse phases as each is associated with a different functional unit of a Norse farmstead (byre/barn, threshing barn and dwelling house), and inter-site comparison with other hand collected mammal and bird assemblages is possible.

1.6 Brough of Birsay, Room 5, Mainland

This small scale excavation took place within one of the many structures on the Brough of Birsay, the tidal island on the western edge of Mainland Orkney that was "a site of exceptional importance, however atypical", and a focus of settlement throughout the Viking Age and medieval periods (Graham-Campbell and Batey 1998, 58). The excavations here aimed to establish a secure stratigraphic sequence and chronology for finds from earlier work at the site (Curle 1982), and Room 5 was chosen as it was known from early excavations to represent the 'full' occupation chronology of the Brough, with little antiquarian disturbance (Hunter and Morris 1982, 124). The room was assumed to be part of a domestic settlement, though within the context of the settlement of some status on the Brough.

Four major phases were identified within this structure, each representing periods of deposit accumulation followed by levelling (Hunter and Morris 1982, 124). It was later realised that the walls of the room were probably later than their contents, creating an unrealistic association between structural and stratigraphic evidence (Graham-Campbell and Batey 1998, 164). Faunal material was not mentioned in conjunction with the first phase, Ia, but by phase Ib, "considerable quantities" of organic material were used to create a level ground surface, some burnt. Phase 2a included a thin layer of occupation debris over a floor surface and associated with hearths. In phase 2b, a "considerable quantity" of organic material was again used for levelling, some burnt; an uncalibrated date of 1305±55 bp was provided (calibrates to AD 660-780 (1 SD) or 640-880 (2 SD) (Bronk Ramsey 2001; Bronk Ramsey 2003)). Phase 3a represented another thin occupation layer over a floor surface and associated with a hearth of a new structure built in line with the old one. An uncalibrated date of 905±60 bp calibrates to AD 980-1160 (1 SD) or 890-1190 (2 SD) (Bronk Ramsey 2001; Bronk Ramsey 2003). Phase 3b was a potential abandonment phase that included a drain (later disturbed by animals and discussed separately) and general fill of rubbish over the area. Phase 4a again contained organic material in thick layers used to level the floor, again some burnt. Phase 4b is unclear as to the presence of organic material (Hunter and Morris 1982, 126-27).

Sellar states that all animal bones "have been assumed to be kitchen refuse" (Sellar 1982, 132), with the exception of smaller rodents. Some material probably represented primary deposits, and others secondary, as implied by the distinction between occupation layers and midden floor fill. Some material may be residual but was thought to be usable for analysis, including faunal remains (Hunter and Morris 1982, 124-25). Because smaller bones from large animals were present – including the metapodials and phalanges – Sellar believed butchery occurred nearby (Sellar 1982, 132). Phase 3b had no older cattle remains compared to other phases, leading Sellar to suggest the inhabitants were not farmers, or were transient (Sellar 1982, 132). The potential inter-site trade in prepared meat from supplier sites in the Birsay Bay area to the Brough was not considered by Sellar, but was discussed later by Ritchie in the context of Buckquoy functioning as a 'home farm' for the Brough (1985, 198) and by Hunter (1986, 68), working on later excavations on the Brough.

Rabbit was found throughout the assemblage, Sellar believing they were evidence of trapping when other food was not available. No mention is made of the potential for rabbit intrusion and mixing of deposits, though this would be the usual conclusion regarding rabbit bones found in layers before the early modern period (the first record of rabbits on Orkney dates to the 17th century (Berry 1985, 139; Booth and Booth 1994, 8)).

Spatial analysis was not discussed overtly. One feature, a drain containing disturbed midden fill, was treated as a separate entity and separately quantified. Each of the four phases consisted of two parts, (a) and (b), thus separating midden fill used for ground levelling from that derived from floor deposits assumed to be *in situ*. This implies a separation of midden redeposited in a secondary location (Phases 1b, 2b, 4a) from that deposited in a primary position on occupation floors (Phases 2a, 3a) or rubbish dumped during an abandonment phase (3b). Phases 1a and 4b also contained faunal material but the nature of those deposits was not described, making complete separation by context type impossible.

No recovery method was stated in the text, implying hand collection, and only cattle and caprines have some degree of element quantification. The NISP by species data can be used for inter-site comparisons, but with caution given that some species, including horse and deer, were not quantified. The NISP by element for cattle and caprines may be used for comparison with other hand-collected sites, but the lack of separation of upper and lower limb bones, or fore and hind limbs, may limit the comparative potential.

Chronologically, this assemblage spans the late Iron Age and early Viking Age period (Phase 1 and 2), to at least the early medieval period (Phases 3, 4 and the drain fill). Chronological change could potentially be examined, but all phases of unmixed feature types are from the later period. Intra-site differences within the early medieval period can be illuminated through comparing the drain fill, the rubbish dump deposits, and the primary occupation layers of phase 3 with the levelling and wall core deposits of phase 4. Large scale differences in fish between the earlier and later periods were interpreted as evidence for change in resource exploitation methods (Sellar 1982, 133).

Overall, this assemblage could be compared to other hand collected material, by species quantifications for cattle, caprines and pigs, by species presence for other species, and by element quantifications for cattle and caprines. Confidence in the quantification itself is good, but because not all elements or species were quantified, the overall potential of this site is limited.

1.7 Brough of Deerness, Deerness

This isolated site was originally thought to be an early Christian monastery with a timber chapel, later replaced by a Norse stone chapel with associated structures surrounding it of possible secular nature (Morris and Emery 1986, 301). After re-evaluation, the "'Celtic' monastery has evaporated", replaced by the idea of a small private chapel with associated settlement of secular nature (Morris 1996b, 191, 197).

The phases of interest are phase A, the timber phase of the chapel's use, dating from approximately the mid 10th century by architectural associations (Morris 1996b, 192; Barrett 2003a, 215); phase B, during which the chapel may have gone out of use (Morris 1996b, 199); and phase C, dating broadly from at least 959 to the medieval period and representing the construction and use of the stone chapel (Morris and Emery 1986, 313, 357; Morris 1996b, 197). The bone assemblage for each of these periods was not large, particularly when divided into the three spatial units. The area outside the enclosure produced less than 20 fragments per phase, so will not be discussed further (Morris and Emery 1986, Microfiche 4 E13-14). Quantities within the chapel are small, as may be expected within such a structure, although the assemblage from phase B may represent a period in which the chapel was not in use and as may therefore be a domestic deposit, or may be associated with the later construction of the stone chapel (Morris and Emery 1986, 358; Rackham 1986, 348; Morris 1996b, 199). The bones from the enclosure area were assumed to be of domestic origin as well, most being contemporary with the active use of the chapel (Morris and Emery 1986, 348).

The bone assemblages from three spatial units were studied in isolation: the chapel interior, the enclosure, and the area outside the enclosure (Rackham 1986, 348). This was partly a functional separation of space, but was also a practical solution to the problem of establishing equal phasing between the units; it was easier to keep them separate rather than enforce a possibly incorrect contemporality (Morris and Emery 1986, 348).

The excavation report provided detailed descriptions of the contents of each phase, but bones were not mentioned, although one can assume they were found. According to the sample list, two of the many layers that were sampled produced burnt bone (Enclosure

Episode 2, Layers GX and GZ) (Morris and Emery 1986, Microfiche 4 D2-3), but these did not correlate with descriptions provided in the text (Morris and Emery 1986, 334). The proportions derived from sampling were not discussed separately from the hand collected material, despite the potential biases this could introduce (Morris and Emery 1986, Microfiche 4 D2); it appears that two or three layers were sampled from the enclosure area, but there is no means to distinguish between them and the hand collected material. Later discussions of the mammal bone from the enclosure suggest that the material was of definite medieval date, and may have been used to level the area during construction of the stone phase of the chapel (Morris 1996b, 197, 199). The ecclesiastical nature of the chapel and enclosure was considered when analysing the bone assemblage, and it was realised that the results from this excavation may not be directly comparable with contemporary assemblages from domestic settlements: "the bone may bear no relation to the economy or subsistence activities of the settlement" (Hunter 1986, 348). Being a coastal cliff site, the effects of scavenging sea birds on the assemblage must be considered, although Rackham made no mention of this taphonomic factor.

It is possible to broadly separate deposits from within the church when it was in use in the Viking Age (though total NISP for this period was <10), when it was in secular use during the interface period (or during construction of the stone phase), and when it was in ecclesiastical use again in the medieval or late medieval periods (but again only with a total NISP of <10). This can be contrasted against the entirely domestic deposits of the enclosure area, although with the caveat that an unknown proportion derived from sampling.

This site is problematic, and although there is no reason to doubt the identifications, the unknown and unequally applied sampling makes comparisons difficult. Furthermore, no element distributions were discussed. It may be possible to use these data to explore the differences between the secular and religious deposits found within the chapel, but the small sample sizes involved will reduce the comparative potential of this site.

1.8 Brough of Birsay, Rescue Excavations, Mainland

Three areas of the settlement on the Brough of Birsay were investigated due to potential coastal erosion damage. These excavations included three main phases of occupation. Phase 1 dated to the late Iron Age period and the early Viking Age (although as the structures were of cellular type, they were unlikely to represent Scandinavian settlement), phase 2 dated to the late Viking Age, and phase 3 dates to the late Viking Age and earlier medieval period. A further fourth phase of kelp-making dates to a much later period and is not discussed further.

Recovery was described as "normal hand-methods and by the wet-sieving of clay soils" (Sellar *et al.* 1986, 208). However, it was also stated that samples were taken from hearths, burnt areas, and charred midden, and were processed by dry sieving to 5mm and paraffin flotation to 300 microns (Hunter 1986, 22; Sellar *et al.* 1986, 217). The proportions of sampled matrix were not provided, nor were the results presented separately. The lack of fish and small mammals throughout all phases suggests sieving was minimal. Approximately half of all bones were identified to species (Sellar *et al.* 1986, 209), which would support the idea that sieving was minimal, because sites with substantial sieved proportions tend to have much higher rates of unidentified bone (see Appendix Five). Therefore, recovery shall be classed as "hand collected" for this site.

The features and contexts containing bone are described in Appendix Table 1.3, along with dates, possible functions, and problems. Structure 7 requires an extra description because of the quantities of bone found associated with it. This poorly preserved structure probably represented a 'crude' reuse of phase 2's structure 3, using existing walling and without a planned building method. Despite the small size of this structure, over 600 bone fragments were found within the floor layer. It may have been an area for dumping waste, because three pits found within this structure contained waste-type material, again including bone. Evidence of smithing would indicate an industrial function (Hunter 1986, 128-28). Perhaps this structure may have served not just as a metal working centre, but also as an area of meat production, possibly secondary butchery following processing off the Brough. If this structure's bone assemblage had been analysed separately, particularly the pit deposits, it might have been possible to investigate this hypothesis and further investigate the subsistence strategies used during this later Norse phase.

Phase	Contexts with bone	Date	Reference
Phase 1	Gullies, hearths and a featureless spread; industrial type finds, so may be industrial area	AD 590-700 (1SD; 1350±60 bp)	Hunter 1986, 30-35, 177
Phase 2	Structure 1a/b floor deposits; two gullies outside this structure produced "a considerable quantity" of bone from silted layers; additional bone from pit outside this structure		Hunter 1986, 78-80
	Fills of a drainage ditch around structure 2 produced a "large quantity" of bone	AD 904-1044 (1SD; 930±70 bp)	Hunter 1986, 81-82, 177
	Structure 3 produced some bone of unknown context type	AD 920-1060 (1SD; 1000±70 bp)	Hunter 1986, 82-85, 177
Phase 3 (restructuring of phase 2 buildings)	Structure 4 contained bone from either floor deposits or wall fill		Hunter 1986, 121-123
	Structure 5 produced bone from a hearth area		Hunter 1986, 123-24
	Structure 6 wall fill deposits, possibly associated with a period of levelling and building that disturbed earlier deposits; this bone may originate from structure 3 of phase 2		Hunter 1986, 125-28
	Structure 7, probably a reuse of phase 2, structure 3; many bone fragments found within the floor layer and within pits; probable industrial function		Hunter 1986, 128-28

Appendix Table 1.3: Site VII, Brough of Birsay, contexts and dates of zooarchaeological material

Site VIII, phase 1 had similar features and a similar chronological range to site VII, though with four sub-phases, including a possible industrial area, a drainage ditch, and a sub-rectangular depression. Little bone was recovered or discussed in the text, but isolated patches of burnt bone were found from a possible structure, from the ditch fill and from a stake-hole (Hunter 1986, 46-54). Two phase 2 structures were found associated with drainage ditch fills that produced some bones. Structure 8 was partly excavated, and an area of stonework and slabs contained "a quantity" of bone, possibly a floor deposit (Hunter 1986, 85-87). Structure 9 was also partly excavated, some bone found in the wall fills, and a thick layer of bone found on the floor surface within the structure. This building may have had an agricultural function, as it had a wide entrance, but it did not have the more typical midden-based floor or stalls built within it (Hunter

1986, 87-88). Floor deposits from two domestic later Norse building in phase 3 included animal bones (Hunter 1986, 137-41).

Site IX, phase 1 was again similar to sites VII and VIII, but with gullies, slots, burnt areas, hearths and possible walling features. Three cellular-type structures were found, associated with some burnt bone on a floor surface (dating to 648-768 (1SD; 1280±60 bp) and a "dense deposit" of bone was found in a gully dating to 630-810 (1SD; 1250±90 bp) and 705-825 (1SD; 1195±60 bp) and associated with a smithy (Hunter 1986, 543-60; 177). Early levelling events during phase 2 included reuse of bone material, possibly from the earliest Viking Age phase, or even pre-Norse occupation. Drainage ditches associated with structure 16a contained fills of bone and a dense spread of bone, much burnt, was found in a feature within this, dating to 874-1034 (1SD; 1045±80 bp); the function of this feature is not known as it was not a hearth. Other bone from this structure originated in a hearth of domestic position (Hunter 1986, 89-95, 177). Overlaying this structure was one of slightly later date containing bone in foundation wall deposits and a hearth area. Other bone fragments were found in a burnt area dating to 852-972 (1SD; 1075±60 bp) and 934-1054 (1SD; 995±60 bp) (Hunter 1986, 95-103, 177).

The bone report for the rescue excavations on the Brough of Birsay, by Seller, Colley and Jones, incorporates a very broad degree of spatial analysis but fails to use the full potential of the contextual variation to understand the bone record more fully. Each site and phase was analysed separately, with no thought to contextual differences. The only concession to spatial analysis was the subdivision of phase 2 into two parts, the first of which related to the occupation of a structure whose bone material probably originated in earlier phases, and was disturbed following a levelling and construction event (Hunter 1986, 116). This assemblage was analysed separately, but only because this structure was slightly earlier than the others in phase 2, and not because the bone material was from disturbed contexts.

The method of analysis was very similar to that also used by Sellar at the Brough of Birsay, Room 5 (Sellar 1982), making these two sites easily comparable. However, as with the Room 5 assemblage, very little raw count data is provided. All percentages for NISP of species and elements needed to be converted back to counts to confirm the integrity of the data. Element proportions were analysed through comparison with complete carcasses of a Chillingham ox and a Soay sheep. Each element from the reference skeleton was expressed as a percentage *by weight* of the complete skeleton, but archaeological material was expressed as a percentage *by count* of the complete NISP for that species. Weights and counts were then compared to determine element variation, despite the impossibility of accurately comparing these two units.

Hares were identified by Sellar, but these were likely misidentifications of rabbits (Rackham 1989, Fiche IV G6), given the absence of any zooarchaeological or historical evidence for their presence in Orkney prior to the early modern period.

In conclusion, this site is only useful for inter-site analysis with other sites that have a comparable recovery programme, although it does provide a useful chronological separation. Fish and birds were only presented qualitatively, and element counts were only provided for the main domestic mammals. It had the potential to illuminate differences between domestic and industrial function, as well as changes through time, but little thought was given to contextual variation.

1.9 The Birsay Bay Project, Volume 1: Brough Road, Mainland

The two volumes of the Birsay Bay Project present the results of survey and small-scale excavation in the area following work on the Brough itself (including Cruden 1965; Curle 1982 and Hunter 1986; see above) and archaeological intervention in the area of Birsay Bay at Buckquoy (Ritchie 1976-77; see above) and Saevar Howe (Hedges 1983; see below). Some of the trial excavations presented in the first volume included material of Viking Age or medieval date; these are presented below and include areas 1 and 2 from the area 'South of Red Craig', and areas 3, 4 and 5 from beside the Brough Road, located about 300m to the northwest of areas 1 and 2 (Morris 1989, Illus. 12). For ease of comparison at the intra-site level, areas 1 to 5 will be termed "Brough Road" throughout this thesis.

The deposits of areas 1 and 2 may have been a rubbish dump for a settlement located nearby, either eroded into the sea or still surviving but unexcavated (Morris 1989, 141). Most of the assemblage from areas 1 and 2 originated in midden layers, phases D and F of area 1 and phases C and E of area 2 (Morris 1989, 232), though other context types were represented. The presence of rabbit bones throughout areas 1 and 2 indicates that the level of disturbance had been high, particularly in the later phases, although the lower levels were likely to have maintained more integrity. The phases, context types and dates for the two areas are presented in Appendix Table 1.4 and Appendix Table 1.5.

Phases	Contexts types containing animal bone	Dates	References
Phase A	Cairns with long cist burials	Roman Iron Age and Pictish	Morris 1989, 109, 113, 123
Phase B	Collapse of the cairns		Morris 1989, 113
Phase C (=Area 2 A)	Sand layer deposited over cairns		Morris 1989, 11, Illus. 102
Phase D (=Area 2 C)	Thick midden deposit, rich in bone, organic material and finds	Lower: AD 620-890 (1250±55 bp; 2SD) Upper: AD 790-1035 (1105±55 bp; 2SD)	Morris 1989, 114, 123, Illus. 102
Phase E (=Area 2 D)	Cist grave in phase D midden, midden over grave; second grave of confused stratigraphy	Cist: AD 600-915 (1240±85 bp; 2SD) Second grave: AD 880-1140 (1040±60 bp; 2SD)	Morris 1989, 114, 116, 123, Illus. 102
Phase F (=Area 2 E)	Midden, rich in ecofacts and artefacts; divided into 2 episodes with F1 less subject to burrowing disturbance than F2	AD 610-1020 (1215±80 bp; 2SD)	Morris 1989, 116, 118, 123, Illus. 102

Appendix Table 1.4: Area 1, Brough Road (South of Red Craig), Birsay Bay, contexts and dates of zooarchaeological material; equal signs are used to indicate contemporaniety with area 2

Phases	Contexts types containing animal bone	Dates	References
Phase A (=Area 1 C)	Sandy layers	AD 625-895 (1230±50 bp; 2SD)	Morris 1989, 128, 141, Illus. 102
Phase B	Flagstone spreads		Morris 1989, 128
Phase C1 (=Area 1 D)	Lower midden: food waste midden material with artefacts, midden without artefacts, burnt layers	AD 885-1245 (975±110 bp; 2SD)	Morris 1989, 128, 131, 141, Illus. 102
Phase C2 (=Area 1 D)	Upper midden	AD 855-1050 (1095±55 bp; 2SD)	Morris 1989, 132, 141, Illus. 102
Phase D (=Area 1 E)	Cist grave in upper midden, grave fill	AD 670-1020 (1140±65 bp; 2SD)	Morris 1989, 137, 141, Illus. 102, Illus 102
Phase E (=Area 1 F)	Disturbed by animal burrowing, sand and stone		Morris 1989, 137
Phase F (=Area 1 G)	Disturbed by animal burrowing, topsoil		Morris 1989, 137, Illus. 102

Appendix Table 1.5: Area 2, Brough Road (South of Red Craig), Birsay Bay, contexts and dates of zooarchaeological material; equal signs are used to indicate contemporaniety with area 1

Bone from areas 1 and 2 was recovered using hand collection, though as the deposits were sand-based, there was little problem recognising and recovering small, fragile or immature material, and fish, bird and eggshell were all recovered. Sampling was later initiated following recovery of midden deposits in area 2, though on a 'judgemental' basis as deemed necessary without a sampling strategy (Rackham 1989, 231). Three recovery levels were selected: hand collection, spoil from hand collection processed using wet sieving through a 1cm sieve, and finally, a limited number of bulk deposits sieved in their entirety to 2.0mm, 1.7mm, 0.895mm and 0.85mm (Rackham 1989, 232). Selected midden layers from area 2 were intensively sampled horizontally and vertically (Rackham 1989, 232).

A 'judgemental' method of sampling was applied to areas 3, 4 and 5 from the beginning of their excavations (Colley 1989, 231). Areas 4 and 5, and area 3 mammal, produced such small quantities of mammal and fish bone that meaningful quantification was impossible; these areas were only attributed a small paragraph in the report and do not require contextual descriptions (Colley 1989; Rackham 1989, 249, 247). The fish assemblage from area 3 comprised over 200 fragments so was quantified separately and compared to other areas and phases containing fish (Rackham 1989, Table 27). Contexts containing fish bone from area 3 included: floor deposits and possible oven feature from phase A, dating from 610 to 1160 (two radiocarbon dates, one of 1240±110 bp, one of 1060±60 bp, both 2SD); hearth and clay layers from phase B; and organic spreads from phase C, dating to 600-910 (1250±110 bp; 2SD) (Morris 1989, 143, 147, 150, 152, 156, 169, 171).

The main analysis of element distributions for the main three domestic species was restricted to midden deposit material, because they comprised the largest bone quantities of any contexts, as well as being from a controlled recovery program (Rackham 1989, 243). Barring one unidentified fragment, all bird bone originated in midden layers as well (Rackham 1989, 247). It appears contextual variation was not considered, but the decision to only analyse midden contexts was a by-product of the large bone content of midden. Element representation suggests all parts of the carcass were present for cattle and sheep, indicating little distribution of processed meat off site (Rackham 1989, 244, 246). The smaller amounts of bone that must have been produced from non-midden contexts were not discussed, but as only the element and ageing data explicitly used only midden context data, it is not known whether the other non-midden context types were ignored completely, or were included in the main NISP data tables. One peculiar aspect of the element representation data is that the phases and areas selected for element data – restricted to midden contexts only – total more than the NISP for those areas, rather than less as would be expected. This indicates some contradiction, and needs further investigation. The fish assemblage suggests other non-midden contexts may have produced some mammal bone worthy of quantification and comparison beyond NISP, even if simply to explore inter-contextual variation. Variation between element distributions within midden deposits from areas 1 and 2 cannot be explored in detail either, because all midden material from these two areas was combined within each of the two broad phases examined (Rackham 1989, Table 25). Although this was done to maximise sample size availability, and is understandable given the desire to compare this assemblage to others of large size, it would have been prudent to ensure the internal homogeneity of all midden deposits first, before combining them. This would enable a better understanding of the diachrony and intra- and inter-midden variety of these two phases and midden areas; the extensive sampling of the area 2 midden would have permitted this. In his conclusion, Morris questioned exactly this amalgamation, suggesting that some "spatial differences" might have been found, particularly as the mammalian element distributions were only presented for areas 1 and 2 in combined form (Morris 1989, 293). Any differences between these two areas would now be extremely difficult to test because the basic NISP data may originate from more than one context type, including material from non-midden contexts, so cannot be directly compared to the combined element data that only included midden contexts. The only indication of differential element survival, possibly due to importation of processed meat to areas 1 and 2, was a large quantity of sheep and cattle rib fragments compared to other elements from the earlier of the two phases that were examined in detail (Morris 1989, 293). Given that a common theme to all Birsay Bay excavations has been the possible movement of livestock or meat from one area to another, this observation was worthy of further investigation, but as the element data are only available in combined and summarised form, we cannot investigate the potential meat trade at any greater resolution.

The fish assemblages from areas 1 and 2 were about twice the size, by fragment count, of the mammalian and bird assemblages. It was difficult to analyse these due to the mixture of sampling strategies used, with the result that all bone per layer was combined regardless of recovery method used. Some bias will be present, because wet sieving and flotation were differentially applied to some midden deposits and not others (Colley 1989, 248). Before Colley discussed chronological change, she assessed the degree to which sample sizes and context type might bias her results; each context was then summarised in turn, with comments as to the confidence of its phasing and potential residuality. Larger context groups from each phase were then presented in tabular form, showing species and element quantities (i.e. the two midden contexts from area 1, phase D, were quantified together in Tab. M26, with metrical data provided in Tab. M27). In most cases these tables represented groups of contexts of the same type, but not always: the majority of almost 3500 fish bones in area 2, phase C1 originated from dark sandy layers with evidence of burning, but 74 fragments were from a midden context and 46 fragments were from sandy layers (Colley 1989, Microfiche IV C8). Problems like this emphasise the reliance that must be placed upon initial context identifications, as the definition of 'midden', versus 'dark sandy layers', may vary by excavator experience and personal preference. However, in all cases here the dominant context type represented at least 95% of the assemblage.

Colley believed that the differences between phases and areas were due to a number of factors, including difference in context types studied, sample size and differentially applied sampling strategies (Colley 1989, 249). Despite this, she chose to present her data by phase because "this is the unit favoured for archaeological interpretation", although she was aware that different contexts have different formation processes and will be more or less indicative of subsistence strategies. In particular, she notes that midden, hearth and occupation floor layers are more likely to contain primary bone material than exterior floor deposits, structural deposits (presumably referring to wall fill and foundation deposits), and rubble deposits, all of which may contain secondary, reused or residual material that will be less representative (Colley 1989, 248). It is for this reason that the fish bone from area 1 midden deposits (Phases D and F) were used for quantification, a decision also taken because of the large numbers of fish bone from these layers, compared to any other context types (Colley 1989, 248). A similar situation was found in area 2 as the phase C midden deposits accounted for much of the fish assemblage. However, in area 2 more fish bone was found in non-midden deposits than in area 1, including sandy layers from phase A and sand and stone layers from phase E. These two context types and phases contained enough material to be discussed separately (Donaldson and Nye 1989, 249).

Despite a definite awareness of contextual variation, the faunal analysts then followed a more traditional route in combining the context types and areas to form one chronologically defined grouping. Although particularly apparent in the mammal bone, this was done to a lesser degree in the fish assemblage. Contextual variation within the botanical assemblages was examined and found to be important: differences between midden and hearth deposits were found (Morris 1996a, 267), but this was not explicitly repeated for the faunal assemblages. Comparisons between the mammal and fish assemblages is now difficult, because despite the added spatial resolution of the fish assemblage, if these two are to be used together then they must be reduced to the lowest common denominator. Together with the unknown quantities of sampled material, the usefulness of these sites is diminished. However, there is no reason to doubt the dating and confidence in the quantification process. The end result was a fish assemblage of hand collected and sieved origin, presented almost entirely by context type. Mammal species and element data were provided for the main midden deposits, combining hand collected and sieved results, which can be compared to other sites. In conclusion, the Brough Road sites are of moderate value for spatial analysis.

1.10 The Birsay Bay Project, Volume 2: Birsay Village, Mainland

The sites investigated in this volume are a continuation of work in the Birsay Bay area described above (Morris 1989). The areas investigated were Beachview Burnside and the 'Studio' site, both located in close proximity on the south side of Birsay village (Morris 1996a, 4).

Beachview Burnside areas 2 and 3 are man-made mounds with deposits of late Viking Age and medieval date (area 2) and at least medieval date (area 3). Area 2 is predominantly a midden deposit possibly associated with a settlement (Morris 1996a, 5). Beachview Studio site is of late Viking Age and medieval date, and was investigated in two parts, area 1 with structures dating to the 11th century and containing midden material that may have been introduced from another occupation area, and area 1 D/E comprising midden deposits from occupation phases as well as small structures and evidence of industrial activity (Morris 1996a, 6). Additional bone was recovered from an undated excavation around St. Magnus' Kirk, Birsay, an upstanding church of several phases (Morris 1996a, 11). Rather than attributing variation within this assemblage solely chronological change, differences between midden and all other deposits was considered, although the small quantities of bone reduced the conclusions that could be made (Morris 1996a, 23, Tab. 4). This assemblage will not be discussed further.

1.10.1 Beachview Burnside area 3

Beachview Burnside area 3 was a small area of excavation that included midden layers. These were regularly sampled; approximately one eighth of the deposits were processed using wet sieving to 1.98mm and 0.895mm (Morris 1996a, 45, Microfiche 1 C6). The sampled deposits produced a substantially different assemblage from the hand collected material recovered from the rest of the layers (Rackham 1996b, 48), but these differences were made explicit. The context types and dates are summarised in Appendix Table 1.6.

Phases	Contexts types containing animal bone	Dates
Phase X (associated with structural stonework)	Midden and sandy loam with midden characteristics	AD1020-1320 (800±90 bp, 2SD)
Phase Y	Windblown sand	
Phase Z	Windblown sand with topsoil and turf inclusions	Possibly includes modern deposits so not used

Source: Morris 1996a, 46, 48, 292

Appendix Table 1.6: Beachview Burnside area 3, Birsay Bay, contexts and dates of zooarchaeological material

Because each phase only contained bone from one context type, the chronological analysis separated midden-type contexts (Phase X) from windblown sand (Phase Y) and from windblown sand mixed with topsoil and turf (Phase Z). Additionally, hand collected and sampled deposits from phase X midden were quantified separately. This approach, although incidentally involving separation both through time and space, allows a fuller consideration of deposit formation processes and sampling biases to be made. Unfortunately, the small size of the identified assemblage limits the conclusions that can be drawn, and no fish bones were recorded for phase X.

Two sample units were chosen for further investigation within area 3. All sampled material in them was weighed and graphed to illustrate fish, mammal and shell content variation with each layer of the midden (Rackham 1996b, Microfiche 1 Tab. C8). No discussion of elements was included, but Tables M6 and M9 did present mammalian and fish element data for phase X.

1.10.2 Beachview Burnside area 2

A moderately complex stratigraphic sequence at Beachview Burnside area 2 produced five separate phases, three of which contained bone as summarised in Appendix Table 1.7.

Phases	Contexts types containing animal bone	Dates
Phase W	Midden dumps, scattered stones with bone and burnt material	AD 1020-1280 (820±80 bp; 2SD)
Phase X	“Particularly rich” midden, midden, sand blow	AD 1030-1280 (850±50 bp; 2SD)
Phase Y	Interface between midden and sand, sand blow	

Source: Morris 1996a, 54-56, 292

Appendix Table 1.7: Beachview Burnside area 2, Birsay Bay, contexts and dates of zooarchaeological material

A sampling strategy was used here, similar to that applied to Beachview Burnside area 3. A sampling grid with units of 1m^2 was created, with four squares selected for complete sampling, equal to one eighth of the area (Rackham 1996c, Microfiche I G1).

Before analysing the results from the middens, the authors decided to test the homogeneity of each of the five sampled midden layers. Each 14L sample taken from each 1m^2 unit was analysed for fish, mammal and shell by weight at several different spit depths, thus providing a measure of density through time and space. The residue from each sample was then sieved and sorted to >3.35mm, >2mm and >1mm. Each fraction was weighed and compared graphically, and used to indicate the different proportions of midden material (assumed by the excavator to equal only the >3.35mm fraction, although the presence of small finds could potentially bias this measure) and shell sand (assumed to be the only contents in the 1-2mm sieve). The >3.35 fraction was therefore used as a measure of “human input”, in contrast to the naturally occurring shell sands represented by the smallest fraction (Rackham 1996c, 64). This does not consider the weight of small bones, particularly fish that could be found in the smaller fractions and it assumes shell sand particles are greater than 1mm; overall it would provide an approximate indication of potential intra-midden variation between samples. Differences between the mammal, fish and shell weights from residues allowed comparisons between these classes of material, both within and between midden layers at one sampled square, or between different sampled squares; conclusions were then drawn regarding the nature of the midden deposits. They were found not to be homogenous, but rather the result of several activities and taphonomic processes, some possibly seasonal (Rackham 1996c, 65). The results were limited by the location of the 1m^2 sample squares, because all were on the edges of the excavation, they could potentially have been influenced by features in the unexcavated areas immediately adjacent. One sampled square in the centre of the excavation would have allowed a better understanding of the surrounding contextual, stratigraphic and structural data.

The finds from area 2, together with the spatial differences viewed within and between the midden deposits, suggest that this area is the edge of a Viking Age and medieval dump with a focus towards the southeast (Rackham 1996c, 67, 72). Phase W may represent a single dumping event, but phase X probably was an accumulation of several such events (Rackham 1996c, 72).

The actual faunal assemblages from these deposits were again presented by phase, separated by recovery method: hand collected or sampled (Rackham 1996c, Tab. 7), although almost complete division into context by species was presented in the microfiche (Rackham 1996c, Microfiche 1 G3, G4). Element NISP remained grouped by phase (Rackham 1996c, Microfiche 2, A3). While it is likely most of the bone originated from midden deposits, phases W, X and Y were all combinations of different context types, including an interface layer and two sand blow events. Some separation by episode (associated context grouping) was presented on microfiche, and although this provided some separation of context types in addition to that included in the printed phase data, some diverse context types were still combined for the hand collected material, yet separated for the sampled data set (Rackham 1996c, Tab. M12, M13). The bird and fish bones were presented by species by individual layer; each context and therefore each context type was separately quantified providing ideal spatial resolution (Allison 1989, Tab. M24; Colley 1989, Tab. M26, M27). The sizes of the assemblages were not large, but their results could have been presented and utilised at the level of the individual midden context for a greater understanding of the formation processes that occurred here.

1.10.3 Beachview Studio site area 1

This area was divided into two sections, the main area 1, and area 1, sub-areas D/E. Sub-areas D/E contained 10 phases, all of which contained bone, from a variety of context types as summarised in Appendix Table 1.8. All phases probably represented a chronologically short period of occupation and use (Morris 1996a, 88; Rackham 1996d, 100).

Phases	Contexts types containing animal bone	Dates	References
Phase Q	Sand, blown sand overlying rubble	AD 980-1206 (960±50 bp; 2SD)	Morris 1996a, 77, 292
Phase R	Sandy wall core deposit, possible enclosure		Morris 1996a, 77
Phase S	Ash dump next to wall from phase R, sand deposits either side of wall from phase R (now disused)	AD1030-1280 (850±50 bp; 2SD)	Morris 1996a, 77
Phase T	Possible midden, white sand possibly associated with features outside excavation area		Morris 1996a, 77, 82
Phase U	Sandy midden layer, sand layer, both overlying wall from phase R	AD 1001-1410 (770±120 bp; 2SD)	Morris 1996a, 82, 292
Phase V	Sand blow, wall		Morris 1996a, 82
Phase W	Sands, a 'black slump', burnt peat, dark sands, fill from a rabbit burrow	AD 1020-1280 (850±60 bp; 2SD)	Morris 1996a, 82, 85, 292
Phase X	Wall rubble of a small shed, earth core of wall		Morris 1996a, 85
Phase Y	Sandy deposit in structure of phase X, but not floor deposit, blown sand, dark sand, slight gully, sand, midden-like deposits, midden, a line of stones, burnt peat, and other contexts of unidentified type		Morris 1996a, 85, 87, 88
Phase Z	Sand, turf	Possibly includes modern deposits so not used	Morris 1996a, 88

Appendix Table 1.8: Beachview Studio site area 1 D/E, Birsay Bay, contexts and dates of zooarchaeological material

No routine sampling method was used at this area, but phases W and Y had some degree of sampling applied and the results from each recovery method were presented separately (Rackham 1996d, Table 11). All material was grouped together by phase without any consideration of context types, though as can be seen from the stratigraphic sequence listed above, each phase contained several context types (Morris 1996a, 77-88). The detailed examination of midden deposits carried out at Beachview Burnside area 2 could not be replicated here because adequate sampling and recording was not applied (Rackham 1996d, 97). However, because it was realised that the spatial variation seen at area 2 could account for more variation than that ascribed to chronological changes, the conclusions drawn from the Studio site D/E took this into consideration. This area of the Studio site must be viewed as supplementary to the structures found in the main area 1, particularly the deposits containing bone from phases U, W and Y, which may have been clearance events or dumps from the main area (Rackham 1996d, 97).

The main Studio site, area 1 was a larger and more complex stratigraphic sequence, with 16 phases and containing a "major structural complex" (Morris 1996a, 132), as summarised in Appendix Table 1.9.

Phases	Contexts types containing animal bone	Dates	References
Phase K	Sub-rectangular structure with a hearth; bone only found in walling		Morris 1996a, 101
Phase L	Peat ash covering hearth of phase K, sandy clay, sand		Morris 1996a, 101
Phase M	No bone, but a corn-drying kiln constructed in corner of structure		Morris 1996a, 104
Phase N	Wall constructed in sub-rectangular structure; wall core contained bone; also sandy layer		Morris 1996a, 104
Phase P	Clay around hearth, burnt layer over hearth, stone fill of hearth		Morris 1996a, 104, 107
Phase Q	Sandy deposits within the structure		Morris 1996a, 107, 111
Phase R	Pit fill (found in structure), midden within structure	AD 1134-1280 (790±50 bp; 2SD)	Morris 1996a, 111, 292
Phase S	Midden deposit in structure overlying phase R midden, sand and clay layer sealing hearth, sand	AD 990-1220 (930±55 bp; 2SD)	Morris 1996a, 113, 116, 292
Phase T	Rebuilding, wall dug into midden layers of previous phases		Morris 1996a, 116
Phase U	Layers accumulated against exterior of building, including peat ash, sand, clay		Morris 1996a, 116
Phase V	Collapse: rubble and sand	AD 1163-1300 (760±50 bp; 2SD)	Morris 1996a, 121, 292
Phase W	Drain fill		Morris 1996, 121
Phase X	Wall constructed containing bone		Morris 1996a, 121
Phase Y	Disuse: sand and ash layers	AD 990-1210 (940±50 bp; 2SD)	Morris 1996a, 121, 123, 126, 127, 128, 292
Phase Z	Sandy layers, included modern and mixed bone deposits, modern rubbish pit	Not included in analysis	Morris 1996a, 128

Appendix Table 1.9: Beachview Studio site area 1, Birsay Bay, contexts and dates of zooarchaeological material

Sampling was used rigorously for a variety of context types (Rackham 1996c, 147-48). The quantity of the sampled and hand collected bone excavated, together with the detailed knowledge of context types and excellent recording has resulted in a data set that could certainly be used for faunal spatial exploration. The sampled deposits from each layer were graphed to show the contributions by weight of mammal, fish and shell; the average per bucket (about 14L) for each layer was then displayed to show the inter-layer variation (Rackham 1996c, Illus 119). As each layer was from a particular context type, this also demonstrates the variation between context types, which appears to be greater than the chronological variation. Layers of the same context type, within the same phase, were found to be surprisingly variable (e.g. the sand layers of phase Y and the midden layers of phase R). Suggestions that differences between phases could be attributed to subsistence changes through time were then mitigated by the realisation that different deposit formation processes and pattern of activity may be responsible (Rackham 1996c, 153; Rackham 1996a, 163). Differences between domestic type deposits found within the structure in area 1, compared to the "more general bulk midden debris" found outside, may explain differences in frequencies of cattle compared to sheep, assuming larger cattle bones were removed from the domestic area (Rackham 1996c, 153). Fragmentation size does not appear to have been considered, and although cattle bones are generally larger than sheep, the degree to which both have been fragmented would be a contributory factor in this spatial arrangement; data from the modern and disturbed phase Z was included in this comparison for reasons unknown, contributing to the uncertainty surrounding it. The small quantities of bone and shell from phases K and L, during which the building was probably in domestic use, may indicate routine clearance and refuse removal to external contexts, but the increase in deposits from the later phases Q and R within the structure may indicate a change of use from domestic, or a period of disuse during which time the roof may have disappeared (Rackham 1996c, 154). The changing function of the site and the contrast between internal and external 'midden' from both domestic and disused phases may each be indicative of site economics and function during a relatively short time period (Rackham 1996c, 154).

The area 1 bone assemblages demonstrated a "marked difference" between the deposits from internal contexts when the building was in use, and those from the exterior and later phases. A graph of weights of shell, fish and mammal bone for all larger layers from Beachview showed that the external contexts from the disused phase of area 1 had much higher proportions of shell than other contexts and phases, suggesting a use as a shell midden, possibly for bait production (Rackham 1996a, 186). The layers from area 2 generally contained more bone, and were more variable than the other areas, possibly representative of a mixed domestic economy. Limpet to periwinkle shell proportions indicates that the occupation phases of area 1 in particular may represent primary food preparation waste, rather than later cooked waste (Rackham 1996a, 184). An examination of the element distributions for these layers would have allowed this pattern to be further investigated, but as they were not provided, any further exploration of this trend must be conjecture.

Looking at the Beachview site as a whole, the greatest variation within the fish bone assemblage was the result of differential recovery methods used, but taking that into consideration, contextual differences also account for some of the variation. Contexts defined as 'midden' during excavation tended to be sampled more than others, possibly over-emphasising the contextual variation (Rackham 1996a, 176). "Variations in the assemblages [of the Beachview area] have been attributed to behavioural, rather than chronological or economic patterns. Recognition of such patterns...permit functional and spatial reconstructions of importance to the interpretation of the settlement organisation and social structure, which it may be impossible to recover from other data." (Rackham 1996a, 191).

The small excavations at Beachview Burnside area 3 were separated spatially, although this occurred incidentally. The spatial variation within each layer of the midden was investigated, and is a useful indicator of intra-midden differentiation. Unfortunately, sample sizes were small and only one phase had element data provided. Beachview Burnside area 2 was again small, but a regular sampling strategy permitted the vertical and horizontal variation within midden deposits to be examined. The data were presented with an almost complete break-down by context type for mammals, fish and birds, but grouped by phase for elements. Intra-context variation was not examined at Beachview Studio area 1, and although spatial analysis was explicitly discussed in the text, the data tables combined all context types. That said, the intra-context variation studied at these sites is of substantial value to the study of spatial variation within the Northern Isles, and as a portion of these data are presented with full species, element and contextual information, this volume is of substantial value to this project.

1.11 Saevar Howe, Mainland

The excavation at Saevar Howe was prompted by coastal erosion, and aimed to assess the archaeological potential of the site for future excavation (that never occurred). An early antiquarian excavation indicated a potential ecclesiastical function to the site, but this has now given way to ideas of secular settlement based on architecture and finds (Batey *et al.* 1983, 85). Phasing was difficult as the excavators expected to return at a later date and because of difficulties in connecting features from each of four separate trenches (Hedges 1983, 77). The first phase (I) was not fully understood because many features were not of recognised function, and it was not C14 dated, but the other phase (II) was better understood (Hedges 1983, 78).

Contexts from phase Ia includes midden, probably from an internal floor. Phase Ib also contained midden, most of which was dug away for a later wall construction. It is not made clear if this was inside or outside a structure (Hedges 1983, 80). No midden was mentioned in phase Ic, and although some may be illustrated on the plans, their position or extent could not be determined (Hedges 1983, 81). The three structures of phase Ic were destroyed or collapsed during an abandonment phase before the three Viking structures of phase II were constructed (Hedges 1983, 81, 82). Phase IIa, a probable hall-house, included a midden that may have been substantial but that was disturbed by the antiquarian intervention. This may connect with another midden deposit, implying that a large area to the west, and outside the hall house, was midden (Hedges 1983, 82). Following abandonment and sand blow, the next hall was constructed as phase IIb, in the same location as the previous one. Midden material was found on the main floor, and in smaller areas to the south and west of the house. Another ground surface contained "much midden" but it is unclear if internal or external (Hedges 1983, 82-83). Another period of abandonment was followed by phase IIc, another rebuilt Viking hall-house similar to its predecessors (Hedges 1983, 84). The final deposit was a midden layer found inside the hall-house and assumed to date from its abandonment (Hedges 1983, 85). All spoil was dry sieved through a 5mm mesh (Colley 1983b, 94).

Dating problems with phase II, including questions surrounding the need to apply marine reservoir correction, and residuality of charcoal samples used for dating, has resulted in the C14 dates being used with caution. A coin of mid 9th century date, later used as a pendent, provided a *terminus ante quem* for phase IIb (Hedges 1983, 93). Phase II therefore is said to date mainly from the 9th century, with the potential for a slightly earlier or later starting and finishing date (Stenhouse *et al.* 1983, 109).

Despite discussing the spatial differences that may be found in the assemblages, the faunal experts do not take full advantage of their datasets. Both Rowley-Conwy and Colley were aware that different context types could contain different patterns of bones because of different formation processes, differential survival, differential rubbish disposal patterns, etc. (Rowley-Conwy 1983, 70; Colley 1983b, 97). The small sample sizes accounted for much of the problem, because with only 459 identified mammal and bird fragments, context types and even sub-phases had to be combined to produce a dataset that could be used (Rowley-Conwy 1983, 70). In particular, all of phase I, the pre-Viking settlement, was combined.

The types of contexts in which bone were found were listed by phase with the quantity of each context type containing bone provided – but without any indication of actual bone quantities (Colley 1983b, Tab. 16; Rowley-Conwy 1983, Tab. 8). Rowley-Conwy attempted the method of Halstead *et al.* (1978) to examine potential differences between internal and external contexts using data from all phases (Rowley-Conwy 1983, 74), but as these values cannot be reconstructed by the reader, the value of this contextual test must be questioned. Rowley-Conwy concludes that this test "does not actually give any clear indication of variability", but he does conclude from his test that proportions of waste are higher for larger species, probably related to element size and recovery patterning (Rowley-Conwy 1983, 74). Although there is no element quantification data to confirm this, it appears that at least meat-rich elements from cattle, if not from caprines, were removed from site. This was not discussed by the authors, yet it is perhaps the most important result of their spatial test, because it has bearing on the location and economic function of Saevar Howe compared to other sites in the Birsay Bay area.

The fish assemblage was more substantial than the mammal and bird assemblages (identified NISP of 1005, compared to 459 for mammals and birds); its analysis was more explicit, and more conclusions could be drawn from it. However, the 5mm sieve size limits the inter-site comparative potential to other sites with similar recovery methods, but most sites use a smaller sieve size. Colley attempted to examine chronological changes at Saevar Howe, but she found this difficult due to differences in sample size and contextual variation, and concluded that similar subsistence strategies were used throughout the occupation of the site (Stenhouse *et al.* 1983, 113).

Buckquoy was used as a comparative site for much of the mammalian domestic faunal assemblage, although the limits of inter-site comparison between these two assemblages were noted. Saevar Howe has a smaller sample size than Buckquoy (Stenhouse *et al.* 1983, 111), and may be less representative of the settlement as a whole than Buckquoy, although the former was subject to more rigorous sieving than the latter (Colley 1983b, 94); both are limiting factors. Regional sites like Buckquoy and Saevar Howe could have provided specialised food for the Brough. However, the authors did not consider that Saevar Howe could have been a supplier settlement itself. A reinvestigation of element proportions at Saevar Howe could have provided further evidence of intra-site variation, but the small sample size, together with the lack of any quantified element data, makes a fully quantified comparison impossible at Saevar Howe.

In conclusion, the mammal and bird remains from Saevar Howe cannot be used for full intra or inter-site comparison. Despite the regular sieving and good preservation throughout the excavation, the quantification of mixed context types and phases, the small sample size, and the lack of element quantification in the report, makes this dataset only useful for quantitative and qualitative comparisons at a broad scale. The fish assemblage has greater potential for comparison because of Colley's more explicit analytical strategy, but again the element quantification data is missing. Reconstructions of fish sizes, together with NISP data by sub-phase, mean that some broadly quantitative data may be used for comparison by period for other sites, bearing in mind the recovery strategy.

1.12 Sandwick, Unst

Excavations at Sandwick produced a rectilinear stone house with a walled enclosure and midden material thought to date from the 12th century to c. AD 1400 by artefactual chronologies (Bigelow 1984, 38; Bigelow 1987, 27). The first phase contained a central hearth, stone-lined pits, a paved cross-passage, a food preparation area and a cow byre (Bigelow 1984, 38). In a second phase, the house was restructured, a new hearth was added, and a raised dais was constructed inside against the gable end. The yard associated with this structure was sampled, and although only 70cm deep, substantial quantities of organic material were produced (Bigelow 1984, 38).

Sampling and good environmental recovery rates were given high priority at Sandwick, but unfortunately different areas of the site had varying proportions of matrix processed through varying sieve sizes (Bigelow 1984, 114). The middens that Bigelow sampled produced over 100,000 bones, of which he identified 8709 during his PhD. These were from three different middens, two found near the house and representing primary domestic food waste, and one from the outer yard representing more general refuse (Bigelow 1984, Tab. 8, 119-20). The former comprised the 'Early' midden dating to the late 12th century, the 'Middle' midden with a substantial ashy component, and the 'Late' midden dating to the late 13th to 14th centuries (Bigelow 1984, 120-21). The outer yard midden was an area of dense fishbone deposits dating to the 13th century and probably contemporary with the middle phases of the other middens (Bigelow 1984, 121), indicating a broad spatial differentiation in rubbish disposal activities. Bigelow examined some intra-site variation at Sandwick. One of the middens near the house was found to contain denser later layers than the other, possibly because of later structural changes that made one midden easier to access than the other. Overall, these two middens were remarkably similar, indicating that they both are representative of long term economic patterns (Bigelow 1984, 127). However, this could indicate that they were both influenced by the same set of spatially defined activities, activities that were applied equally to both of these middens, but differently to the fish-rich outer yard midden. Bigelow used ratios to examine proportions of species and elements, and their changes in both space and time. This allowed him to hypothesise that, during certain time periods, one midden had an under-representation of fish vertebrae, indicating possible trade off site or processing of fish in an unexcavated area (Bigelow 1984, 128-29). The mammalian assemblage was not studied in as much detail, but different densities of species through both time and space were investigated (Bigelow 1984, Tab. 11-13).

At the time of writing, Bigelow did not have a large comparative data set like that now available, nor did he see the need to fully quantify element proportions. Data are provided for mammal and fish species for each of the three middens, covering three phases (Bigelow 1984, Tab. 11-13). No quantitative element or mammal ageing data were provided, and no distinction was made between sampled and hand collected material. An additional problem was that the fish bone identification system was by no means as comprehensive as at other sites: only six fish elements were identified to species (articulars dentaries, maxillae, premaxillae, vomers and otoliths) and only some vertebrae were identified if they were from trace species. Other vertebrae were counted, but no other fish fragments were identified or counted, making comparison difficult (Bigelow 1984, 122).

Bigelow was interested in the spatial patterning of Viking Age and medieval settlements in Shetland as compared to other North Atlantic colonies and the Scandinavian homeland. He examined the geographical arrangement, the possible differences in status between settlements, and chronological changes, but found that there was no single pattern type in the Northern Isles because of the diverse nature of settlement and the small numbers of excavated sites (Bigelow 1984, 77-78). Turning then to the intra-site spatial arrangements, he commented that "it is the 'micro-level' spatial organisation, the division and use of interior space ... that most clearly unifies Late Norse Shetland sites and distinguishes them from earlier and later forms" (Bigelow 1984, 79). Although his emphasis was placed on architectural and artefactual evidence, he did consider the changing nature of domestic and byre structures and their need to include housing for stock (Bigelow 1984, 79-82). His conclusions concerning spatial patterning at Sandwick could have been greatly extending by including an analysis of element distributions, both within each midden and between all three. This may have included meat or prepared fish traded offsite, which would have improved our knowledge of trade and subsistence economics in Shetland.

Bigelow's data can be used for intra- and inter- site spatial analysis because its contextual origin is known. Although his assemblage is large, not all of his data have been published and his identification methodology is more limited than most. Despite these problems, Bigelow's study incorporates a high degree of spatial analysis of non-faunal activities and architecture, and his species data will provide a good contribution to the spatial analysis of the medieval Northern Isles. Unfortunately, he does not provide quantified element proportions; had these been included, the potential intra-midden and inter-site analysis of this data set would have been substantial. Sandwick is particularly valuable because it is one of only three Shetlandic sites with Norse faunal data, so Bigelow's data must be used as best possible.

1.13 Freswick Links, Caithness

Antiquarian excavations in the area of Freswick Links, Caithness, were carried out by Anderson (1901), Edwards (1925; 1927), Curle (1939) (including qualitative faunal analysis by Miss Platt similar to Jarlshof) and Childe (1943). Modern excavations include Rackham *et al.* (1984) (on the environmental survey of Freswick Links in 1979); Batey *et al.* (1984) (on the excavations and survey at Freswick Castle, 1979), Batey (1987) (on the artefacts from erosion) Morris *et al.* (1992) (on the environmental remains from cliff samples), and the final excavation report, Morris *et al.* (1995). The survey in 1979 was a pilot study that investigated the archaeological resource at Freswick and assessed erosion damage; together with the excavations at Freswick Castle, the Freswick Links area was deemed larger and more important than previously believed. Excavation then focussed on the richest areas that were in danger of erosion or sand quarrying; these largely correspond to the 'heart' of the site (Morris *et al.* 1995, 6).

Excavation focussed on a few different areas, including the Northern Cliff, the Central Cliff, the Southern Cliff, and the Inland excavations that included the spatially separate areas 1, 3 and 9. The context types for each, and dating evidence, are summarised below in Appendix Table 1.10 to Appendix Table 1.15. These tables also link the chronological evidence for each context together, presenting the entire area in chronological as well as stratigraphic order.

1.13.1 The Northern Cliff area

Areas 4, 5 and 6 were probably deflated middens, having lost their sand content leaving the heavier contents on the underlying dune (Morris *et al.* 1995, 58). No structures were expected or encountered, and all deposits were either midden or sand, except for the cultivation horizon in area 6 and a sandy container type feature in area 4, possibly natural (Morris *et al.* 1995, 50, 60). The midden deposits of area 5, phases R and T, may be indicative of a nearby occupation centre, not excavated. Areas 6 and 4 may have been in fields, given the cultivation horizon of area 6. Area 10 is further north, and was only used for midden deposition in the latest phase, implying occupation spread or movement through time from a more restricted settlement.

1.13.2 The Central Cliff area

Further excavation was planned for areas 7 and 8, the 1995 publication thus representing an interim report. Significant quantities of bloom-working wastes and some structural evidence were found in both areas, as well as debris from either raking out a smithing furnace, or from the furnace itself in area 8 (Batey 1995, 133). The context types and dates of zooarchaeological material are summarised in Appendix Table 1.13 and Appendix Table 1.14.

1.13.3 Southern Cliff area

Finds from areas 11, 12, 13 and 14 suggested industrial activity (Batey 1995, 134). The contextual and chronological evidence for the excavation units in this area are shown in Appendix Table 1.11.

1.13.4 Inland Excavations areas

Area 1 was located at the broch excavated by antiquarians, areas 3 and 9 were rescue excavations in eroded areas, and because further work was going to occur in area 2, it was not discussed in the 1995 publication. A variety of midden layers were found in area 1, including several associated with structural deposits that had higher densities of midden than those to the exterior (Morris *et al.* 1995, 98, 103). Area 3 features included a possible cultivation horizon, possible post-holes, a curvilinear ditch, a stone feature and a cist-burial (disturbed) (Morris *et al.* 1995, 120). Finds indicate this central area was an industrial centre for the settlement, as iron smithies must have been located in this area. The context types and dating evidence for the zooarchaeological material from areas 3 and 9 are summarised in Appendix Table 1.12 and Appendix Table 1.15.

Area 4 Phase (earliest first)	*Context types containing bone*	*Dates*	*Area 5 Phase (earliest first)*	*Context types containing bone*	*Dates*	*Area 6 Phase (earliest first)*	*Context types containing bone*	*Dates*	*Area 10 Phase (earliest first)*	*Context types containing bone*	*Dates*
			Phase R Sample 358	Midden dumps included sand with peat, sand with charcoal or peat, and a grey clayey layer with stones							
						Phase V Samples 262 (from dune sand) 263-266, 268-269 (from cultivation layer)	Dune sand and a dark shell sand cultivation layer				
			Phase T Sample 357	Grey clayey sandy midden with charcoal or peat							
									Phase W Samples 561-562	Two coarse grey shell sand layers with molluscs, probably an open surface near an occupation site	
			Phase V Sample 350-352	Brown layer, probably deflated midden, sampled totally		Phase W Samples 170-171, 255-261	Occupation or midden-like layer, possibly a blown-out and deflated midden	Find of possible Viking type, or later			

			Phase W Sample 282, 355, 356	Greyish clean shell sand					Phase X Samples 550-560, 573, 574, 578-586	Thick layer of coarse white shell sand, dune formation	
			Phase X	Clean grey wind-blown sand		Phase X	Sand blow	Correlation with Zone D dates this to later Viking Age and earlier medieval			
Phase T Samples 68, 72-92, 94-96	Midden (several tipping events) including small dumps of burnt stones and shell midden, midden with charcoal inclusions	AD 1074-1280 (795±50 bp; 2SD)									
Phase U Samples 67-69	Rich shelly midden containing most of an adult cattle skeleton	AD 1020-1260 (870±50 bp; 2SD)	Phase Y Samples 154-169, 275-282, 284-288, 291, 294, 298	Dark brown stony midden with small dumps of peat ash or shell, variable consistency	AD 1005-1255 by pottery TL, C14 AD 1020-1276 (860±50 bp; 2SD); "Viking to Medieval" finds	Phase Y Samples 181-191	Dark brown midden layer, and an upper conflated midden dark sand with stones	Probably AD 1140-1400	Phase Y Samples 565, 566, 569, 570, 576, 582, 584, 585	Thin midden deflation including burnt stones and shell, mixed with modern turf	Pottery TL 950-1210

Phase V Samples 35-42, 44-66, 70-71	*Midden, a lower sandy deposit and* a darker upper deposit with mammal, burnt stones and ash	*This date referenced* the midden layer of phase U but was included here: AD 1044-1280 (810±50 bp; 2SD)									
Phase X Samples 2-34	Fish rich midden, also with shell, burnt stone and mammal and very solid; associated with a second solid fish rich layer found in adjacent cliff-section Column 2 (Rackham *et al.* 1984)	Associated dates suggest 12th to early 14th century; "Viking to Medieval" finds									
			Phase Z	Sand dune, turf and topsoil	Antler comb of 12-13th c. type	Phase Z	Light coloured sand dune				
Source: Morris *et al.* 1995, 50, 52, 61, 260, 277			Morris *et al.* 1995, 52-54, 61, 260, 277			Morris *et al.* 1995, 55, 57, 61, 260			Morris *et al.* 1995, 58-59, 61		

Appendix Table 1.10: Freswick Links, Northern Cliff, context types and dates of zooarchaeological material

Area 11			Area 12			Area 13			Area 14		
Phase (chronological, earliest first)	Context types containing bone	Dates	Phase (chronological, earliest first)	Context types containing bone	Dates	Phase (chronological, earliest first)	Context types containing bone	Dates	Phase (chronological, earliest first)	Context types containing bone	Dates
									Phase Q Sample 1080	Dark sand with shells and stones, organic but without enough inclusions to be midden, may be occupation layer	
									Phase R Samples 1047-1049, 110-1102 [sic]	Clean light sand with bands of darker, wind blown sand	
Phase T Samples 1519-1546	Layer of dark brown sand representing successive cultivations										
									Phase U Samples 1013-1021	Features with dark sand fill, including a post-hole, slot, stake-holes, all of which probably held timbers for a fence line	“Viking” style bone pin
									Phase V Samples 698, 699, 1000-1012	Cultivation layer with bands of dark and light sand	
						Phase V Samples 1073-1079	Brown sand with a stone feature				

			Phase W	*Sand dune*		*Phase W Samples 797-799, 1050-1058, 1063-1072*	*Light and dark sand layers, wind blown*	*AD 640-862 (1300±50 bp; 2SD)*	*Phase W Samples 686-697*	*Light loose sand, wind blow*	
Phase X Samples 618-624	Light sand		Phase X Samples 709-733	Brown sand covering previous cultivation marks, possibly representing part of the cultivation layer	AD 580-798 (1350±60 bp; 2SD)	Phase X Samples 755-784, 788-796, 1059-1062	Brown sand with patches of discoloured sand and bands of grey clay sand	"Viking" style comb fragment	Phase X Samples 654-685	Brown sands with shell	AD 694-1000 (1150±50 bp; 2SD)
Phase Y Samples 600-617	Midden in two layers without a distinction between them, possibly deflated		Phase Y Samples 700-703	Dark sand with shell and stones, probably a deflated midden		Phase Y Samples 750-754	Thin midden of dark sand with stones and shells, very eroded, and with a black sand dump		Phase Y Samples 630-653	Thin deflated midden, dark sandy earth with stones and shells	
Phase Z	Loose sandy topsoil, probably the top of the previous midden layer		Phase Z	Loose sandy topsoil on top of eroded midden		Phase Z	Topsoil		Phase Z	Loose sandy topsoil	
Source: Morris *et al.* 1995, 86-87			Morris *et al.* 1995, 88-89, 277			Morris *et al.* 1995, 90, 92, 260, 277			Morris *et al.* 1995, 93-95, 260		

Appendix Table 1.11: Freswick Links, Southern Cliff area, context types and dates for zooarchaeological material

Area 3 West			Area 3			Area 3 East		
Phase (chronological, earliest first)	Context types containing bone	Dates	Phase (chronological, earliest first)	Context types containing bone	Dates	Phase (chronological, earliest first)	Context types containing bone	Dates
			Phase P	Dark pink/brown sand 'a little midden-like'		Phase P	Sand layers containing midden or burrow fill	
Phase S	Midden with extensive mammal and burnt stone quantities		Phase S	Dark brown midden-like sandy loam		Phase S	Midden edged with a line of small stones	
Phase V	Large brown midden		Phase V	Sandy layers containing midden		Phase V	Widespread midden	
Phase X	Small midden-like patches possibly derived from an eroded midden							

Source: Morris *et al.* 1995, 114, 117

Appendix Table 1.12: Freswick Links, area 3, context types and dates of zooarchaeological material

Phase (chronological, earliest first)	Context types containing bone	Dates
Phase O	Mixed 'light' midden	
Phase P	Not containing bone: stone features including a drain, a possible wall	
Phase Q	Burnt midden covering stone features	
Phase R	Widespread discoloured sand and 'light' midden	
Phase S	Fairly thick sandy midden, and sandier midden	
Phase T	Thick mixed sandy layer with midden inclusions and burning	
Phase U	Rich midden layers	
Phase X	Not bone: drain from structure off site	
Phase Y	Dark clay sand with organic and midden material	

Source: Morris *et al.* 1995, 65, 68

Appendix Table 1.13: Freswick Links Central Cliff area 7, context types and dates of zooarchaeological material

Phase (chronological, earliest first)	Context types containing bone	Dates
Phase P	Thick rich midden	
Phase Q	Light sand	
Phase R	Extensive midden dump of mixed and variable nature, including a concentrated shelly deposit	
Phase S	Dune sands ranging in colour, and (not bone) features including small hollows and a gulley	
Phase T	A midden in two phases: upper, darker and richer, and lower and lighter; some areas of shelly concentrations	
Phase U	Continuation of previous midden, but darker and more compact, containing charcoal, burnt peat and stone inclusions	C14 to AD 540-980 (1290±110 bp; 2SD), TL to AD 1175-1345
Phase W	Not bone: features, possibly a wall line	
Phase Y	Midden, dark and well compacted with sand and burnt peat inclusions	

Source: Morris *et al.* 1995, 72, 83, 277

Appendix Table 1.14: Freswick Links Central Cliff area 8, context types and dates of zooarchaeological material

Phase (chronological, earliest first)	Context types containing bone	Dates
Phase O	Deep and disturbed midden layers associated with possible structures, and a cut fill containing large quantities of shells suggesting 'specialised' midden, and possible midden	
Phase Q	Midden layers of sand and sandy loam with burnt peat	
Phase S	Thin midden	
Phase U	Midden and sand blow lenses, not domestic midden due to industrial debris associated	Medieval date
Phase V	High quantities of midden probably due to earlier layers degrading, so of questionable date	
Phase W	Mixed sandy midden deposit	

Source: Morris *et al.* 1995, 105, 108, 109

Appendix Table 1.15: Freswick Links Inland area 9, context types and dates of zooarchaeological material

Sampling strategies used at Freswick were 'judgemental', because completely random or uniform locating of trenches was interrupted by sand dunes, the need to focus on areas of erosion, and the desire to revisit areas of previous antiquarian intervention. Sampling methods varied between areas, though an attempt was made at uniformity, with most midden and features sampled in quantity and sieved to 1mm. All other deposits used hand collection recovery (Jones 1995, 149). Considerable quantities of fish bones had been noted from earlier excavations and were taken into account when developing the sampling strategy. This therefore focused on fish recovery and aimed to identify species present, relative abundance, size, distribution across Freswick, and taphonomic background (Jones 1995, 149-50). Fish identification was not consistent across the site, with the differences between areas summarised in Appendix Table 1.16.

Area	Identification method	
Column samples	All bones and otoliths identified	
Areas 1, 3, 9	All bones and otoliths identified	
All other areas	Cod, ling, saithe, pollack, haddock	Otolith, premaxilla, dentary, cleithrum identified, all others not counted
	<300mm total length other gadids	All bones except vertebrae
	All other species	All bones

Source: Jones 1995, 153

Appendix Table 1.16: Fish identification methods used at Freswick

In general, the finds were of smaller quantity and lesser quality that those recovered from earlier excavations at Freswick. Metal working finds at Freswick suggest crude iron was refined here, probably in the vicinity of areas 2 and 3 of the inland focus (Batey 1995, 134-35). Middens investigated were not thought to be domestic dumps, suggesting they may all represent industrial function and therefore did not contain the wealth of artefacts expected in a domestic midden. Differences in artefactual, zooarchaeological and archaeobotanical assemblages between the southern area and the central and northern areas suggest some functional or temporal contrast, or at least a taphonomic difference (Batey 1995, 135), confirmed by the pottery analysis (Gaimster 1995, 144-47).

A chronological comparison between "Pictish" and Viking or medieval deposits suggested a general similarity in species and elements, though the earlier deposits were less densely deposited and were in poorer condition than the later ones (Jones 1995, 184-85, 188, 191). This could be a result of the younger age – and therefore better preservation – of the Viking and medieval material, or it could be a reflection of differential taphonomic histories. Some of the "Pictish" layers containing fish bone may have been cultivation horizons, suggesting midden material was used to fertilise fields, therefore becoming eroded. They could also represent deflated middens subject to wind scouring and erosion (Jones 1995, 188).

Before assessing any chronological change, the results of radiocarbon dating must be taken into account. Jones labelled the deposits from the Southern Cliff area as "Pictish", yet the dates for this phase include 580-798, 640-862 and 694-1000. All of these were taken on material which underlied the main deflated middens, suggesting that the midden material is more recent. Finds from this area include an antler comb fragment and a bone pin of "Viking" type, both of which are from layers that *pre-date* the midden deposits. Assuming that the middens contained more of the bone than the underlying cultivation layers and timber fenceline feature, the animal bone assemblage cannot justifiable be called "Pictish". Pictish items were found at Freswick (i.e. the copper alloy pin from area 3 but "essentially unstratified"), so there is no doubting that the site includes material from both the late Iron Age, the Viking Age and the medieval periods, but care must be taken in assuming that the Southern Cliff area deposits are solely "Pictish". Instead, the Southern Cliff area deposits should be termed late Iron Age to Viking Age, as will be used here.

Comparisons of mammal bones from all areas indicated substantial differences along the coastal strip. The Northern Cliff areas were more like 'true' midden, while those to the south were lighter and less rich and had cultivation marks. Quantities were variable: area 4 contained larger amounts than all three areas to its north, while within the Southern Cliff excavation units, quantities increased to the south away from the centre. Despite similar total weights of bone, the Northern Cliff area contained about half as many fragments as the Southern Cliff area, and correspondingly the rate of identification in the Northern area was much better than that in the South (Gidney 1995, 201). Cattle were found throughout both areas, yet caprines and pigs were found in greater numbers in the Southern areas. Clearly there are different economic patterns influencing both North and South deposits (Gidney 1995, 202).

Area 1, destruction layers from the broch, was not extensively sampled. This small assemblage probably dates to the late Iron Age or Pictish period, and has higher proportions of caprines compared to cattle – a contrast to the coastal cliff areas (Gidney 1995, 203). As larger ungulate fragments would likely be found during hand collection, this suggests a real difference in economic patterning between areas.

The deposit types and taphonomic processes that influenced the assemblage included midden dumps, sand blow, dune collapse, cultivation, manuring, naturally occurring soils, erosion, and conflation (Rackham 1995, 227). The differences found in the fish, mammal and bird reports may reflect taphonomic differences more than activity and behaviour variation. Rackham states, rather belatedly as this follows rather than precedes the specialist reports, that

> "comparisons [already made] between the areas therefore provide rather poor generalisations. The sequence in each trench needs to be interpreted, the layers with human influence identified and the nature of each of these determined. Comparisons between trenches should then be made on the basis of either changes in the manner of deposit formation, and what this might mean in terms of the human activities on the site, or on a comparison of layers with either probably or definitely similar formation processes, in order to establish the nature of any variability and to make valid interpretations" (Rackham 1995, 228).

Exact chronological equivalence is not required before a comparison can be made, because the interest lies more in spatial variation, not temporal. Rather than approaching this through identified fragments, the pre-identification post-sorting weights from samples was used to investigate variation within and between contexts, context types, phases and areas. Visual 3D graphs were preferred over any statistical analysis because they provided a more easily recognisable format that could be widely understood (Rackham 1995, 229). The main problem with this is that only fish bones of interest were sorted from sample residues and weighed, so although this was consistent within the Freswick project, comparisons with external data are impossible. Furthermore, recognising and collecting the four main elements from the five main gadids, while ignoring all other main gadid bones BUT collecting all bones from species other than those five main gadids, leads one to wonder how much was missed. Problems with this choice of display method include the difficulty of reading off all values from each layer or material type, because the three dimensional nature of the bar charts used often mean bars to the front of the graph obscure those to the back (i.e. Rackham 1995, Fig. 144). But, where visible, these graphs do provide an immediate idea of the variation within a layer both horizontally (between sample squares) and vertically (between spits).

Chronologically, similar function or consistency does not mean similar dates: variation is found throughout the deposits. Two alternative hypotheses regarding diachronic change were suggested: one, that activity shifted from the Southern Cliff area to the Central and Northern Cliff areas about the time of the Viking arrival, and two, that cultivation shifted to the Northern area from the south in the Viking period, with occupation continuing in the southern area (Morris *et al.* 1995, 264). However, it must be emphasised that the two periods cannot be directly compared because they each encompass different deposit types. Cultivation and manuring levels were found in the late Iron Age-Viking Age phases, and middens were conflated and eroded, while the later deposits represented primary midden and were better preserved (Morris *et al.* 1995, 268).

A 'spatial model' was suggested to explain most of the variety observed chronologically and spatially. Deposits biased towards marine resources were found near the shore, while the structural evidence and associated mammal bone were found further inland. Because of the greater erosion that had occurred from the late Iron Age-Viking Age period, these deposits were more in keeping with the inland later period deposits despite being located near the sea. Further excavation may in future reveal more medieval domestic style deposits, particularly at area 2 (this area was incompletely excavated and not discussed in any detail in the excavation report; the bone from this area was therefore not assessed).

Freswick was revisited by James Barrett during the course of his PhD, and multivariate statistical methods were applied to the dataset (Barrett 1995, 195). As discussed above, using the sample data from Freswick is difficult because not all elements of fish bone were removed from samples, nor were they completely sorted into their constituent components. However, as this method was applied consistently throughout the excavation, variation within Freswick can be approached. Weights of fish, mammal, bird and shell were investigated using correspondence analysis (Barrett 1995, Fig. 7.1), the results producing a scatter plot very similar to a tri-polar plot because of the overwhelming influence of the contributions of three inclusions: mammal, fish and shell (Barrett 1995, 195). Several trends were observed, as summarised in Appendix Table 1.17.

Area	Trend
Some samples from the central and northern cliff areas and area 9	Comprising almost entirely of fish bone
"Vast majority" of central and northern cliff area samples	Comprising shell and fish bone, with very little mammal
Some samples from the central cliff area and area 9	Comprising largely of mammal bone
Most northern cliff area samples	Contain very little mammal
Southern cliff area and area 3	Comprising largely shell and mammal

Source: Barrett 1995, 195-96

Appendix Table 1.17: Trends observed among the Freswick assemblage using correspondence analysis

Freswick provides an excellent example of the degree of spatial variation that can be investigated at a site. However, as with all sites, it is not without problems. The sheer quantity of data investigated here in a coherent manner is very useful, particularly as so many separate aspects of deposition formation and variation have been investigated. Comparison with other assemblages is possible for the mammal and bird assemblages, as they have been presented by layer, phase and area for species and elements (mammal only).

1.14 Tuquoy, Westray

Tuquoy is a major Viking Age and medieval settlement that has yet to be published (but see Owen 1993; Owen 2005). A survey carried out in 1981 identified quantities of midden overlaying and surrounding structural features, including externally plastered walls, floors and hearths; some of this was eroding out of the cliff edge (Owen 1993, 324). An excavation took place in 1982-83, revealing a rectilinear hall with high quality artefacts and a substantial bone assemblage (Owen 1993, 325). Later assessment using a trial trench running through the site, and supplementary auguring, identified the focus of settlement, with quantities of midden found towards the peripheries of that centre (Owen 1993, 324-25). A waterlogged pit was C14 dated to 820-950 (uncalibrated data not available) and located to the west of the excavation area, leading to suggestions that an earlier 9th or 10th century Viking Age settlement, with byres, may be the predecessor to the high status medieval features excavated in the 1982-83 season (Owen 1988, 8; Owen 1993, 330). Samples were taken from a variety of features, including middens, structures, cultivation layers, and the waterlogged pit; 20kg from each context was processed by flotation and wet sieving at 5mm and 1mm resolutions (Colley 1988, 1; Owen 1988, 6). The remainder of the matrix from these contexts was coarse sieved for artefacts and ecofacts; midden was the predominant content of all features in this trial trench (Owen 1993, 325).

The latest phase of the hall structure excavated during the 1982-83 season was dated to the mid 12th century by a runic inscription, and is thought to be of high status and probably comparable to the drinking hall at Earl's Bu, Orphir (Owen 1993, 327-28). This was then used as a dump for midden material from the later medieval settlement (Owen 1993, 328). A building was later constructed across the hall, possibly functioning as a smithy, but the stratigraphical relationship with the extensive midden deposits has not yet been made clear. Tuquoy has the advantage that settlement apparently extends into a later period without the disturbance of rabbits or modern interference as seen at other sites, permitting this site to be used as an indicator of chronological change for the end of the medieval period.

An unpublished report of the fish bone from the 1982-83 excavation, by Sarah Colley, is available (1988). This substantial assemblage of over 140,000 fragments from 135 contexts was derived from both hand collection and wet sieving to 5mm or 1mm. Proportions sampled varied by layer from 33%, 20% or lower (Colley 1988, 1). Colley investigated the variation found within the site, both between individual contexts, and between phases, and discovered that the species and elements represented and their sizes proportions were "remarkably similar" (Colley 1988, 6). The only variation observed was found in the last phases on the site, representing a period of dereliction and a post-medieval croft (Colley 1988, 7). Element proportions among the gadid family suggested no elements were over or under represented, indicating no evidence for interaction with other sites through the trade of prepared fish (Colley 1988, 3).

The full phasing information is not provided with this report, but some indications are provided of later medieval and post medieval phases, leaving those predating the medieval phases to be of assumed Viking Age or medieval date. These data are summarised in Appendix Table 1.18.

Phases (in stratigraphic order, lowest first)	Context types containing fish bone	Dates
Phase 1	Sandy layers below structure 1; not used because of the "uncertain nature of the deposits"	
Phase IIa	Construction of structure 1; two contexts with fish bone but <30 fragments	
Phase IIb	Wall fills of structure 1	
Phase IIIb	Floor of structure 1a, floor deposits (the floor may have been paved but later removed, although the report is not clear whether these deposits underlay the paving or were deposited at a later date), and peat ash spreads	
Phase IV	Floor and debris contexts associated with the construction of internal partitioning	

Phase V	Additional partitioning, flagged floor and soil floor	
Phase VI	Additional partitioning, wall fill and soil found within the building	
Contexts external to structure 1, not precisely phased	Entrance area, a soil surface, flagstones, an ash spread, and pit fills	
Phase VII	Destruction of structure 1, rubble deposits	
Phase VIII	Construction of structure 2a, wall cores	
Phase IX	Occupation of structure 2a, floor deposits, a stone 'box' of possible industrial function, and an external context	
Phase Xa	Destruction of structure 2a and construction of 2b, robber trench, an earth layer inside the structure, and a burnt patch	
Phase Xb	Wall core from structure 2b	
Phase XI	Occupation of structure 2B, floor layers, flagstones, burning and ash deposits	
Phase XIa	Re-use of structure 1d, wall core, floor layers and rubble deposits	
Phase XIb	Midden, rubble, clay soil, collapsed stones, clean soils, wall fill, windblown and disturbed	
Phase XIc	Midden deposits, fill and rubble	
Phase XIIa	Midden dumping, peat ash, stone scatter, middens, a winkle dump, soils and sandy earth	
Phase XIIb	Collapse, middens, rubble, ash and sand layers	
Phase XIIa-b	Interior of structure 2b, windblown sand, soil and stony sand	
Phase XIIIa	Wall fill, rubble, floor surface, midden and middeny earth	"Post-Norse"
Phase XIIIb	Wall fill, soil from floor, sandy soil, rubble and midden	
Phase XIIIa-b	Sand	
Phase XIVa	Dereliction phase, rubble, wall fill and midden contexts	
Phase XIVb	Sand	
Phase XV & XVIb	Building and kelp burning pits	Post-medieval

Source: Colley 1988, 15-19, 21

Appendix Table 1.18: Tuquoy, Westray, contextual and dating evidence for zooarchaeological material

Individual context summaries by species were provided for the larger phases, including IIIb, Xa, XIb (external), XIc (external), XIIa, XIIb, XIIIa and XVIa. Each phase had species and element data provided, though only for each combination of elements (cranial, jaw, other head, vertebrae, etc.). In general the only spatial comparisons made were related to sample size rather than context type: the larger the sample, the more diverse the range of species. The larger midden deposits from phase XIc were surprising in that they contained almost no non-gadid species (Colley 1988, 19), suggesting some behavioural patterns were responsible for this variation.

A similarly unpublished report by Sheila Hamilton-Dyer (1991) provides access to the bird bone assemblage. The site produced 657 bird bones, spread throughout all phases and context types. The number of identified fragments in any one phase was small, making statistical comparisons difficult. Hamilton-Dyer recognised that what might appear as chronological changes may actually be reflections of different context types (1991, 4). Data are provided by species, context and phase (Hamilton-Dyer 1991, Tab. 1); element data are not included but metrical data are (Hamilton-Dyer 1991, 8).

Tuquoy offers the greatest potential of any one site for spatial analysis of faunal material because of the wealth of contextual information available, together with access to the primary summary data for fish and birds. The lack of mammal data is a problem, as is the lack of securely dated phasing. However, the fish and bird assemblages will provide an extremely useful contribution to the project data set. These reports did not investigate the spatial nature of the site in detail, although they hinted at spatial patterning. No statistical comparisons were produced, and the only intra-site comments were reproduced above, but the great value of this site lies in its potential to illuminate inter- and intra-site spatial patterning.

1.15 Pool, Sanday

Pool phases 7 and 8 contain deposits that include the late Pictish period and the Viking Age. Phase 7 dated to the 'interface' period during which a roundhouse, already in use, was adapted for use into a longhouse type structure. Phase 8 represents the Viking Age settlement at Pool that ended in the mid 11th century (Bond 1994, 121). The site has not been published in full yet, and the only published reports that are available are incomplete: Julie Bond's PhD thesis (1994) discussed the mammal bone, though not in detail, and summary results were presented later by Bond (1998) and Nicholson (1998); a draft of the mammal bone chapter was provided (TP O'Connor pers. comm.) but only the text was available.

Sampling and hand collection were both used, and hand collection rates were apparently good. An unspecified quantity of soil from each context was dry sieved to 1cm and residues from flotation were sieved to 3mm (Nicholson 1998, 17). No significant differences were noted between the sieved and hand collected fish assemblages, suggesting hand collection was extremely diligent (Nicholson 1998, 17).

Midden material recovered during excavation was found associated with structures that had a long history of use and disuse. Midden was found infilling abandoned structures and alternately being dug into by later ones. Contexts were vetoed from inclusion in the faunal analysis if they could not be securely dated, or were mixed. Midden reused in other contexts, particularly wall coring, was not included due to the uncertainty surrounding its origin (Bond 1994, 267).

Bond discussed the problems of combining data from sub-phases together, a practise she followed for the earlier and smaller bone assemblages from Pool. However, for the later ones, including phases 7 and 8, she maintains all sub-phasing: two sub phases for phase 7 and five for phase 8. This is partly a reflection that each sub phase represents unique "major structural (and possibly functional) changes" (Bond 1994, 272). Despite recognising that each sub-phase may potentially represent a different functional unit of the site, or originate from a spatially separate unit possibly representing different human activities, the faunal discussions that followed did not test these differences. As the excavation of the site has not yet been fully published, the exact origins of the bones from phases 7 and 8 cannot be ascertained with certainty. While it may be assumed that they originate from middens, the spatial arrangements and their associated finds may provide information about status and function. It is not yet known whether the sub-phases are in chronological sequence, or if their order is defined in spatial and functional terms, as implied by the quote above. Nicholson mentioned that one context comprised otter spraint, but in general although there was probably some contextual variation, "details about the types of deposits producing fish bones will be given in the site report" (Nicholson 1998, 17). Phase 7.2 material mostly originated from large tip or midden contexts (Nicholson 1998, 22), but not entirely; the other deposits contributing to this phase must remain unknown for now. Some spatial patterning might be observed among the fish bones, to be discussed in the forthcoming excavation report, but "[i]n summary, there was no clear difference between the species or the size of bones from contexts within and outside buildings. None of the material could cogently be seen as directly associated with the use of a building" (Nicholson 1998, 22).

Bond's data tables presented the mammalian results by NISP and MNI (Bond 1994, Tab. B1, B2 and B3). Element distributions were discussed qualitatively in her text, but full quantification must wait for the finished report. Comparative data for the later phases included most of the published material available for Orkney and Shetland, and some consideration of the assemblages from other North Atlantic Norse colonies was included despite the economics of those island groups being substantially different from the Northern Isles.

In conclusion, the published Pool assemblage will be of great value to the zooarchaeology of the Northern Isles, but the various reports available now are limited. Spatial patterning has been considered for both the mammal and fish assemblages, but not fully investigated, yet. The data now available are from mixed context types and cannot be separated into their constituent parts. The value of this site to a spatial analysis of Orcadian bone must therefore be limited.

1.16 Scalloway, Shetland

Rescue excavations on the edge of the town of Scalloway revealed a lengthy settlement sequence from the Bronze Age to the medieval period, including a broch settlement and a medieval cemetery. The broch fell into disuse about the 8th century AD, and although there were no recognisably Viking or Norse structures excavated, an unknown settlement nearby probably used the broch as a site for rubbish disposal (Sharples 1998, Synopsis). This phase contained diagnostically Norse artefacts of 9th or 10th century date (Sharples 1998, 186), within a period of accumulation from the 8th to 14th centuries; this was classed as Block 7.1 within the "Final phase 3" (Sharples 1998, 206). Block 7.1 contained high quantities of fish and bird bone without comparison in earlier levels, and was associated with lower than expected quantities of finds and carbonised botanical remains (Sharples 1998, 80). The possibility that the Block 7.1 faunal assemblage represented natural deaths was rejected given the evidence for human activity provided by the fish assemblage (Sharples 1998, 206). Bone material from "Late phase 3" was interpreted as late Iron Age during excavation, on the basis of distinctive architectural features, but the bone may post-date the structure. Radiocarbon dates from this material extend into both the late Iron Age and Viking Age, suggesting a transitional date would be more appropriate for all bone from Late phase 3 (also confirmed by Barrett *et al.* (2001, 148)).

Almost 300 samples were taken from the entire site, each on average between 7 and 14L (Sharples 1998, 89). Spatial units of $2m^2$ were used during excavation (Sharples 1998, Fig. 69), and these were then graphically represented using three dimensional plots, similar to those used at Freswick Links (i.e. Morris *et al.* 1995, Fig. 154). Each corner of the *x* and *y* axes was anchored in space, with each vertical bar then representing the density of finds for each $2m^2$ unit. Comparing the quantities of bone and finds from this destruction phase (Block 7.1), it is possible to detect different spatial patterns of artefacts versus ecofacts. This may indicates the artefacts are residual while the environmental assemblage was not related to the earlier occupation of the site, but was the result of a different activity (Sharples 1998, 82). However, these graphs do not take into account differences in recovery strategies through block 7.1, or the potentially different volumes of soil processed. Also, because counts are used rather than weights, and not every context included in the graphs was sieved, a definite bias in fish bone counts is to be expected compared to mammal bone.

Mammal bone quantification was provided by raw NISP counts per context by species (i.e. Sharples 1998, Tab. 23), but all discussion followed quantification by MNI determined by pairing, without any consideration of size or fusion. Although this means that quantification by NISP and context type could be calculated for mammals, there are no comparative fish or bird values. The MNI value for each context was summed to produce a value for each block, in turn summed to produce a total for each phase (Sharples 1998, 91). The exception was Block 7.1, kept separate from associated blocks of the same phase because of its different origin and contextual associations. The emphasis of the mammal report was very much aimed at using metrical variation to assess change (O'Sullivan 1998b, 106-108), so although measurements were well recorded, element absolute counts were not provided. A substantial increase in the proportion of sheep was seen in Block 7.1 as compared to earlier layers (O'Sullivan 1998b, 109), but the quantification problems caused by successively summing MNI means this would have to be tested using the raw context-by-context counts. No differentiation between recovery methods was provided. Fusion data were provided by count, but these were combined for the entirety of the site, making it difficult to assess spatial or temporal variation (O'Sullivan 1998b, 128-29).

The fish recording method was explicitly described, but unfortunately MNI quantification was again applied to these data, and context-by-context counts were by class only (Sharples 1998, 93). A substantial increase in the number of fish bones recovered occurred between the early and late portions of phase 3, though again the proportions of sediment excavated and sampled was not taken into account (Cerón-Carrasco 1998a, Fig. 75). MNI was used for quantification, despite its problems as pointed out by the author (Cerón-Carrasco 1998a, 113). Block 7.1 was again kept separate from the other blocks that were quantified by phase, and although fish sizes were presented, these again used MNI counts (Cerón-Carrasco 1998a, Tab. 53). No element proportions were discussed, nor were any absolute NISP counts mentioned or differentiation in recovery methods provided.

Bird bone was quantified by NISP by species and by phase, and raw context-by-context counts were provided for the class. Block 7.1 kept separate from other phases (O'Sullivan 1998a, 116). The small size of this assemblage negated the calculation of MNI values, but this NISP approach would have made the fish and mammal bone assemblages much more useful for comparison.

Some additional data are provided by the site archive (Sharples 2003), including primary metrical data for cattle, sheep and pigs (but without phasing). Raw fish data are provided by context (therefore context type and block), recovery method, quantity, side, texture (1-5), erosion (1-5), condition (texture + erosion), species, size (vs/s/m/l/vl) and comments, including fragment area (proximal or distal), butchery, burning and pathologies. No lookup table is provided for the species and element lists, but if deciphered, this could provide access to the NISP counts by species and element by context and context type. No detailed mammal or bird bone reports were provided.

In conclusion, the Viking Age material from Scalloway are of moderate to excellent use by class, but very little use as a whole. Mammals had full NISP by species data provided for all contexts (and therefore context types), birds had full NISP by species data for Block 7.1, while fish species were quantified by successively-summed MNI counts, making them extremely difficult to use unless time is taken to quantify the archive report. No element distribution data were provided, but fish sizes were discussed by phase. Contextual variation has been considered at a broad level at Scalloway, in that the deposits from Block 7.1 (relating to the later deposition of bone in rubble layers of the broch) were quantified separately from the deposits that were contemporary with the broch and settlement. A useful method of initial non-statistical spatial analysis was used to illustrate spatial variation within the rubble layers overlying the broch, but this was not continued at a more detailed level using species data.

1.17 St. Boniface, Papa Westray

The area of archaeological importance at St. Boniface includes a high status late Iron Age settlement and what was probably "the premier ecclesiastical missionary centre for Orkney", with phases dating to both the pre-Norse and Norse periods, including a 12th century church (Lowe 1998, 3, 5, 9). Phase 5 represented a roundhouse settlement dating to the Early Iron Age. During phase 6.1 this became enclosed, then refurbished in the Middle Iron Age phase 6.2. This was then abandoned, settlement moving north to what became phase 7. Dates for this phase ranged from AD 250 to 750, though tending towards the later years. Phase 7.2 represented a period of plaggen soil formation during the late Iron Age or early Christian settlement. The site was then abandoned for much of the Viking Age, becoming resettled c. 1100-1250 (phase 8). During that time the farm mound was formed, and some post-roundhouse type structures may date to between 1100 and 1500 (Lowe 1998, 89, 124).

Sampling was extensive in area 1, the medieval farm mound: four columns were fully sampled from along the cliff face, their locations were chosen to "provide the optimum amount of spatial information on the mound's formation, allowing an assessment of both inter- and intra-context and context-group or 'block' variability". Every context from area 1 had at least 20L of sediment taken for processing. Each context from areas 2 and 3, the Iron Age settlement, were similarly sampled (Lowe 1998, 16-17).

About 3400L of sediment were processed, from all phases; individual quantities per phase are provided in order to estimate the differences in quantities sampled between phases (Lowe 1998, Tab. 15), although as the estimated volume of sediment per phase is not provided, it is difficult to fully estimate the proportion of sampled vs. unsampled sediment per phase. Densities of bone from each block were provided in g/L, and then discussed. Values of under 100g/L for mammal bone were defined as 'low'; only 5 blocks exceeded this, including infilling contexts from the abandonment of phase 6 and from rubble of phase 9. These small values led to the suggestion that the main midden deposits possibly were not been excavated (Lowe 1998, 109). Only three blocks had a density of greater than 20g/L of fish bone; these were from the farm mound. Fish bone density was low in phases 1 to 7, indicating fish were a barely exploited resource – but they later became used on a 'semi-industrial' scale in phase 8 (Lowe 1998, 109). Table 16 presented the density per 10L of sediment for all environmental components of samples, by context block. While this immediately allows a comparison between the different blocks, each block type was not included and must be cross-referenced with individual block descriptions. The potential bias that context types could introduce to this density study were not directly considered, despite the possibility that much of the variation observed could be caused by the sampling of different context types.

Despite the extensive sampling regime, the bone assemblages were small; mammal identified NISP for phase 7 was 19, and for phase 8 was 33 (McCormick 1998b, Tab. 26). Bird bone quantities were too small to permit any analysis; only 60 fragments were recovered from the entire St. Boniface site (Hamilton-Dyer 1998, 155).

No mention was made of hand collected material, so it may be assumed these data were derived only from samples. Using the material from the four sample columns taken from the farm mound, area 1, the internal variation of the mound was investigated. The average weight of bone (presumably mammal, fish and bird bone, although unspecified) was presented in Table 31 for contexts that were found in two or more of the sample columns, with the aim of using this measure to investigate the intra-context variation within the farm mound and attempt to estimate its centre. This proved unsuccessful, or rather, no patterns were observed because the sample sizes were so small (McCormick 1998b, 149), and no other methods were attempted. However, using the average weight within each context and sample column may have been a poor choice of statistic; ideally, a comparison of the classes present, by weight, taking into account sediment volume, may have been a better method of investigating intra-context variation. Or, species proportions of each context by sample column could have investigated this question. These could have allowed spatial trends to be noted that were hidden behind the total bone weight statistic. An approach like that used in the Birsay Bay area – where intra- and inter-context variation was approached by comparing weights of fish, mammal and shell – would have again provided an alternative method for exploring this spatial variation within the farm mound.

The fish assemblage was substantially larger than the mammal assemblage. All data were derived from samples sieved to 1mm (Cerón-Carrasco 1998b, 149). Fish were presented by phase only (with phase 6 divided into three parts), without a consideration of contextual or spatial variation. That said, the general consideration of fishing in phase 6 was "unclear...this reflects the mixture of contexts assigned to the phase" (Cerón-Carrasco 1998b, 153); why this contextual variation was not further investigated, given that the data must have been available, is not known. Phase 8, the medieval deposits from the farm mound, were investigated in greater detail by discussing element and butchery distributions (Cerón-Carrasco 1998b, 153-54, Tab. 38), but no intra-farm mound variation was examined. Samples sizes were large enough to warrant such an investigation, along similar lines to McCormick's inconclusive study of intra-site variation within the farm mound; this would have been an excellent opportunity to study both the different layers of the farm mound, and the variation within each layer. The required level of detail is not provided for further investigation. The potential differences between the representation of various elements as indicative of trade or exchange outside of St. Boniface was not discussed, although some patterns can be reconstructed using the published data. As elements were only discussed for one phase, chronological variation cannot be examined. In short, although some comparisons were made within St. Boniface and between comparative sites, more can be done.

In conclusion, the mammal and fish assemblages from phase 8 can be compared to other sieved assemblages of medieval date. Full species and element representation was provided for the fish assemblage, but only species identifications were provided for the mammals. Earlier and later phases were only quantified by species. Although an attempt had been made at examining the spatial analysis of the phase 8 mammal bone farm mound assemblage, the sample sizes were too small and the method used too imprecise to permit conclusions; the fish bone assemblage may have provided some answers, but those data were not investigated for spatial patterning.

1.18 Robert's Haven, Caithness

Seven columns were investigated at this medieval coastal site in Caithness after quantities of midden were found eroding out of a wave cut bank. Three areas of archaeological interest were identified, area A, a fish midden sampled using three columns, area B, midden and some structural evidence sampled using two columns, and area E, disturbed midden inland and associated with a ruined structure, sampled with a column and test pit (Barrett 2000a, 1-2). Area A contained only deposits from phase 1 (11th to 13th centuries), area B had some phase 1, some phase 2 (12th – 13th centuries) and some phase 3 (12th to 13th centuries) deposits, while area E dated from the 14th to 16th centuries (Barrett 2000a, 2; Mainland nd.a, 1). Although area A was dominated by fish, the presence of some domestic debris (including pottery that may indicate a "relatively high status domestic settlement") indicates the midden in that area was only a semi-specialised deposit (Barrett 1995, 216). Soil micromorphology samples were taken in addition to the sample strategy used to collect bone, with the aim of determining spatial patterning across the site in order to understand trends in rubbish disposal (Simpson and Barrett 1996, 543). Environmental sampling was complete: all sediment was processed through a flotation tank to 1mm (heavy) and 0.5mm (flot), with residues sorted to >4mm and some select sorting of the <4mm fraction (Barrett 2000a, 3). Some additional fish and bird bone has been recently identified from areas B and E, and the raw data has been made available for inclusion in this study (RL Parks pers. comm.).

Correspondence analysis was used to investigate the variation in weights of fish, mammal, bird and shell within >4mm sample residues (Barrett 1995, Fig. 7.2). The contributions of bird bone to samples had little effect on the results because the samples were dominated by the other components (Barrett 1995, 196). The main trends included samples from area A being mainly composed of fish (and shell), while areas E and B contained lower quantities of fish and higher proportions of mammal (Barrett 1995, 197). The quantities of the three classes of bone were then investigated using tripolar plots to graph proportional data (Barrett 1995, figures 7.4 – 7.7). Area A samples contained a much higher proportion of fish than mammal or bird, while area E samples had a generally higher level of mammal bone than fish bone (Barrett 1995, 197). Area B was more variable (Barrett 1995, 197, Figs. 7.5-7.6).

These spatial and chronological patterns were then investigated further by considering the densities of deposits throughout Robert's Haven. This was measured using grams of bone per litre of sediment (Barrett 1995, Figs. 7.8-7.11). Densities were variable, with a general trend towards higher values for area A and lower values for the later phase groups. The obvious conclusion from these investigations was that each area was subject to different taphonomic processes linked to spatially defined activities: area A was dominated by fish and probably was part of a midden containing waste from fish processing activities, area B was more variable and less dense, so probably was not the result of solely fish-based activity, while area E was spatially separate from the shore areas, was associated with a structure that may indicate domestic deposition, and was subject to taphonomic processes that resulted in a less well preserved assemblage (Barrett 1995, 198). These variables, though considerable, are both spatial and taphonomic with less emphasis on chronological variation. Turning then to the variable that could next be investigated, taphonomic patterning was examined in detail using thin section micromorphology and chemical analysis: area A may have experienced some pedoturbation but area B probably accumulated with little disturbance, while the upper layers of area E were probably affected by ploughing damage. The pH levels were consistent across all areas, accounting for none of the spatial variation (Barrett 1995, 199).

The proportion of identifiable mammal bone from hand collected material was very low at 4%, indicating a high rate of fragmentation (Mainland nd.a, 1, 2). As only 111 mammal fragments could be identified from the entire site (not including small mammals), full analysis was not possible. Most of the mammal bone was found in the phase 1 middens, with some from phase 2 middens and very small quantities from the post-medieval phases 3 and 4 (Mainland nd.a, 1). Condition was generally good indicating rapid burial. High proportions of neonatal and juvenile bone in phase 1 could reflect stock management or poor nutrition, but given the very small area and sample size investigated, it could represent spatial variation within the middens, "a heterogeneous bone distribution within the midden deposits" (Mainland nd.a, 3).

In conclusion, the fish data are ideal for both intra- and inter-site spatial analysis because they include not only species and element counts, but deposit types are known and additional information about them is available following micromorphology sampling

(Simpson and Barrett 1996). The mammal and bird assemblages are less useful because of their small sample sizes.

1.19 Sandwick North, Shetland

This rescue excavation on Unst, Shetland, produced three phases containing bone: phase 2, a midden dating to the 11-12th century; faunal material associated with structures in phase 3 dating to the 12-13th century; and phase 4, a midden deposit of 13-14th century that accumulated against a structure from phase 3 (Barrett and Oltmann 2000, 1). The nature of the deposit in phase 3 is not explicitly described, but the presence of a partial articulated sheep (Barrett and Oltmann 2000, 14) would indicate these were not floor deposits contemporary with occupation, but rather a later re-use or dumping in a disused building. Collection was mainly by hand recovery, with a small number of samples separately processed and sieved to 4mm, from which all bone was identified, 2-4mm, from which fish were identified, and <2mm (Barrett and Oltmann 2000, 1). Fish was the only class of material recovered in any quantity from sampled material, suggesting hand recovery of mammals and birds was good (Barrett and Oltmann 2000, 2). Unlike many other Northern Isles sites, the recording procedure is made explicit (Barrett and Oltmann 2000, 2-3), allowing both reconstruction of conclusions, and accurate comparisons with other assemblages to be made.

Butchery and element proportions indicate entire mammal carcasses were prepared and consumed on site, while fish were prepared, dried and consumed on site as well (Barrett and Oltmann 2000, 12, 16, 18). This suggests a self-sufficient subsistence economy based on fishing and pastoral agriculture, with wild bird exploitation as a secondary resource. Both inshore and deep water fishing was used, though a gradual shift towards predominately inshore occurred towards the last phase. The general shift towards smaller fish and increased sheep may indicate a reduction in wealth of the settlement over time (Barrett and Oltmann 2000, 20); this shall be explored in detail in Chapters Eight and Nine.

Tests comparing the degree of fragmentation, measured by contrasting the maximum linear dimension of each phase, resulted in some statistical differences: cod fragmentation was consistent throughout, but saithe were different between phases 2 and 3, and 2 and 4 (Barrett and Oltmann 2000, 4). The percent completeness for the main elements from cod and saithe was found to vary significantly between phases 2 and 4 for several elements, suggesting some real differences in the degree of fragmentation experienced by each phase. Phase 4 tended towards more complete specimens than phase 2 (Barrett and Oltmann 2000, Tab. 4), indicating a potential taphonomic bias towards duration of buried deposits. No significant differences were found when examining the maximum linear dimensions of cattle or caprines through the phases (Barrett and Oltmann 2000, 4), and no attempt was made to compare percent completeness of the mammalian elements through time, despite this having the potential to illuminate this pattern further. These statistical tests are unique in the zooarchaeological record of the Northern Isles: no other published or archive report has routinely applied statistics to such research questions.

Deposit type and location may have influenced the type of bone deposited. The assemblage from phase 3 was associated with a structure and contained higher proportions of mammal bone by both weight and total fragment count than the other two phases (Barrett and Oltmann 2000, 6). Phases 2 and 4 were both middens, although the phase 4 midden accumulated against an apparently disused structure, presumably to the exterior though unspecified. The greatest variation between these three phases is apparent in phase 4, with phases 2 and 3 tending to be more similar by both weight and fragment count proportions. The predominance of fish in phase 4 suggests its midden has a more specialised function than that of phase 2 or the deposits associated with structural remains in phase 3. Phase 4 tends towards statistically smaller cod and saithe than the earlier deposits (not because of preservation biases), as well as a smaller ratio of cod to saithe than earlier deposits (Barrett and Oltmann 2000, 8); both of these suggest a change in fishing and economic activity. The authors emphasised the correlation observed elsewhere, that middens with a dominant fish content tend to be located away from structures, while those with high mammalian content are positively associated with structures.

In conclusion, the spatial analysis applied to Sandwick North is ideal. Not only are spatial methods considered when analysing the data, but adequate data are provided for further work at this site. All methodology is explicit, and a thorough exploration of taphonomic issues has been included. This site has the potential to be compared both with hand collected and sieved assemblages so will prove very useful.

1.20 Conclusion

A summary of all the zooarchaeological sites critiqued above was provided in Chapter One, Table 1.1, using the assessments of each site provided in this appendix. Several themes became apparent when critiquing the ways in which spatial analysis had been applied to Northern Isles faunal data sets. Firstly, spatial considerations of assemblages were usually an incidental by-product of a chronological assessment, or where spatial analysis was used explicitly, it usually was lower in importance than temporal analysis. Secondly, the importance of well documented sampling procedures to spatial analysis became apparent. Finally, it is possible to compare the developments in zooarchaeology in the Northern Isles with more general trends in spatial analysis used in archaeology and zooarchaeology in Britain as a whole. These influences tended to be subtle but important.

The importance of sampling to spatial analysis has been noted above, particularly at sites with explicit methodologies and detailed data. Sampling permits an exploration of intra-context variation, as well as intra-feature homogeneity. Vertical and horizontal sampling of midden deposits, for example, illustrates changes in behavioural patterns and accumulation processes, as well as indicating taphonomic variation. Sampling in the Birsay Bay area has indicated that intra-context variation is best and easiest approached when weights of sample residues are compared. The weights of each class of bone can be used, to give an indication of different subsistence methods contributing to midden formation. This approach was used to success in the Birsay Bay area, but a later and similar method applied at St. Boniface to test variation within the farm mound was less successful.

The integration of the Northern Isles sites into the general trends of spatial analysis used in archaeology and zooarchaeology was not explicitly discussed. Only one spatial methodology paper was cited, and that was Halstead *et al.* (1978). This method of contrasting internal and external contexts was applied with limited success to the data from Saevar Howe. Hedges had difficultly assigning contexts to 'in' or 'out', nor did he discuss the problem of the interior of disused buildings being used as a dumping ground, and inadvertently, his test proved to be of greater interest to inter-site spatial analysis around the Birsay Bay area than to intra-site analysis of Saevar Howe. However, at least he used a method that was then current, and in doing so performed the first (by publication date) exploration of spatial patterning in the Northern Isles and Caithness. Many of the other methods used in spatial analysis in the 1970s and 80s were aimed at sites with higher levels of spatial resolution than those applied to sites in the Northern Isles and Caithness, and the emphasis that spatial analysis literature then placed upon prehistoric and ethnoarchaeological activity areas was not directly applicable either. The more statistically complex methods of spatial analysis were not applied either, but the later excavations in the Northern Isles could have considered them. Some tests of statistical significance began to be applied to sites from the 1990s (i.e. Sandwick North), but these were rare despite their relatively simple methodology. The calculation of ratios was applied by Bigelow at Sandwick to investigate proportions of gadid fish through time and between middens, and by the author to investigate changes through time (and intra-site functionality) in domestic mammal measurements at Newark Bay.

In conclusion, although spatial analysis was considered throughout many of the zooarchaeological investigations in the Northern Isles, it could have been applied in more detail. Statistical methods have been noticeably lacking at most sites, but most assemblages were published in a form that permits retrospective statistical analyses. The problems and advantages of using the data from each site have been discussed above and will be considered throughout this thesis.

Appendix Two: Statistical methods and examples

This appendix provides detailed examples of all inferential statistical techniques used in this thesis, including Chi Square, Kruskal-Wallis, Kolmogorov-Smirnov, Spearman's Rho and Mann-Whitney U. An example from the text is provided for each type of test, together with descriptions of how the results in the text should be interpreted.

24.1 Chi Square Tests

Chi Square tests were applied to counts of species, usually arranged by phase, and were useful to define significant spatial or chronological patterning. Examples included testing if there was a significant change in species compositions within each class of animal at sites that had been well sieved and that had large assemblages. What follows describes the process of determining the level of significance from the raw dataset for a given question, using data from Quoygrew.

Question: is there no significant difference in bird species by NISP between phases?

The raw NISP data were extracted from Access into Excel and transformed into a contingency table using the pivot table function. The resulting spreadsheet displayed columns of NISP counts for each phase, against rows displaying species names. These were exported into Minitab and a Chi-Square test was applied, using the selected phases as the column variables. Results were generated, providing a Chi-Square value (e.g. 49.803), the degrees of freedom (e.g. 10) and the significance level (e.g. $p<0.001$). Occasionally cells will have expected values <5.0, which is problematic if more than a fifth of all cells have expected values of <5.0 (Decon nd.). The test cannot proceed if any cells have expected values of <1.0. In this case, one cell has an expected values of <5.0, which is acceptable given that it represents less than one fifth of all cases. However, for tests that produce a statistically significant result yet have expected values of <5.0 for over one fifth of all cases, the data need to be manipulated to reduce the number of unacceptable cases. This can include grouping smaller variables (e.g. combining species at the family level), or removing cases altogether.

Answer: there is a statistical difference in bird species by NISP, between phases.

24.2 Kruskal-Wallis Tests

The Kruskal-Wallis test was applied to larger datasets or ordinal data to determine if any significant difference was present within them, and whether they would be appropriate for further testing of each pair of variables within the dataset using the Kolmogorov-Smirnov test. Examples include testing if there was a significant difference in fish textures between all phase groups from a site, or whether or not size category variation in fish differed significantly between phase groups within a site. If results were significant, the Kolmogorov-Smirnov test could be applied to pairs of phases to isolate the significant patterning. What follows describes the process of determining the level of significance from the raw dataset for a given question, using data from Earl's Bu.

Question: is there no significant difference in cod textures between phase groups?

The raw data were extracted from the Access database into an Excel spreadsheet, and re-coded into a form suitable for SPSS (each phase group was given a code from 1 to 10, and each texture from 1=excellent to 3=poor). The resulting spreadsheet looked as follows, each row representing one cod recorded bone fragment:

Phase group	Texture
10	2
8	2
3	3
...	...

This was then exported into SPSS and a Kruskal-Wallis test for several independent samples was applied to the data, the test variable being the texture, the grouping variable the phase groups. The results were as follows:

Test Statistics[a,b]

	TEXT
Chi-Square	183.396
df	9
Asymp. Sig.	.000

[a] Kruskal Wallis Test

[b] Grouping Variable: PH

The values quoted in the text of the thesis are the Chi-Square value (183.396), the degrees of freedom (9), and the level of significance (<0.001).

Answer: there is a statistically significant difference in cod textures between phase groups. In order to find which phase groups differ significantly from others, the Kolmogorov-Smirnov test must be applied to the data.

24.3 Kolmogorov-Smirnov Tests

Two sample Kolmogorov-Smirnov tests were used to investigate the statistical significance of variations in ordinal categories such as size, recovery methods, element percent completeness, phase groups, etc., sometimes following a Kruskal Wallis test on larger datasets (described above). What follows describes the process of determining the level of significance from the raw dataset for a given question, using data from Earl's Bu.

Question: is there no statistical difference between the sizes of cod recovered by hand, against those recovered by sieving (>4mm)?

The raw data were then extracted from the Access database into an Excel spreadsheet, and re-coded into a form suitable for SPSS (numerical codes given to recovery methods, 1=sieved, 2= hand collection, and fish sizes, 1=<150mm ... 6=>1000mm total length. The resulting spreadsheet looked as follows, each row representing one cod recorded bone fragment:

Recovery method	Element size
1	6
2	5
1	3
...	...

This was exported into SPSS and a two-independent samples Kolmogorov-Smirnov Z test was applied to the data, the test variable being the element size, and the grouping variable the recovery method. The results were as follows:

Test Statistics[a]

		SZGM
Most Extreme Differences	Absolute	.359
	Positive	.359
	Negative	.000
Kolmogorov-Smirnov Z		4.340
Asymp. Sig. (2-tailed)		.000

[a] Grouping Variable: RECGM

The values quoted in thesis text are the greatest difference (0.359), the Kolmogorov-Smirnov Z value (4.340), and the significance level (<0.001).

Answer: there is a statistically significant difference between sizes of cod recovered by hand and by sieving (>4mm).

Some of the results of the Kolmogorov-Smirnov tests are displayed in large tables, in order to present the results of many significance tests in the most condensed way. This can be problematic, in that any repetition of a test will increase the opportunities for random errors to become incorporated in the results (Bernard 1994). These groups of tests should therefore be used more of as a heuristic guide than as an absolute answer, and as such, they are still an important method of pattern recognition. An example is presented below, using data from Earl's Bu. Each cell contains the result of a Kolmogorov-Smirnov test comparing the two phase groups listed in the row and column. For example, the first cell with values is the result of a Kolmogorov-Smirnov test of cod textures from phase group M3 compared to phase group M3c. Each cell lists the greatest difference, the Kolmogorov-Smirnov Z value, and the significance level. The results from the first cell are therefore not significant; there is no significant difference between textures in these two phase groups. Any cells displaying a significant result are highlighted in bold format.

Phase groups:	M3	M3a	M3b
M3c	0.020; 0.213; 1.000	**0.155; 2.941; 0.000**	0.044; 0.888; 0.410
M3b	0.064; 0.672; 0.757	**0.111; 2.073; 0.000**	
M3a	**0.175; 1.802; 0.003**		

24.4 Spearman's Rho Tests

Spearman's Rho tests were used to test various data that were in rank order, including to compare the rank order of elements from each phase. This describes the process of deriving a level of significance from raw NISP counts of elements, using data from Earl's Bu.

Question: Is there no statistical difference between the rank order of cod QC1 elements between phase groups C2 and M1?

The NISP counts for each of the nine QC1 elements were produced and ranked in order using Excel:

Elements	NISP		Rank order	
	C2	M1	C2	M1
Articular	2	4	3.5	1.0
Cleithrum	2	9	3.5	5.5
Dentary	1	7	1.5	3.0
Maxilla	4	7	5.5	3.0
Parasphenoid	13	11	9.0	7.5
Posttemporal	1	7	1.5	3.0
Premaxilla	7	11	7.5	7.5
Quadrate	7	16	7.5	9.0
Vomer	4	9	5.5	5.5

The rank orders were then pasted into SPSS and a bivariate correlation was applied to the data, with the ranks of both phases compared. The results were as follows:

Correlations

			cod C2	cod M1
Spearman's rho	cod C2	Correlation Coefficient	1.000	.778*
		Sig. (2-tailed)	.	.013
		N	9	9
	cod M1	Correlation Coefficient	.778*	1.000
		Sig. (2-tailed)	.013	.
		N	9	9

*. Correlation is significant at the .05 level (2-tailed).

The values quoted throughout the thesis are the correlation coefficient (0.778), the number of categories tested (n=9) and the significance level (<0.013).

Answer: there is a significant difference in the rank order of cod QC1 elements between phase groups C2 and M1.

Some of the results of the Spearman's Rho tests are occasionally presented in large tables when multiple phases are tested, as discussed above for Kolmogorov-Smirnov tests.

24.5Mann-Whitney U Test

The Mann-Whitney U test was applied to metrical data that were not normally distributed to determine if there was a significant difference in sizes between phases, including assessing differences in fragmentation levels between phases. Maximum linear dimensions for the most frequently occurring element from one species and size of fish could be tested to establish if some phases were more fragmented than others, and thus provide a baseline taphonomic fragmentation signature. What follows describes this process, using data from Quoygrew.

Question: is there no statistical difference in fragmentation levels between phases for dentaries from 800 to 1000mm length cod (all from >4mm recovery)?

The raw data were extracted from Access into Excel, and re-coded into a form suitable for SPSS (Area G, phase ii became 602, phase iii 603). The resulting spreadsheet looked as follows, each row representing one cod dentary from 800-1000mm length cod:

Maximum linear dimension (mm)	Phase
39.05	603
40.60	603
41.87	602
...	...

This was exported into SPSS and a two-independent samples Mann-Whitney U test was applied to the data, the test variable being the maximum linear dimension, and the grouping variable the two phases. The results were as follows:

Test Statistics[a]

	Maximum linear dimension
Mann-Whitney U	494.000
Wilcoxon W	770.000
Z	-3.427
Asymp. Sig. (2-tailed)	.001

[a] Grouping Variable: PHASENUM

The values quoted in the thesis text are the Mann-Whitney U value (494.000), the Z value (-3.427) and the significance level (0.001).

Answer: there is a statistically significant difference between the maximum linear dimension of dentaries from 800-1000mm total length cod between phases.

Appendix Three: Latin names and element codes

25.1 Common and latin names of fish species

Following Wheeler (1992)

Common name	*Latin name*
Basking shark	*Cetorhinus maximus*
Smallspotted catshark	*Scyliorhinus canicula*
Tope shark	*Galeorhinus galeus*
Spurdog	*Squalus acanthias*
Thornback ray	*Raja clavata*
Atlantic herrings	*Clupea harengus*
Allis Shad/Twaite Shad	*Alosa alosa/Alosa fallax*
Atlantic salmon	*Salmo salar*
Trout	*Salmo trutta*
Eel	*Anguilla anguilla*
Conger eel	*Conger conger*
Needlefishes/Sauries	*Belonidae/Scomberesocidae*
Garfish	*Belone belone*
Three-spined stickleback	*Gasterosteus aculeatus*
Hake	*Merluccius merluccius*
Cod	*Gadus morhua*
Haddock	*Melanogrammus aeglefinus*
Whiting	*Merlangius merlangus*
Pollack	*Pollachius pollachius*
Saithe	*Pollachius virens*
Norway pout	*Trisopterus esmarki*
Bib	*Trisopterus luscus*
Poor-cod	*Trisopterus minutus*
Torsk	*Brosme brosme*
Rockling	*Ciliata/Gaidropsarus*
Five-bearded rockling	*Ciliata mustela*
Four-bearded rockling	*Rhinonemus cimbrius*
Shore rockling	*Gaidropsarus mediterraneus*
Three-bearded rockling	*Gaidropsaurus vulgaris*
Tadpole fish	*Raniceps raninus*
Ling	*Molva molva*
Greater fork-beard	*Phycis blennoides*
John Dory	*Zeus faber*
European seabass	*Dicentrarchus labrax*
Atlantic horse-mackerel	*Trachurus trachurus*
Red sea bream	*Pagellus bogaraveo*
Black sea bream	*Spondyliosoma cantharus*
Goldsinny wrasse	*Ctenolabrus rupestris*
Ballan wrasse	*Labrus bergylta*
Cuckoo wrasse	*Labrus bimaculatus*
Corkwing wrasse	*Symphodus (Crenilabrus) melops*
Greater sand-eel	*Hyperoplus lanceolatus*

Tuna	*Katsuwonus/Sarda/Thunnus*
Atlantic mackerel	*Scomber scombrus*
Black goby	*Gobius niger*
Dragonet	*Callionymus*
Shanny	*Lipophrys pholis*
Wolf-fish	*Anarhichas lupus*
Yarrell's blenny	*Chirolophis ascanii*
Snake blenny	*Lumpenus lampretaeformis*
Butterfish	*Pholis gunnellus*
Viviparous eelpout	*Zoarces viviparus*
Thick-lipped grey mullet	*Chelon labrosus*
Red gurnard	*Aspitrigla cuculus*
Grey gurnard	*Eutrigla gurnardus*
Tub gurnard	*Trigla lucerna*
Bull-rout	*Myoxocephalus scorpius*
Sea scorpion	*Taurulus bubalis*
Bullhead	*Cottus gobio*
Hooknose	*Agonus cataphractus*
Lumpsucker	*Cyclopterus lumpus*
Megrim	*Lepidorhombus whiffiagonis*
Turbot	*Scophthalmus maximus*
Topknot	*Zeugopterus punctatus*
Witch	*Glyptocephalus cynoglossus*
Halibut	*Hippoglossus hippoglossus*
Dab	*Limanda limanda*
Lemon sole	*Microstomus kitt*
Flounder	*Pleuronectes flesus*
Plaice	*Pleuronectes platessa*
Sole	*Solea solea*
Angler	*Lophius piscatorius*

25.2 Common and latin names of mammal species

Following Gentry *et al.* (2004)

Common name	Latin name
Pigmy shrew	*Sorex minutus*
Common shrew	*Sorex araneus*
Mole	*Talpa europaea*
Dog	*Canis familiaris*
Stoat	*Mustela erminea*
Otter	*Lutra lutra*
Cat	*Felis catus*
Horse	*Equus caballus*
Pig	*Sus domesticus*
Red deer	*Cervus elaphus*
Roe deer	*Capreolus capreolus*
Cattle	*Bos taurus*
Sheep	*Ovis aries*
Goat	*Capra hircus*
Bank vole	*Clethrionomys glareolus*
Orkney vole	*Microtus arvalis*
Water vole	*Arvicola terrestris*
Wood Mouse	*Apodemus sylvaticus*
House Mouse	*Mus musculus*
Common rat	*Rattus norvegicus*
Rabbit	*Oryctolagus cuniculus*

25.3 Common and latin names of bird species

Following Snow and Perrins (1997)

Common name	Latin name
Great Northern Diver	*Gavia immer*
Red-throated Diver	*Gavia stellata*
Shearwater sp.	*Puffinus sp.*
Fulmar	*Fulmarus glacialis*
Manx Shearwater	*Puffinus puffinus*
Gannet	*Morus bassanus*
Cormorant	*Phalacrocorax carbo*
Shag	*Phalacrocorax aristotelis*
Grey Heron	*Ardea cinerea*
Swans	*Cygnus sp.*
Mute Swan	*Cygnus olor*
Whooper Swan	*Cygnus cygnus*
Goose	*Anser sp.*
Greylag Goose/ Bean Goose	*Anser anser/fabalis*
Domestic/Wild Greylag Goose	*Anser anser*
Shelduck	*Tadorna tadorna*
Mallard	*Anas platyrhynchos*
Teal	*Anas crecca*
Wigeon	*Anas penelope*
Shoveler	*Anas clypeata*
Eider	*Somateria mollissima*
Goldeneye	*Bucephala clangula*
Pochard	*Aythya ferina*
Red-breasted Merganser	*Mergus serrator*
White-tailed Eagle	*Haliaeetus albicilla*
Goshawk	*Accipiter gentilis*
Buzzard	*Buteo buteo*
Kestrel	*Falco tinnunculus*
Merlin	*Falco columbarius*
Red Grouse	*Lagopus lagopus*
Fowl	*Gallus gallus*
Crane	*Grus grus*
Oystercatcher	*Haematopus ostralegus*
Water Rail	*Rallus aquaticus*
Lapwing	*Vanellus vanellus*
Golden Plover	*Pluvialis apricaria*
Dunlin	*Calidris alpina*
Knot	*Calidris canutus*
Bar-tailed Godwit	*Limosa lapponica*
Curlew	*Numenius arquata*
Whimbrel	*Numenius phaeopus*
Greenshank	*Tringa nebularia*
Snipe	*Gallinago sp.*
Grey Phalarope	*Phalaropus fulicarius*

Pomarine Skua	*Stercorarius pomarinus*
Common Gull	*Larus canus*
Herring Gull	*Larus argentatus*
Lesser Black-backed Gull	*Larus fuscus*
Great Black-backed Gull	*Larus marinus*
Black-headed Gull	*Larus ridibundus*
Kittiwake	*Rissa tridactyla*
Great Auk	*Pinguinus impennis*
Razorbill	*Alca torda*
Guillemot	*Uria aalge*
Puffin	*Fratercula arctica*
Black Guillemot	*Cepphus grylle*
Little Auk	*Alle alle*
Rock Dove	*Columba livia*
Stock Dove	*Columba oenas*
Wood Pigeon	*Columba palumbus*
Short-eared Owl	*Asio flammeus*
Blackbird/Ring Ouzel	*Turdus merula/torquatus*
Redwing/ Song Thrush	*Turdus iliacus/philomelos*
Starling	*Sturnus vulgaris*
Rook/ Crow	*Corvus frugilegus/corone*
Carrion Crow	*Corvus corone*
Raven	*Corvus corax*

25.4 Earl's Bu fish element codes

QC1 elements:

Code	Full element name
a	Articular
cl	Cleithrum
d	Dentary
qd	Quadrate
mx	Maxilla
par	Parasphenoid
pt	Posttemporal
px	Premaxilla
vo	Vomer

QC2 elements:

Code	Full element name
av	Abdominal Vertebra
av1	Abdominal Vertebra Group 1
av2	Abdominal Vertebra Group 2
av3	Abdominal Vertebra Group 3
cv	Caudal Vertebra
cv1	Caudal Vertebra Group 1
cv2	Caudal Vertebra Group 2
fv	First Vertebra
puv	Penultimate Vertebra
uv	Ultimate Vertebra
v	Vertebra

QC3 elements:

Code	Full element name
bb	Basibranchial
bo	Basioccipital
bpt	Basipterygium
cd	Coracoid
ch	Ceratohyal
e	Ethmoid
ecp	Ectopterygoid
ex	Exoccipital
f	Frontal
hy	Hyomandibular
ih	Interhyal
io	Interopercular
la	Lacrimal
lhh	Lower Hypohyal
o	Opercular
opo	Opisthotic
pa	Palatine
pf	Prefrontal
pro	Prootic
pto	Pterotic
scl	Supracleithrum
scp	Scapula
soc	Supraoccipital
sph	Sphenotic
sy	Symplectic
uh	Urohyal
uhh	Upper Hypohyal

25.5 Quoygrew fish element codes

QC1 elements:

Code	Full element name
a	Articular
bo	Basioccipital
ch	Ceratohyal
cl	Cleithrum
d	Dentary
hy	Hyomandibular
iph	Infrapharyngeal
mx	Maxilla
o	Opercular
pa	Palatine
par	Parasphenoid
pt	Posttemporal
px	Premaxilla
po	Preopercular
qd	Quadrate
scp	Scapula
scl	Supracleithrum
vo	Vomer

QC2 elements:

Code	Full element name
av	Abdominal Vertebra
av1	Abdominal Vertebra Group 1
av2	Abdominal Vertebra Group 2
av3	Abdominal Vertebra Group 3
cv	Caudal Vertebra
cv1	Caudal Vertebra Group 1
cv2	Caudal Vertebra Group 2
fv	First Vertebra
puv	Penultimate Vertebra
uv	Ultimate Vertebra
v	Vertebra

QC4 elements:

Code	Full element name
ot	Otolith

Appendix Four: Quoygrew worked bone

The purpose of this appendix is primarily to illustrate the worked bone that was found when recording the mammal bone from Quoygrew. Bone artefacts are not included in this summary, and are outside of the scope of this thesis. These worked bones are of limited artefactual value because they are not of recognisable function – but some of them still have important ramifications for North Atlantic zooarchaeology.

Bigelow identified the trend for Norse sites to contain bi-perforated sheep metapodials, in which there is a perforation through to the marrow cavity on the distal shaft of the metapodial, either on the anterior or posterior aspects, and another perforation actually on the proximal articular surface, again through into the marrow cavity (1993, 441). One example from Quoygrew fulfils that criteria; this was from phase iii of the farm mound, and was a juvenile caprine metacarpal (illustrated below, Appendix Figure 4.1). A second example is fragmented, but shows a perforation in the proximal articular surface of a caprine metatarsal (Appendix Figure 4.2), again from phase iii of the farm mound. At least two further examples are known from floor layers and demolition fill from structures 1 and 2 in area F, but these have yet to be fully identified or analysed.

Appendix Figure 4.1: Bi-perforated caprine metacarpal from Quoygrew phase iii, inset shows proximal articular surface in greater detail (scale in cm)

Appendix Figure 4.2: Two views of the same proximal articular surface of a caprine metatarsal, from Quoygrew phase iii (scale in cm)

Examples of these metapodials have been previously found at Sandwick North, dating from c. 1100-1400. There, over 50 were found with various modifications, with about 30 to 35 bi-perforated (Bigelow 1993, 444). No examples had been found in Orkney or

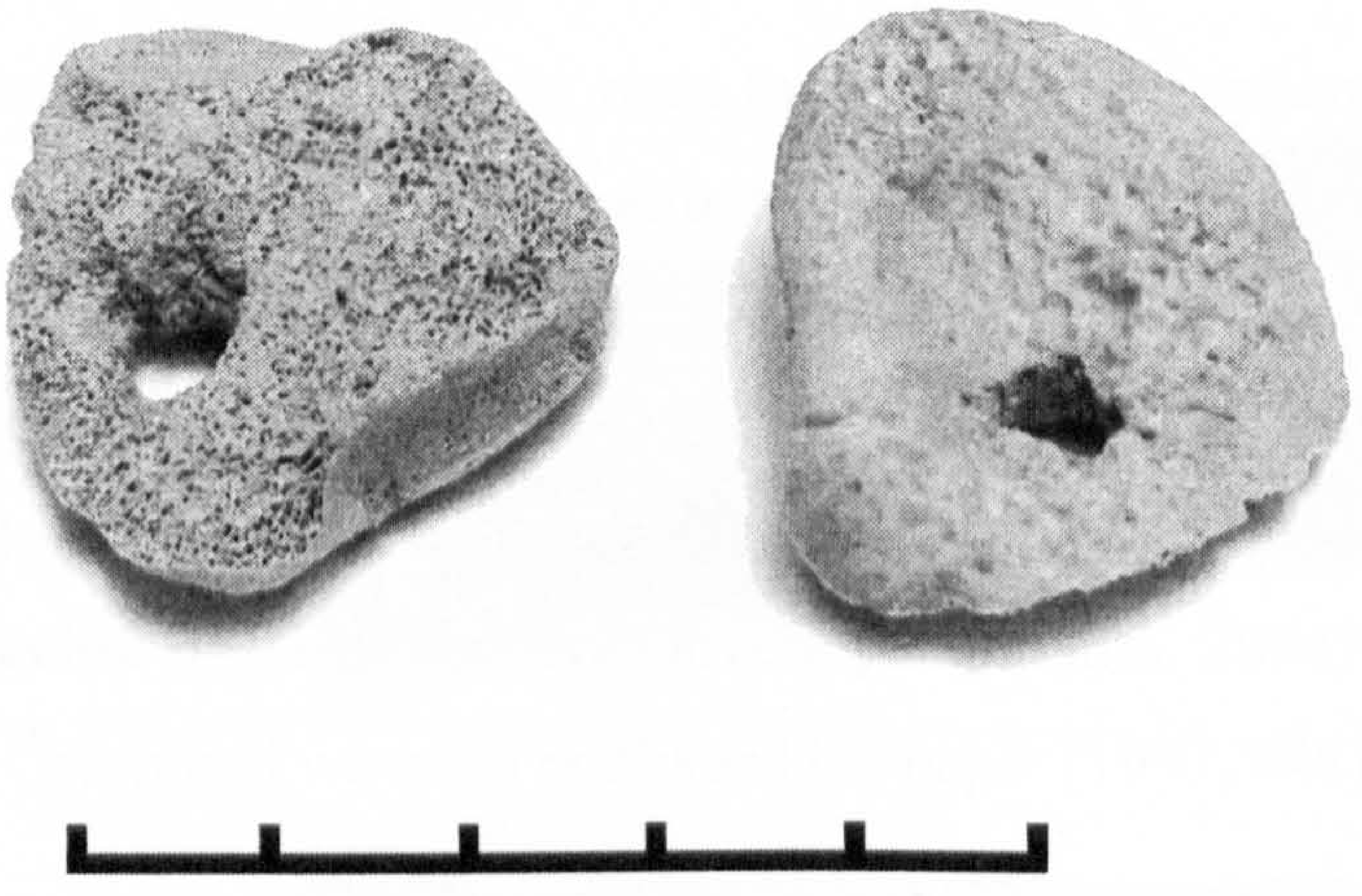
Caithness when Bigelow published his paper, and no examples were noted in the excavation reports for sites since published. At Pool, similar but not identical metapodials were found. Some of these were perforated proximally and are found from the 8th-9th century onwards, but some of these were modified into tools (JM Bond, pers. comm. 2004). Likewise, none had ever been found in Norway when Bigelow published his paper, but it was impossible to confirm that none has since been recorded in zooarchaeological reports since then. Bigelow knew of no examples from the Faroes, but some have since come to light from 1100-1200 (Arge 1995, as cited in O'Connor 2000, 47). In contrast "hundreds of examples" have been found in Iceland dating from about 1200 onwards (Bigelow 1993, 447; T McGovern pers. comm. 2004). Bigelow knew of no examples from Greenland when he published his paper (1993, 448).

The purpose of these metapodials is difficult to ascertain, because most do not appear to be tools because few show signs of wear around either perforation (Bigelow 1993, 443; also observed at Quoygrew). A 19th century account from Iceland provides one possible explanation: the holes were made to permit the marrow to be sucked out (Bigelow 1993, 449). This confirms a modern account from the Faroe Islands, "Arge (1995 [writing in Faeroese])... gives a delightful account from a present-day Faroe Islander which shows that the purpose was to blow nutritious bone marrow out of the marrow cavity, preferably straight into a child's mouth" (O'Connor 2000, 47). As has been illustrated using a simplified version of Outram's methods for assessing grease and marrow extraction, the long bones at Quoygrew were being exploited for marrow extraction (see Chapter Six). This explanation would fit, but it still leaves open the question of why the bones were not just cracked open or split at midshaft, as happened to most other bones from Quoygrew. They may have had additional value as a raw material, or there may have been taboos surrounding indeterminate cracking (as suggested in the 19th century explanation of bi-perforations in Iceland (Bigelow 1993, 449)).

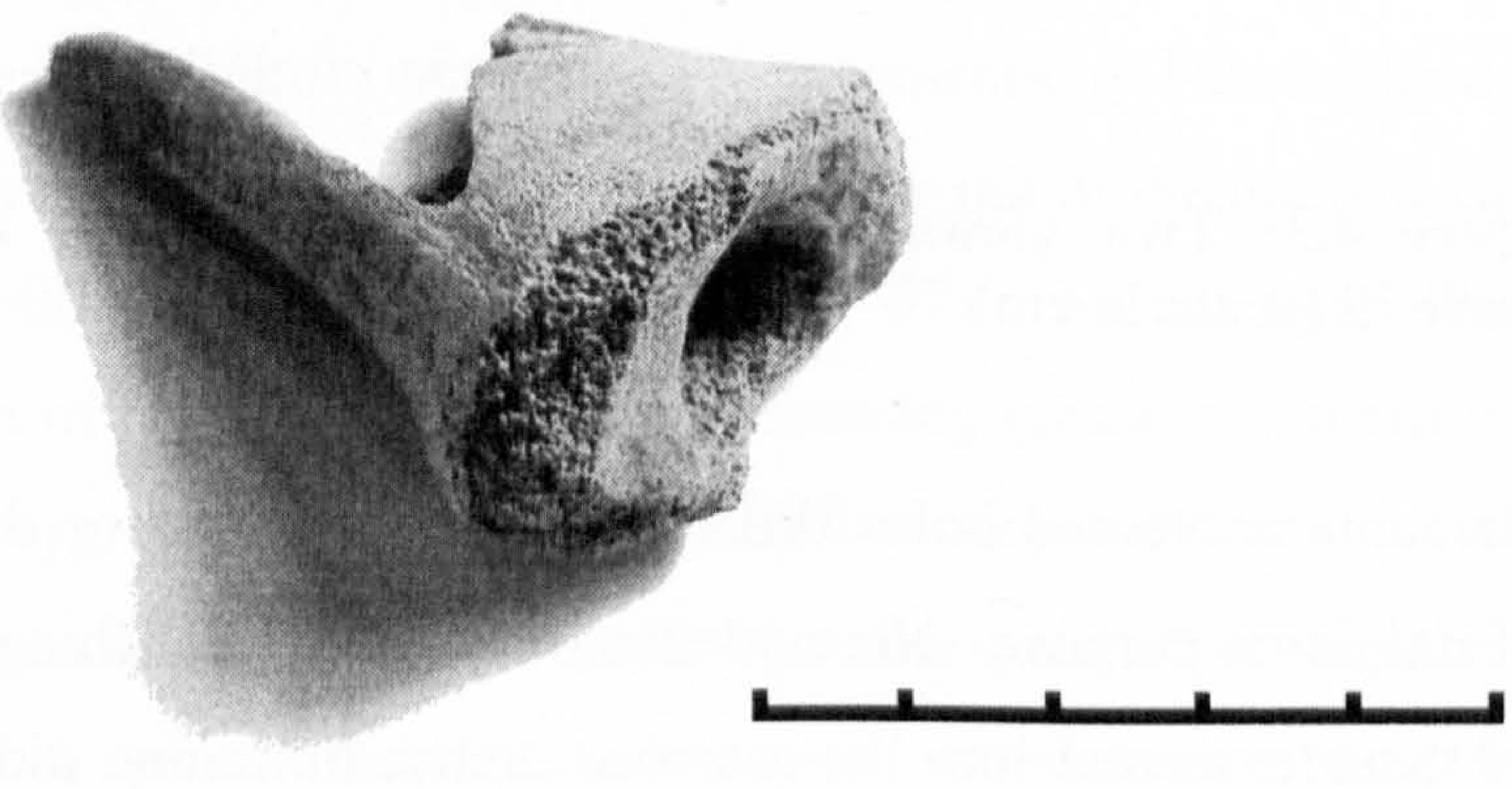
Metapodials and other elements pierced through the middle of the shaft can act as toggles, but these are very different from the bi-perforated examples discussed above. One juvenile pig metacarpal from phase iii at Quoygrew (Appendix Figure 4.3) likely functioned as a toggle (MacGregor 1985, 102-03), as did an unillustrated caprine metatarsal that was pierced at midshaft. This was recovered from a test pit near to Quoygrew, but is as yet undated. Perforated proximal cattle metapodials have been recovered from Anglo-Scandinavian contexts at York and other English sites, as well as from similar dates at Dorestad, but in these cases, the shaft tapered to a point and displayed evidence of wear (MacGregor 1985, 174-75).

Appendix Figure 4.3: Two views of the same perforated pig metacarpal from Quoygrew, phase iii (scale in cm)

Five further elements contained holes drilled into the proximal or distal ends of long bones, again of unknown purpose. No evidence of wear and polishing was noted in any case. Some of these extended into the marrow cavity, but some did not, though they extended quite a distance into the cancellous tissue of the epiphysis. Three of these are illustrated here. Appendix Figure 4.4 illustrates an unidentified element from phase ii (possibly juvenile cattle), and Appendix Figure 4.5 and Appendix Figure 4.6 both illustrate neonatal cattle proximal elements from phase iii. An adult cattle distal humerus from phase iii is illustrated in Appendix Figure 4.7. The one example not illustrated is a cattle neonatal proximal humerus, also from phase iii. All of these were very similar to the holes pierced in the proximal caprine metapodials, and may represent attempts to expose the marrow cavity, but neonatal bone does not generally contain marrow worth exploiting. In all cases, the shafts were broken, so it was not possible to see if any corresponding holes were found at the opposite epiphyses. The function of these is difficult to ascertain, but the presence of several elements with very similar holes suggests these represent a repeated action with a purpose.



Appendix Figure 4.4: Two views of the same unidentified mammal element with hole, from Quoygrew phase ii (scale in cm)

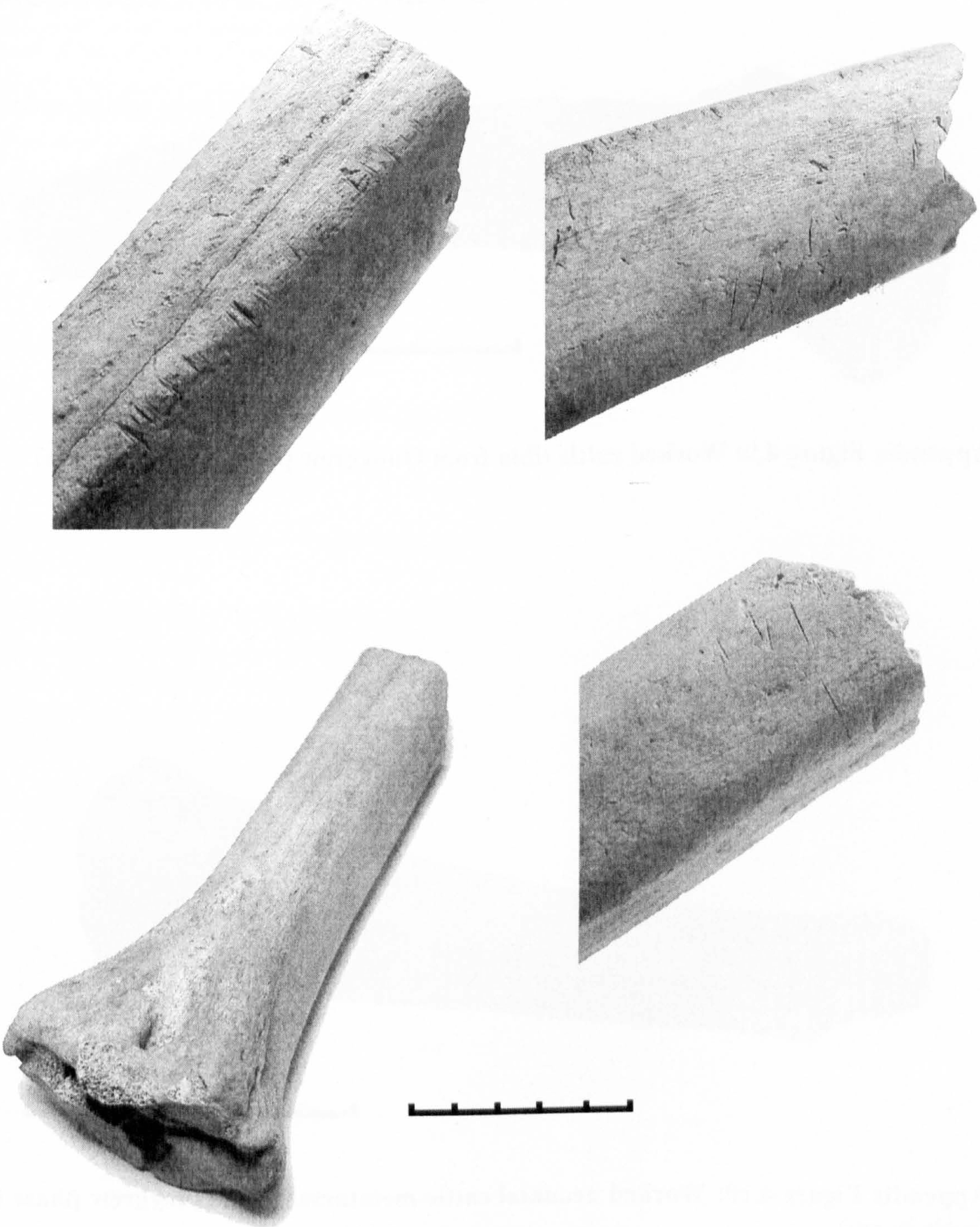


Appendix Figure 4.5: Neonatal proximal cattle radius with hole from Quoygrew phase iii (scale in cm)

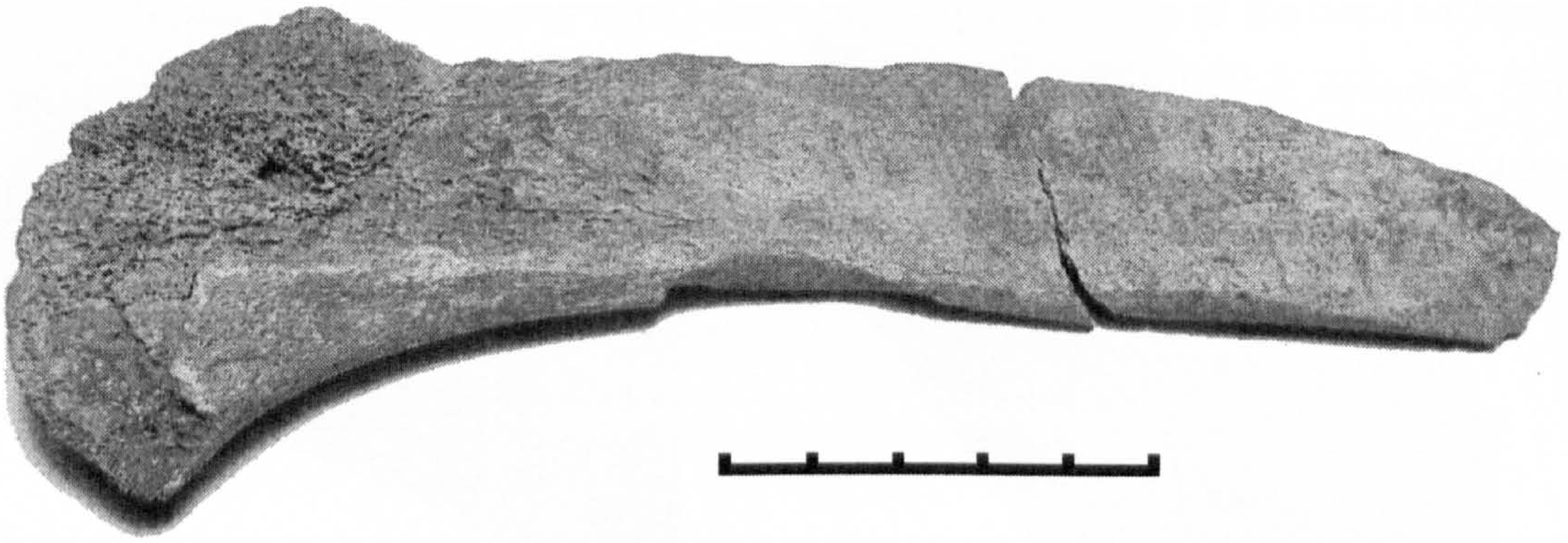
Appendix Figure 4.6: Juvenile proximal cattle tibia with hole, from Quoygrew phase iii (scale in cm)

Appendix Figure 4.7: Adult cattle distal humerus with hole, from Quoygrew phase iii (scale in cm)

Three further examples of worked bone are illustrated here. The first is a cattle metatarsal, illustrated in Appendix Figure 4.8. This was from phase iii and was covered with many fine knife cuts. The purpose of these is unknown. Two pieces of a proximal cattle tibia from phase ii may represent a 'blank' for artefact manufacture, illustrated in Appendix Figure 4.9, because rasp marks were found on the inside of the bone surface as though attempts had been made to flatten the surface. Finally, a neonatal cattle metatarsal from phase iii shows signs of working towards the distal epiphysis, illustrated in Appendix Figure 4.10. Neonatal bone tends to be weak and crumbles easily, making it a poor choice for bone working, which may explain why it was not worked further.



Appendix Figure 4.8: Four views of a cattle metatarsal from Quoygrew phase iii, many fine knife cuts; scale refers to complete picture (scale in cm)



Appendix Figure 4.9: Worked cattle tibia from Quoygrew phase ii (scale in mm)

Appendix Figure 4.10: Worked neonatal cattle metatarsal from Quoygrew phase iii (scale in cm)

Appendix Five: NISP Tables

Abbreviations used in the following tables:

Med: medieval
Hc: hand collected

Appendix Table 5.1: Fish NISP

Site	Sandwick North						Sandwick							Scalloway	
Dates	Med	11-12th c.	11-12th c.	12-13th c.	12-13th c.	13-14th c.	late 12th c.	late 12th c.	13th c.	13th c.	13th c.	late 13th to 14th c.	late 13th to 14th c.	late Iron Age to Viking Age	9-10th c.
Context types	?Midden	Midden	Midden	Midden associated with structure	Midden associated with structure	Midden associated with structure	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Mixed including midden infill, ditch fills	Midden in disused and collapsing broch
Recovery	Hc	>2mm	Hc	>2mm	Hc	Hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	Hc and sieving, MNI only	Hc and sieving, MNI only
Phase or area	Phase 1	Phase 2	Phase 2	Phase 3	Phase 3	Phase 4	Early phase, area 3	Early phase, area 4	Middle phase, area 2	Middle phase, area 3	Middle phase, area 4	Late phase, area 3	Late phase, area 4	Late phase 3	Block 7.1
Shark, skate, ray & chimaera							p			p	p				
Shark order							p	p					p	1 2.7%	10 5 3%
Shark, skate & ray orders															
Basking shark															
Dogfish family				1 0.6%											
Dogfish families															
Smallspotted catshark															
Tope shark															
Spurdog															
Ray family								p							1 0 5%
Thornback ray															
Atlantic herrings															
Allis Shad/Twaite Shad														4 10 8%	1 0 5%
Salmon & trout family															
Salmon/trout															
Atlantic salmon															
Trout														5 13 5%	6 3 2%
Eel															1 0 5%
Conger eel															
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake					1 0 2%			1 2.7%		1 0 9%	2 6.3%	1 0.1%	1 0 3%		
Gadid	28	341 99 7%	2033 100%	161 99 4%	642 99 5%	810 99 8%	106 100%	36 97.3%	906 99 8%	111 98.2%	29 90 6%	806 99 8%	324 99 7%	23 62.2%	167 87 9%
John Dory															
Seabass Family															
European seabass															
Perch family															
Atlantic horse-mackerel			1 0%												
Sea beam family															
Red sea bream															
Black sea bream															
Wrasse family															
Goldsinny wrasse											1 3.1%	1 0.1%			
Ballan wrasse															

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																													
Corkwing wrasse																													
Sand-eel family																													
Greater sand-eel																													
Tuna																													
Atlantic mackerel		1	0.3%													2	0.2%	p		p		p		p					
Goby family																													
Black goby																													
Dragonet																													
Shanny																													
Wolf-fish																													
Yarrell's/ Snake blenny																													
Yarrell's blenny																													
Snake blenny																													
Butterfish																													
Eelpout Family																													
Viviparous eelpout																													
Thick-lipped grey mullet																													
Gurnard family								1	0.2%																				
Red gurnard																													
Grey gurnard						p																						1	0.5%
Tub gurnard																													
Sea scorpion family																													
Bull-rout																										1	2.7%	1	0.5%
Sea scorpion																													
Bullhead																													
Hooknose																													
Lumpsucker																													
Flatfish order								1	0.2%									1	0.9%							3	8.1%	2	1.1%
Turbot family																													
Megrim																													
Turbot																													
Topknot																													
Halibut family										1	0.1%																		
Witch																													
Halibut																													
Dab																													
Lemon sole																													
Flounder or plaice																													
Flounder																													
Plaice										1	0.1%																		
Sole																													
Angler																													
Total identified fish	28	342	100%	2034	100%	162	100%	645	100%	812	100%	106	100%	37	100%	908	100%	113	100%	32	100%	808	100%	325	100%	37	100%	190	100%
Unidentified fish	96	1293		4209		298		1370		1370		812		325		8321		882		267		4131		2556					
Total fish	124	1635		6243		460		2015		2182		918		362		9229		995		299		4939		2881		37		190	
Sources	Barrett and Oltmann 2000, Tables 11, 12											Bigelow 1984, Tables 11, 12, 13														Ceron-Cerrasco 1998, Tables 50, 53			
Notes	>4mm, plus vertebrae dentaries and premaxillae from >2mm											only 6 cranial elements and vertebrae identified and counted																	

Appendix Table 5.1: Fish NISP

Site	Jarlshof	St. Boniface						Quoygrew												Tuquoy							
Dates	early 9th c. to med	250 to 750		1100-1250		Med?		676-896		1066-1294		Med		Viking Age		779-981		1035-1261		Viking Age to med		Viking Age to med		Viking Age to med		Viking Age to med	
Context types	Mostly midden	Plaggen soils, ?midden		?Midden		?Midden		Fish midden		Fish midden		Fish midden		Farm mound midden		Farm mound midden		Farm mound midden		Sandy, mixed		Constru-ction		Wall fills		Floor deposits and ash layers	
Recovery	Selective hc	>1mm		>1mm		>1mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc	
Phase or area	Viking and medieval	Phase 7		Phase 8		Phase 9		Phase 1.2		Phase 2		Phase 7		Phase i		Phase ii		Phase iii		Phase I		Phase IIa		Phase IIb		Phase IIIb	
Shark, skate, ray & chimaera				4	0%	2	0.1%																				
Shark order																											
Shark, skate & ray orders																								1	0.3%		
Basking shark																											
Dogfish family						2	0.1%							2	1.7%	1	0%										
Dogfish families										1	0%			2	1.7%	33	0.9%	11	0.3%					4	1.2%		
Smallspotted catshark																											
Tope shark																											
Spurdog																5	0.1%										
Ray family										1	0%					1	0%										
Thornback ray				1	0%																						
Atlantic herrings				35	0.4%					9	0.4%					24	0.6%	20	0.6%								
Allis Shad/Twaite Shad																											
Salmon & trout family												1	2.8%														
Salmon/trout																											
Atlantic salmon																											
Trout																											
Eel				1	0%					2	0.1%					2	0.1%										
Conger eel				12	0.1%					2	0.1%							1	0%								
Needlefishes/Sauries										5	0.2%	1	2.8%	5	4.3%	169	4.4%	6	0.2%								
Garfish																68	1.8%										
Stickleback family																											
Three-spined stickleback																											
Hake																1	0%	1	0%								
Gadid	p	1315	99.3%	9144	98.9%	1354	99.1%	155	87.1%	2465	97.4%	33	91.7%	104	90.4%	3510	90.9%	3058	96%	161	100%	21		318	97.2%	574	99.8%
John Dory																											
Seabass Family																2	0.1%										
European seabass																											
Perch family																											
Atlantic horse-mackerel								2	1.1%							1	0%	1	0%								
Sea beam family																											
Red sea bream																											
Black sea bream																											
Wrasse family																1	0%										
Goldsinny wrasse																											
Ballan wrasse										1	0%					4	0.1%	1	0%					1	0.3%	1	0.2%

Appendix Table 5.1: Fish NISP

Cuckoo wrasse										1	0%																
Corkwing wrasse																											
Sand-eel family		3	0.2%	22	0.2%	4	0.3%	3	1.7%	10	0.4%					4	0.1%	22	0.7%								
Greater sand-eel																											
Tuna																											
Atlantic mackerel				1	0%											1	0%										
Goby family																											
Black goby																											
Dragonet														1	0.9%	1	0%	2	0.1%								
Shanny																											
Wolf-fish										9	0.4%																
Yarrell's/ Snake blenny																											
Yarrell's blenny																											
Snake blenny								4	2.2%	1	0%					1	0%	3	0.1%								
Butterfish				11	0.1%	2	0.1%			10	0.4%					3	0.1%	3	0.1%								
Eelpout Family								2	1.1%									5	0.2%								
Viviparous eelpout								1	0.6%	7	0.3%	1	2.8%					6	0.2%								
Thick-lipped grey mullet																											
Gurnard family																8	0.2%	1	0%								
Red gurnard																											
Grey gurnard																1	0%										
Tub gurnard								1	0.6%																		
Sea scorpion family		4	0.3%							3	0.1%					3	0.1%	8	0.3%								
Bull-rout		2	0.2%	7	0.1%	1	0.1%									1	0%	8	0.3%					1	0.3%		
Sea scorpion				3	0%					1	0%							3	0.1%								
Bullhead																		1	0%								
Hooknose						1	0.1%																				
Lumpsucker																											
Flatfish order								1	0.6%	1	0%					3	0.1%										
Turbot family																											
Megrim																								2	0.6%		
Turbot								1	0.6%									1	0%								
Topknot																											
Halibut family				7	0.1%			8	4.5%	1	0%			1	0.9%	9	0.2%	18	0.6%								
Witch																											
Halibut																											
Dab																1	0%										
Lemon sole																		3	0.1%								
Flounder or plaice																1	0%										
Flounder										1	0%					1	0%	2	0.1%								
Plaice																1	0%										
Sole																											
Angler																											
Total identified fish		1324	100%	9248	100%	1366	100%	178	100%	2531	100%	36	100%	115	100%	3861	100%	3185	100%	161	100%	21		327	100%	575	100%
Unidentified fish		1327		15642		2070		1049		10802		24		331		9443		16167		989		8		1014		3554	
Total fish		2651		24890		3436		1227		13333		60		446		13304		19352		1150		29		1341		4129	
Sources	Platt 1956	Ceron-Carrasco 1998b, Table 32						Chapter Six												Colley 1988							

Appendix Table 5.1: Fish NISP

Site	Tuquoy (continued)														
Dates	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med
Context types	Floor deposits, debris associated with interior building work	Floor deposits, debris associated with interior building work	Floor deposits, debris associated with interior building work	External to structure 1, including pit fills, ash, flagstone paving	Destruction and rubble	Construction and wall cores	Occupation, floor deposits, possible industrial function	Unknown	Destruction and construction	Wall cores	Occupation, floor deposits, ash	Unknown	Wall core, floor layers, rubble	Midden, rubble, collapse, wall fill etc.	Midden
Recovery	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc
Phase or area	Phase IV	Phase V	Phase VI	Phase III-VI	Phase VII	Phase VIII	Phase IX internal	Phase IX external	Phase Xa	Phase Xb	Phase XI internal	Phase XIa exterior	Phase XIa exterior S3	Phase XIb exterior	Phase XIb exterior midden only
Shark, skate, ray & chimaera							2 0.3%		1 0.1%					2 0.1%	
Shark order															
Shark, skate & ray orders							1 0.2%							5 0.3%	
Basking shark															
Dogfish family		1 0.4%		1 0.5%											
Dogfish families										2 1.3%				1 0.1%	
Smallspotted catshark															
Tope shark															
Spurdog															
Ray family															
Thornback ray		1 0.4%	1 0.4%			1 0.8%				1 0.6%					
Atlantic herrings															
Allis Shad/Twaite Shad															
Salmon & trout family															
Salmon/trout															
Atlantic salmon															
Trout															
Eel															
Conger eel												1 0.2%		1 0.1%	
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake															
Gadid	293 100%	260 99.2%	234 99.6%	217 99.1%	89 100%	119 99.2%	585 99.5%	30 100%	975 99.2%	154 98.1%	306 100%	548 99.5%	12 92.3%	1523 98.8%	455 100%
John Dory															
Seabass Family															
European seabass															
Perch family															
Atlantic horse-mackerel															
Sea beam family															
Red sea bream															
Black sea bream															
Wrasse family															
Goldsinny wrasse															
Ballan wrasse				1								1 0.2%		5 0.3%	

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																														
Corkwing wrasse																														
Sand-eel family																														
Greater sand-eel																														
Tuna																														
Atlantic mackerel																														
Goby family																														
Black goby																														
Dragonet																														
Shanny																														
Wolf-fish																														
Yarrell's/ Snake blenny																														
Yarrell's blenny																														
Snake blenny																														
Butterfish																											1	0.1%		
Eelpout Family																														
Viviparous eelpout																														
Thick-lipped grey mullet																														
Gurnard family																														
Red gurnard																														
Grey gurnard																														
Tub gurnard																														
Sea scorpion family																														
Bull-rout																														
Sea scorpion																														
Bullhead																														
Hooknose																														
Lumpsucker																														
Flatfish order																	1	0.1%					1	0.2%						
Turbot family																														
Megrim																	3	0.3%							1	7.7%				
Turbot																														
Topknot																														
Halibut family																														
Witch																														
Halibut																														
Dab																														
Lemon sole																														
Flounder or plaice																														
Flounder																														
Plaice																														
Sole																														
Angler																	3	0.3%									4	0.3%		
Total identified fish	293	100%	262	100%	235	100%	219	100%	89	100%	120	100%	588	100%	30	100%	983	100%	157	100%	306	100%	551	100%	13	100%	1542	100%	455	100%
Unidentified fish	1739		759		1610		2081		1199		63		3083		291		3229		230		1523		1591		5		5491		1155	
Total fish	2032		1021		1845		2300		1288		183		3671		321		4212		387		1829		2142		18		7033		1610	
Sources	Colley 1988																													

Appendix Table 5.1: Fish NISP

Site	Tuquoy (continued)																													
Dates	Viking Age to med		Viking Age to med		Viking Age to med		Viking Age to med		Viking Age to med		Viking Age to med		Viking Age to med		Viking Age to med		Med		Med		Med		Med		Med		Med		Med	
Context types	Unknown		Midden, rubble		Midden		Unknown		Midden		Unknown		Midden		Sand, soil, stony fill		Wall cores, floor surface, midden		Midden		Wall fill, soil, rubble, midden		Sand		Disuse, rubble, wall fill, middens		Midden		Sand	
Recovery	>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc	
Phase or area	Phase XIb exterior S3		Phase XIc exterior		Phase XIc exterior midden only		Phase XIIa		Phase XIIa midden only		Phase XIIb		Phase XIIb midden only		Phase XIIa/b		Phase XIIIa		Phase XIIIa midden only		Phase XIIIb		Phase XIIIa/b		Phase XIVa		Phase XIVa midden only		Phase XIVb	
Shark, skate, ray & chimaera							2	0%	2	0%	2	0%	2	0%																
Shark order			1	0%			2	0%			1	0%	1	0%											1	0.1%	1	0.1%	1	1.3%
Shark, skate & ray orders			1	0%			8	0.1%	8	0.1%	19	0.3%	16	0.3%	4	0.9%	5	0.2%	3	0.1%					6	0.3%	5	0.3%	1	1.3%
Basking shark																														
Dogfish family																														
Dogfish families							10	0.1%	5	0.1%	6	0.1%	6	0.1%	1	0.2%									35	1.8%	34	1.9%	4	5.1%
Smallspotted catshark																														
Tope shark																														
Spurdog																														
Ray family																														
Thornback ray															2	0.4%														
Atlantic herrings																														
Allis Shad/Twaite Shad																														
Salmon & trout family																														
Salmon/trout																														
Atlantic salmon																														
Trout																														
Eel							7	0.1%	7	0.1%	3	0%	3	0.1%	1	0.2%					2	0.5%			6	0.3%	6	0.3%		
Conger eel							1	0%	1	0%	1	0%													3	0.2%	2	0.1%	1	1.3%
Needlefishes/Sauries																														
Garfish																														
Stickleback family																														
Three-spined stickleback																														
Hake							2	0%	2	0%	1	0%	1	0%																
Gadid	31	100%	3119	99.7%	2459	99.9%	10251	99%	9395	99.1%	6073	98.7%	5096	98.6%	438	98%	2515	99.6%	2032	99.9%	427	97.5%	5		1732	91.3%	1616	91%	70	88.6%
John Dory																														
Seabass Family																														
European seabass																														
Perch family																														
Atlantic horse-mackerel																														
Sea beam family							1	0%	1	0%																				
Red sea bream			1	0%	1	0%																								
Black sea bream																														
Wrasse family											1	0%	1	0%																
Goldsinny wrasse																														
Ballan wrasse											1	0%	1	0%	1	0.2%									1	0.1%	1	0.1%		

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																														
Corkwing wrasse							3	0%	1	0%	4	0.1%	4	0.1%											4	0.2%	4	0.2%		
Sand-eel family																														
Greater sand-eel																														
Tuna																														
Atlantic mackerel																														
Goby family																														
Black goby																														
Dragonet																														
Shanny																														
Wolf-fish																														
Yarrell's/ Snake blenny																														
Yarrell's blenny																														
Snake blenny																														
Butterfish							11	0.1%	8	0.1%	10	0.2%	10	0.2%							8	1.8%			96	5.1%	95	5.3%	1	1.3%
Eelpout Family																														
Viviparous eelpout																														
Thick-lipped grey mullet																														
Gurnard family																														
Red gurnard																														
Grey gurnard																														
Tub gurnard																														
Sea scorpion family							6	0.1%	5	0.1%	2	0%	2	0%											6	0.3%	6	0.3%		
Bull-rout							1	0%	1	0%	16	0.3%	15	0.3%															1	1.3%
Sea scorpion							5	0%	3	0%	1	0%	1	0%											2	0.1%	2	0.1%		
Bullhead																														
Hooknose																														
Lumpsucker																					1	0.2%								
Flatfish order			4	0.1%			6	0.1%	6	0.1%							1	0%							1	0.1%	1	0.1%		
Turbot family																														
Megrim			1	0%	1	0%	2	0%	2	0%	2	0%	1	0%			2	0.1%							1	0.1%	1	0.1%		
Turbot																														
Topknot																														
Halibut family																														
Witch																														
Halibut																	1	0%							1	0.1%				
Dab																														
Lemon sole																														
Flounder or plaice																														
Flounder																									1	0.1%	1	0.1%		
Plaice							2	0%	1	0%															1	0.1%	1	0.1%		
Sole																														
Angler			1	0%			35	0.3%	32	0.3%	10	0.2%	9	0.2%			1	0%												
Total identified fish	31	100%	3128	100%	2461	100%	10355	100%	9480	100%	6153	100%	5169	100%	447	100%	2525	100%	2035	100%	438	100%	5		1897	100%	1776	100%	79	100%
Unidentified fish	759		8958		7220		31446		26194		24002		19278		1312		6566		5169		545		1		6790		5997		74	
Total fish	790		12086		9681		41801		35674		30155		24447		1759		9091		7204		983		6		8687		7773		153	
Sources	Colley 1988																													

Appendix Table 5.1: Fish NISP

Site	Pool							Brough of Birsay Rescue Excavations					
Dates	late Iron Age - Viking Age interface	late Iron Age - Viking Age interface	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Late Iron Age to early Viking Age	Late Viking Age	Late Viking Age	Late Viking Age	Late Viking-Age to early med	Late Viking-Age to early med
Context types	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Industrial spreads	Gullies, pits, drainage ditch	Floor, drainage, wall fill, agricultural function	Drainage, wall foundations, hearth	Floor, wall fill, hearth, pits, some industrial fuction	Floor deposits, domestic
Recovery	Hc only	Hc and >3mm	Hc, >3mm and >100mm	Hc only	Hc only	Hc and >3mm	Hc and >3mm	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Pool 7.1	Pool 7.2	Pool 8.1	Pool 8.2	Pool 8.2.1	Pool 8.2.2	Pool 8.2.3	Phase 1, site VII	Phase 2.2, site VII	Phase 2.2, site VIII	Phase 2.2, site IX	Phase 3, site VII	Phase 3, site VIII
Shark, skate, ray & chimaera													
Shark order												p	
Shark, skate & ray orders		2 0%	1 0.1%										
Basking shark													
Dogfish family													
Dogfish families													
Smallspotted catshark													
Tope shark													
Spurdog		1 0%				2 0.2%	3 0.1%						
Ray family													
Thornback ray													
Atlantic herrings													
Allis Shad/Twaite Shad													
Salmon & trout family													
Salmon/trout													
Atlantic salmon													
Trout													
Eel													
Conger eel	6 4.5%	3 0.1%				4 0.4%	1 0%						
Needlefishes/Sauries													
Garfish													
Stickleback family													
Three-spined stickleback													
Hake			1 0.1%				5 0.2%						
Gadid	116 86.6%	4318 98.8%	726 96.2%	199 98.5%	216 100%	1017 99%	2111 99.4%	p	p			p	
John Dory													
Seabass Family													
European seabass													
Perch family													
Atlantic horse-mackerel													
Sea beam family	2 1.5%	29 0.7%		2 1%		p	1 0%						
Red sea bream			27 3.6%										
Black sea bream		2 0%											
Wrasse family	3 2.2%	2 0%					1 0%						
Goldsinny wrasse													
Ballan wrasse		1 0%											

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																				
Corkwing wrasse																				
Sand-eel family																				
Greater sand-eel																				
Tuna			2	0%																
Atlantic mackerel																				
Goby family																				
Black goby																				
Dragonet																				
Shanny																				
Wolf-fish																				
Yarrell's/ Snake blenny																				
Yarrell's blenny																				
Snake blenny																				
Butterfish																				
Eelpout Family																				
Viviparous eelpout																				
Thick-lipped grey mullet																				
Gurnard family																p				
Red gurnard																				
Grey gurnard																				
Tub gurnard																				
Sea scorpion family																				
Bull-rout																				
Sea scorpion																				
Bullhead																				
Hooknose																				
Lumpsucker																				
Flatfish order	2	1.5%	1	0%							2	0.2%								
Turbot family																				
Megrim	5	3.7%	2	0%							1	0.1%								
Turbot			6	0.1%			1	0.5%												
Topknot																				
Halibut family																				
Witch																				
Halibut																				
Dab																				
Lemon sole																				
Flounder or plaice			1	0%							1	0.1%								
Flounder																				
Plaice																				
Sole																				
Angler													2	0.1%						
Total identified fish	134	100%	4370	100%	755	100%	202	100%	216	100%	1027	100%	2124							
Unidentified fish	91		1882		371		40		107		492		1060							
Total fish	225		6252		1126		242		323		1519		3184		5	45	1	4	35	5
Sources	Nicholson 1998 Table 5														Sellar *et al.* 1986, Tables 11, 18 25 see note regarding recovery in Appendix One					

Appendix Table 5.1: Fish NISP

Site	Brough of Birsay Room 5						Brough Road								
Dates	late Iron Age - Viking Age	640-880	890-1190	Viking Age-Med	Viking Age-Med	890-1190		7-11th c.	7-12th c.	7-11th c.	7-11th c.	7-9th c.			9-13th c.
Context types	Floor deposits	Floor surface, levelling	Occupation layers	Abandonment, general rubbish	Levelling, floor deposits	Abandonment period	Sand	Midden	Cist graves and associated midden	Midden	Disturbed midden	Sand	Stone spread	Flagstones	Midden
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc, sieved to 1cm and some sieved to >1mm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc, sieved to 1cm and some sieved to >1mm
Phase or area	Phase 1	Phase 2	Phase 3a	Phase 3b	Phase 4	Drain fill	Area 1, phase C	Area 1, phase D	Area 1, phase E	Area 1, phase F1	Area 1, phase F2	Area 2, phase A	Area 2, phase B1	Area 2, phase B2	Area 2, phase C1
Shark, skate, ray & chimaera															
Shark order															
Shark, skate & ray orders															
Basking shark															
Dogfish family										3 1.3%	1				
Dogfish families															
Smallspotted catshark															
Tope shark															
Spurdog															
Ray family				1 2.4%	2 0.5%										
Thornback ray															
Atlantic herrings															
Allis Shad/Twaite Shad															
Salmon & trout family															
Salmon/trout															1 0.1%
Atlantic salmon															
Trout															
Eel															
Conger eel															
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake												1 0.5%			5 0.3%
Gadid	5	3	32	36 87.8%	438 98.9%	22	4	335 99.4%	8	229 97.4%	28	213 98.2%	15	64 100%	1782 97.5%
John Dory															
Seabass Family															
European seabass															
Perch family															
Atlantic horse-mackerel															
Sea beam family															
Red sea bream												1 0.5%			2 0.1%
Black sea bream															
Wrasse family															
Goldsinny wrasse															
Ballan wrasse										2 0.9%	1	2 0.9%	1		28 1.5%

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																						
Corkwing wrasse																						
Sand-eel family																						
Greater sand-eel																						
Tuna																						
Atlantic mackerel				4	9.8%	3	0.7%															
Goby family																						
Black goby																						
Dragonet																						
Shanny																						
Wolf-fish																						
Yarrell's/ Snake blenny																						
Yarrell's blenny																						
Snake blenny																						
Butterfish																						
Eelpout Family																						
Viviparous eelpout																						
Thick-lipped grey mullet																						
Gurnard family												1										
Red gurnard																						
Grey gurnard																					1	0.1%
Tub gurnard																						
Sea scorpion family										1	0.3%											
Bull-rout										1	0.3%		1	0.4%							4	0.2%
Sea scorpion																						
Bullhead																						
Hooknose																						
Lumpsucker																						
Flatfish order																						
Turbot family																						
Megrim																						
Turbot																						
Topknot																						
Halibut family																						
Witch																						
Halibut																						
Dab																						
Lemon sole																						
Flounder or plaice																						
Flounder																					3	0.2%
Plaice																					2	0.1%
Sole																						
Angler																						
Total identified fish	5	3	32	41	100%	443	100%	22	4	337	100%	9	235	100%	30	217	100%	16	64	100%	1828	100%
Unidentified fish									4	267		5	310		13	208		3	85		1657	
Total fish	5	3	32	41		443		22	8	604		14	545		43	425		19	149		3485	
Sources	Sellar 1982, Tables 1, 2								Rackham 1989, Tables 18, 19													

Appendix Table 5.1: Fish NISP

Site	Brough Road (continued)							Beachview (Burnside)					
Dates	9-11th c.	7-11th c.	7-12th c.				7-10th c.	1020-1320	1020-1320	1020-1280	1020-1280	1020-1280	1020-1280
Context types	Midden	Cist graves and associated midden	Stone spread with sand	Sand	Floor deposits	Hearth and clay deposits	Organic spreads	Midden	Midden	Midden	Midden	Midden	Midden
Recovery	Hc, sieved to 1cm and some sieved to >1mm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc	>2mm	Hc	Hc	Hc	Hc
Phase or area	Area 2, phase C2	Area 2, phase D	Area 2, phase E1	Area 2, phase E2	Area 3, phase A	Area 3, phase B	Area 3, phase C	Area 3 phase X	Area 3 phase X	Area 2, phase W, episode 3 PL	Area 2, phase W, episode 3 PT	Area 2, phase W, episode 5	Area 2, phase W total
Shark, skate, ray & chimaera									9 2%				
Shark order	1 0.1%												
Shark, skate & ray orders									2 0.4%				
Basking shark													
Dogfish family	1 0.1%												
Dogfish families													
Smallspotted catshark													
Tope shark													
Spurdog													
Ray family													
Thornback ray									1 0.2%				
Atlantic herrings									3 0.7%				
Allis Shad/Twaite Shad													
Salmon & trout family													
Salmon/trout	3 0.2%								7 1.6%				
Atlantic salmon													
Trout													
Eel						4			17 3.8%				
Conger eel	1 0.1%	3											
Needlefishes/Sauries													
Garfish													
Stickleback family									1 0.2%				
Three-spined stickleback													
Hake	8 0.4%		1 0.6%					1					
Gadid	1894 98%	8	176 97.2%	18	26	5	45 93.8%	24	382 84.7%	3	5	52 100%	60 100%
John Dory													
Seabass Family													
European seabass													
Perch family													
Atlantic horse-mackerel													
Sea beam family													
Red sea bream			1 0.6%										
Black sea bream													
Wrasse family									18 4%				
Goldsinny wrasse													
Ballan wrasse	18 0.9%		3 1.7%		2		3 6.3%		6 1.3%				

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																			
Corkwing wrasse																			
Sand-eel family																			
Greater sand-eel																			
Tuna																			
Atlantic mackerel																			
Goby family																			
Black goby																			
Dragonet																			
Shanny																			
Wolf-fish																			
Yarrell's/ Snake blenny																			
Yarrell's blenny																			
Snake blenny																			
Butterfish												5	1.1%						
Eelpout Family																			
Viviparous eelpout																			
Thick-lipped grey mullet																			
Gurnard family	1	0.1%																	
Red gurnard																			
Grey gurnard	1	0.1%																	
Tub gurnard																			
Sea scorpion family																			
Bull-rout	2	0.1%																	
Sea scorpion	1	0.1%																	
Bullhead																			
Hooknose																			
Lumpsucker																			
Flatfish order	1	0.1%																	
Turbot family																			
Megrim																			
Turbot																			
Topknot																			
Halibut family																			
Witch																			
Halibut																			
Dab																			
Lemon sole																			
Flounder or plaice																			
Flounder																			
Plaice																			
Sole																			
Angler																			
Total identified fish	1932	100%	11	181	100%	18	28	9	48	100%	25	451	100%	3	5	52	100%	60	100%
Unidentified fish	4068			162		30	25	59	196		27	12968		10	3	77		90	
Total fish	6000		11	343		48	53	68	244		52	13419		13	8	129		150	
Sources	Rackham 1989, Tables 19, 20										Colley and Rackham 1996, Tables M8, M26								

Appendix Table 5.1: Fish NISP

Site	Beachview (Burnside) (continued)														
Dates	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280
Context types	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden
Recovery	>2mm	>2mm	>2mm	Hc	Hc	Hc	Hc	Hc	Hc	Hc	>2mm	>2mm	>2mm	>2mm	>2mm
Phase or area	Area 2, phase W, episode 3	Area 2, phase W, episode 5	Area 2, phase W total	Area 2, phase X, episode 6 PN	Area 2, phase X, episode 6 PK	Area 2, phase X, episode 7 PM	Area 2, phase X, episode 7 PU	Area 2, phase X, episode 7 PW	Area 2, phase X, episode 8	Area 2, phase X total	Area 2, phase X, episode 6	Area 2, phase X, episode 7 PG	Area 2, phase X, episode 7 PW	Area 2, phase X, episode 8	Area 2, phase X total
Shark, skate, ray & chimaera	4 6.1%		4 2.9%								3 0.4%	54 18.8%		4 0.2%	61 1.8%
Shark order														9 0.4%	9 0.3%
Shark, skate & ray orders															
Basking shark															
Dogfish family												9 3.1%			9 0.3%
Dogfish families															
Smallspotted catshark															
Tope shark															
Spurdog															
Ray family															
Thornback ray	2 3%		2 1.4%										1		1 0%
Atlantic herrings														4 0.2%	4 0.1%
Allis Shad/Twaite Shad															
Salmon & trout family															
Salmon/trout											3 0.4%	1 0.3%		2 0.1%	6 0.2%
Atlantic salmon															
Trout															
Eel		22 30.1%	22 15.8%								51 6.1%	3 1%		34 1.5%	88 2.6%
Conger eel															
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake															
Gadid	58 87.9%	51 69.9%	109 78.4%	29	682 100%	7	3	70 100%	505 100%	1296 100%	770 91.9%	217 75.3%	17	2182 97.3%	3186 94.1%
John Dory															
Seabass Family															
European seabass															
Perch family															
Atlantic horse-mackerel															
Sea beam family															
Red sea bream															
Black sea bream															
Wrasse family	1 1.5%		1 0.7%								2 0.2%	3 1%		2 0.1%	7 0.2%
Goldsinny wrasse											1 0.1%				1 0%
Ballan wrasse															0 0%

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																										
Corkwing wrasse																										
Sand-eel family																										
Greater sand-eel																										
Tuna																										
Atlantic mackerel																										
Goby family																										
Black goby																										
Dragonet																										
Shanny																										
Wolf-fish																										
Yarrell's/ Snake blenny																										
Yarrell's blenny																										
Snake blenny																										
Butterfish																							5	0.2%	5	0.1%
Eelpout Family																										
Viviparous eelpout																										
Thick-lipped grey mullet																										
Gurnard family																	1	0.1%								
Red gurnard																										
Grey gurnard																										
Tub gurnard																										
Sea scorpion family	1	1.5%			1	0.7%																				
Bull-rout																										
Sea scorpion																										
Bullhead																										
Hooknose																										
Lumpsucker																										
Flatfish order																	1	0.1%							1	0%
Turbot family																										
Megrim																										
Turbot																										
Topknot																										
Halibut family																										
Witch																										
Halibut																										
Dab																										
Lemon sole																			1	0.3%					1	0%
Flounder or plaice																										
Flounder																										
Plaice																	6	0.7%							6	0.2%
Sole																										
Angler																										
Total identified fish	66	100%	73	100%	139	100%	29	682	100%	7	3	70	100%	505	100%	1296	100%	838	100%	288	0%	18	2242	100%	3386	
Unidentified fish	758		1099		1857		31	551		15		51		298		946		15145		3941		15	32273		51374	
Total fish	824		1172		1996		60	1233		22	3	121		803		2242		15983		4229		33	34515		54760	
Sources												Colley and Rackham 1996 Tables M26 M27														

Appendix Table 5.1: Fish NISP

Site	Beachview (Burnside) (continued)										Beachview Studio						
Dates	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	Med	Med	Med	Med	1020-1320	980-1206	1030-1280		1001-1410		1020-1280	1020-1280
Context types	Midden	Midden	Midden	Midden	Midden	Interface of midden and sand	Interface of midden and sand	Interface of midden and sand	Interface of midden and sand	Midden	Sand overlying rubble	Ash dump, sandy deposits	Midden	Midden	Sand blow, wall	Sands, burnt peat	Sands, burnt peat
Recovery	>2mm	>2mm	>2mm	>2mm	>2mm	Hc	Hc	Hc	Hc	>2mm	Hc	Hc	Hc	Hc	Hc	Hc	>3.5mm
Phase or area	Area 2, phase X, episode 6	Area 2, phase X, episode 7 PG	Area 2, phase X, episode 7 PW	Area 2, phase X, episode 8	Area 2, phase X total	Area 2, phase Y, episode 9	Area 2, phase Y, episode 10	Area 2, phase Y, episode 11	Area 2, phase Y total	Total areas 2 and 3	Area 1D/E, phase Q	Area 1D/E, phase S	Area 1D/E, phase T	Area 1D/E, phase U	Area 1D/E, phase V	Area 1D/E, phase W	Area 1D/E, phase W
Shark, skate, ray & chimaera	3 0.4%	54 18.8%		4 0.2%	61 1.8%					74 1.9%							
Shark order				9 0.4%	9 0.3%					9 0.2%							
Shark, skate & ray orders										2 0.1%							
Basking shark																	
Dogfish family		9 3.1%			9 0.3%					9 0.2%							
Dogfish families																	
Smallspotted catshark																	
Tope shark																	
Spurdog																	
Ray family																	
Thornback ray			1		1 0%					4 0.1%							
Atlantic herrings				4 0.2%	4 0.1%					7 0.2%							
Allis Shad/Twaite Shad																	
Salmon & trout family																	
Salmon/trout	3 0.4%	1 0.3%		2 0.1%	6 0.2%					13 0.3%		1 0.6%					
Atlantic salmon																	
Trout																	
Eel	51 6.1%	3 1%		34 1.5%	88 2.6%					127 3.2%							
Conger eel												3 1.9%				2	
Needlefishes/Sauries																	
Garfish																	
Stickleback family										1 0%							
Three-spined stickleback																	
Hake																	
Gadid	770 91.9%	217 75.3%	17	2182 97.3%	3186 94.1%	2	0	0	2	3677 92.5%	16	152 97.4%	1	105 100%	3	30	2
John Dory																	
Seabass Family																	
European seabass																	
Perch family																	
Atlantic horse-mackerel																	
Sea beam family																	
Red sea bream																	
Black sea bream																	
Wrasse family	2 0.2%	3 1%		2 0.1%	7 0.2%					26 0.7%							
Goldsinny wrasse	1 0.1%				1 0%					1 0%							
Ballan wrasse										6 0.2%							

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																								
Corkwing wrasse																								
Sand-eel family																								
Greater sand-eel																								
Tuna																								
Atlantic mackerel																								
Goby family																								
Black goby																								
Dragonet																								
Shanny																								
Wolf-fish																								
Yarrell's/ Snake blenny																								
Yarrell's blenny																								
Snake blenny																								
Butterfish						5	0.2%	5	0.1%					10	0.3%									
Eelpout Family																								
Viviparous eelpout																								
Thick-lipped grey mullet																								
Gurnard family	1	0.1%						1	0%					1	0%									
Red gurnard																								
Grey gurnard																								
Tub gurnard																								
Sea scorpion family														1	0%									
Bull-rout																								
Sea scorpion																								
Bullhead																								
Hooknose																								
Lumpsucker																								
Flatfish order	1	0.1%						1	0%					1	0%									
Turbot family																								
Megrim																								
Turbot																								
Topknot																								
Halibut family																								
Witch																								
Halibut																								
Dab																								
Lemon sole			1	0.3%				1	0%					1	0%									
Flounder or plaice																								
Flounder																								
Plaice	6	0.7%						6	0.2%					6	0.2%									
Sole																								
Angler																1								
Total identified fish	838	100%	288	100%	18	2242	100%	3386	100%	2	0	0	2	3976	100%	17	156	100%	1	105	100%	3	32	2
Unidentified fish	15145		3941		15	32273		51374			2	1	3	66199		1	150			139		2	40	130
Total fish	15983		4229		33	34515		54760		2	2	1	5	70175		18	306		1	244		5	72	132
Sources	Colley and Rackham 1996 Tables M26, M27															Colley and Rackham 1996 Table 11								

Appendix Table 5.1: Fish NISP

Site	Beachview Studio (continued)														
Dates												1134-1280	1134-1280	990-1220	990-1220
Context types	Wall fill and rubble	Mixed, including midden	Mixed, including midden	Wall fill	Peat ash, sandy layers	Wall fill, sandy layer	Wall fill, sandy layer	Hearth deposits	Hearth deposits	Sandy deposits in structure	Sandy deposits in structure	Pit fill and midden in structure	Pit fill and midden in structure	Midden, sand and clay layers	Midden, sand and clay layers
Recovery	Hc	Hc	>3.5	Hc	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm
Phase or area	Area 1D/E, phase X	Area 1D/E, phase Y	Area 1D/E, phase Y	Area 1, phase K	Area 1, phase L	Area 1, phase N	Area 1, phase N	Area 1, phase P	Area 1, phase P	Area 1, phase Q	Area 1, phase Q	Area 1, phase R	Area 1, phase R	Area 1, phase S	Area 1, phase S
Shark, skate, ray & chimaera															
Shark order															
Shark, skate & ray orders															
Basking shark															
Dogfish family															
Dogfish families															
Smallspotted catshark															
Tope shark															
Spurdog															
Ray family															
Thornback ray															
Atlantic herrings								1							1 0.1%
Allis Shad/Twaite Shad															
Salmon & trout family															
Salmon/trout															4 0.4%
Atlantic salmon															
Trout															
Eel					5 3.1%						1 0.5%		25 2.3%		20 2.2%
Conger eel		3 0.4%				1					3 1.4%				
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake			1 2.3%												
Gadid	18	760 99.3%	42 97.7%	3	156 96.9%	7	6	9	6	2	203 98.1%	2	1072 97.5%	63 100%	880 96.8%
John Dory															
Seabass Family															
European seabass															
Perch family															
Atlantic horse-mackerel															
Sea beam family															
Red sea bream															
Black sea bream															
Wrasse family															
Goldsinny wrasse															
Ballan wrasse									1				2 0.2%		4 0.4%

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																						
Corkwing wrasse																						
Sand-eel family																						
Greater sand-eel																						
Tuna																						
Atlantic mackerel																						
Goby family																						
Black goby																						
Dragonet																						
Shanny																						
Wolf-fish																						
Yarrell's/ Snake blenny																						
Yarrell's blenny																						
Snake blenny																						
Butterfish																						
Eelpout Family																						
Viviparous eelpout																						
Thick-lipped grey mullet																						
Gurnard family																						
Red gurnard																						
Grey gurnard																						
Tub gurnard																						
Sea scorpion family																						
Bull-rout		2	0.3%																			
Sea scorpion																						
Bullhead																						
Hooknose																						
Lumpsucker																						
Flatfish order																						
Turbot family																						
Megrim																						
Turbot																						
Topknot																						
Halibut family																						
Witch																						
Halibut																						
Dab																						
Lemon sole																						
Flounder or plaice																						
Flounder																						
Plaice																						
Sole																						
Angler																						
Total identified fish	18	765	100%	43	100%	3	161	100%	8	6	10	7	2	207	100%	2	1099	100%	63	100%	909	100%
Unidentified fish	4	1255		84			2873		47	103	2	80		2283		2	10330		38		7297	
Total fish	22	2020		127		3	3034		55	109	12	87	2	2490		4	11429		101		8206	
Sources											Colley and Rackham 1996 Tables 11, 13 14											

Appendix Table 5.1: Fish NISP

Site	Beachview Studio (continued)							Buckquoy					Saevar Howe				
Dates	1163-1300					990-1210	990-1210	Pictish	Pictish	Viking Age	Viking Age	Viking Age	Iron Age	9th c. +/-	9th c. +/-	9th c. +/-	9th c. +/-
Context types	Wall dug into midden	Peat ash, clay layers built up to exterior of structure	Rubble collapse layers	Drain fill	Wall fill	Sand and ash layers associated with disuse of structure	Sand and ash layers associated with disuse of structure	Mixed, including ?Ritual	Mixed, including ?Ritual	?Entirely midden	?Entirely midden	?Entirely midden	Mostly midden	Construction, midden	Construction, midden	Construct-ion, midden	Construction, midden, abandonment
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	>2mm	Hc	Hc	Hc	Hc	Hc	>5mm	>5mm	>5mm	>5mm	>5mm
Phase or area	Area 1, Phase T	Area 1, Phase U	Area 1, Phase V	Area 1, Phase W	Area 1, Phase X	Area 1, Phase Y	Area 1, Phase Y	Phase I all	Phase II all	Phase III	Phase IV	Phase V	Phase I all	Phase IIa	Phase IIb	Phase IIb/c	Phase IIc
Shark, skate, ray & chimaera																	
Shark order																	
Shark, skate & ray orders											p	p					
Basking shark																	
Dogfish family																	
Dogfish families																	
Smallspotted catshark																	
Tope shark																	
Spurdog																	
Ray family																	
Thornback ray																	
Atlantic herrings																	
Allis Shad/Twaite Shad																	
Salmon & trout family																	
Salmon/trout							4 0.4%										
Atlantic salmon															1 0.2%		
Trout												1					
Eel						1 0.1%	4 0.4%										
Conger eel						1 0.1%		1	1		2	1	1 0.9%		1 0.2%		1 0.7%
Needlefishes/Sauries																	
Garfish																	
Stickleback family																	
Three-spined stickleback																	
Hake						1 0.1%	1 0.1%	1					2 1.7%	1 1.3%			1 0.7%
Gadid	27	128 97.7%	129 100%	23	2	1005 98.8%	1091 98.6%	2	1		20	12	86 74.8%	76 95%	525 98.7%	106 99.1%	147 98%
John Dory																	
Seabass Family																	
European seabass																	
Perch family																	
Atlantic horse-mackerel																	
Sea beam family																	
Red sea bream										1	1	2	4 3.5%		1 0.2%	1 0.9%	
Black sea bream																	
Wrasse family							2 0.2%										
Goldsinny wrasse																	
Ballan wrasse		2 1.5%				4 0.4%	2 0.2%	1			2	1	22 19.1%	2 2.5%	3 0.6%		1 0.7%

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																										
Corkwing wrasse																										
Sand-eel family																										
Greater sand-eel																										
Tuna																										
Atlantic mackerel															1	1										
Goby family																										
Black goby																										
Dragonet																										
Shanny																										
Wolf-fish																										
Yarrell's/ Snake blenny																										
Yarrell's blenny																										
Snake blenny																										
Butterfish																										
Eelpout Family																										
Viviparous eelpout																										
Thick-lipped grey mullet																										
Gurnard family																										
Red gurnard																										
Grey gurnard															1	1										
Tub gurnard																										
Sea scorpion family																					1	0.2%				
Bull-rout		1	0.8%					4	0.4%																	
Sea scorpion																										
Bullhead																										
Hooknose																										
Lumpsucker																										
Flatfish order																										
Turbot family																										
Megrim																										
Turbot																										
Topknot																										
Halibut family																										
Witch																										
Halibut										1	0.1%															
Dab																										
Lemon sole																										
Flounder or plaice																										
Flounder																										
Plaice								1	0.1%	1	0.1%								1	1.3%						
Sole																										
Angler																										
Total identified fish	27	131	100%	129	100%	23	2	1017	100%	1106	100%	5	2	1	27	19	115	100%	80	100%	532	100%	107	100%	150	100%
Unidentified fish	196	24					786			9190							46		46		342		100		155	
Total fish	223	155		129		23	788	1017		10296		5	2	1	27	19	161		126		874		207		305	
Sources	Colley and Rackham 1996 Tables 12, 13 14											Wheeler 1976-77, Table 12					Colley 1983a, Table 13									

Appendix Table 5.1: Fish NISP

Site	Brough of Deerness					Skaill	Newark Bay				Earl's Bu				
Dates	Viking Age to med	Med	Med and ?later	late Iron Age	Med and ?later	?Viking Age and ?med	?Late Iron Age	Med	?Med	Med	Viking Age-med	Med	970-1220	880-1160	Med
Context types	Construction	Construction and use	Decay and collapse, possibly non-anthropogenic	Construction	Decay and collapse, possibly non-anthropogenic	Probably all midden	Souterrains	Associated with burials	Floor fill	Below drain	Construction and use of mill	Collapse features of mill	Mill features	Midden	Midden
Recovery	Mixed	Mixed	Mixed	Mixed	Mixed	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Chapel interior phase B	Chapel interior phase C	Chapel interior phase D	Enclosure phase A	Enclosure phase D	Site 2 'Norse'	Souterrains	Associated with burials	Floor fill	Below drain	C2	C3	F2	M1	M3
Shark, skate, ray & chimaera															
Shark order															
Shark, skate & ray orders															
Basking shark															
Dogfish family															
Dogfish families						2 0.1%									
Smallspotted catshark															
Tope shark						1 0.1%									
Spurdog															
Ray family															
Thornback ray															
Atlantic herrings															
Allis Shad/Twaite Shad															
Salmon & trout family															
Salmon/trout															
Atlantic salmon															
Trout															
Eel															
Conger eel		4				14 0.8%									
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake															
Gadid	2	3	8	1	1	1596 94%	1	22	20	2	14	35 100%	9	16	147 100%
John Dory															
Seabass Family															
European seabass						2 0.1%									
Perch family															
Atlantic horse-mackerel															
Sea beam family															
Red sea bream															
Black sea bream															
Wrasse family						6 0.4%		1							
Goldsinny wrasse															
Ballan wrasse			1			4 0.2%									

Appendix Table 5.1: Fish NISP

Cuckoo wrasse						2	0.1%											
Corkwing wrasse																		
Sand-eel family																		
Greater sand-eel																		
Tuna																		
Atlantic mackerel						2	0.1%											
Goby family																		
Black goby																		
Dragonet																		
Shanny																		
Wolf-fish																		
Yarrell's/ Snake blenny																		
Yarrell's blenny																		
Snake blenny																		
Butterfish																		
Eelpout Family																		
Viviparous eelpout																		
Thick-lipped grey mullet						1	0.1%											
Gurnard family						4	0.2%											
Red gurnard																		
Grey gurnard						43	2.5%											
Tub gurnard																		
Sea scorpion family						2	0.1%											
Bull-rout			7															
Sea scorpion						2	0.1%											
Bullhead																		
Hooknose																		
Lumpsucker																		
Flatfish order																		
Turbot family																		
Megrim						1	0.1%		2									
Turbot																		
Topknot																		
Halibut family																		
Witch																		
Halibut																		
Dab																		
Lemon sole																		
Flounder or plaice						7	0.4%											
Flounder																		
Plaice						7	0.4%											
Sole						1	0.1%											
Angler																		
Total identified fish	2	7	16	1	1	1697	100%	1	25	20	2	14	35	100%	9	16	147	100%
Unidentified fish	7	6	11						12	43		31	102		12	44	430	
Total fish	9	13	27	1	1	1697		1	37	63	2	45	137		21	60	577	
Sources	Rackham 1986, Table 6, 7					Nicholson 1997, Table 18 1		Harland 2001b				Chapter Five						

Appendix Table 5.1: Fish NISP

Site	Earl's Bu (continued)														
Dates	Med	990-1190	890-1160	Viking Age-med	Med	Viking Age-med	Med	970-1220	880-1160	Med	Med	990-1190	890-1160	Viking Age-med	Med
Context types	Midden	Midden	Midden	Redeposited midden	Redeposited midden	Construction and use of mill	Collapse features of mill	Mill features	Midden	Midden	Midden	Midden	Midden	Redeposited midden	Redeposited midden
Recovery	Hc	Hc	Hc	Hc	Hc	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm	>4mm, >2mm
Phase or area	M3a	M3b	M3c	R1	R3	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3
Shark, skate, ray & chimaera													1 0%		
Shark order															
Shark, skate & ray orders															
Basking shark															
Dogfish family															
Dogfish families						1 0.2%		2 0.7%	8 1.3%	1 0.1%	10 0.4%	33 0.8%	4 0.1%	4 0.3%	2 0.7%
Smallspotted catshark															
Tope shark															
Spurdog												1 0%	12 0.2%		
Ray family						219 51%		1 0.3%	1 0.2%		7 0.3%	6 0.1%	1 0%		
Thornback ray						2 0.5%					3 0.1%	1 0%	7 0.1%		
Atlantic herrings									2 0.3%		2 0.1%	17 0.4%	3 0%		
Allis Shad/Twaite Shad														1 0.1%	
Salmon & trout family			1 0.3%			2 0.5%			8 1.3%	1 0.1%	26 1.1%	28 0.7%	23 0.3%	20 1.3%	1 0.4%
Salmon/trout															
Atlantic salmon															
Trout									1 0.2%		2 0.1%				
Eel						1 0.2%		2 0.7%	23 3.7%	1 0.1%	77 3.3%	147 3.6%	118 1.5%	21 1.4%	1 0.4%
Conger eel												2 0%			
Needlefishes/Sauries															
Garfish															
Stickleback family															
Three-spined stickleback															
Hake		3 1.4%			5 4.5%				1 0.2%		3 0.1%	14 0.3%	11 0.1%	2 0.1%	
Gadid	37 100%	204 98.6%	291 99.3%	57 100%	107 95.5%	204 47.6%	26	292 98.3%	568 91.2%	859 99.1%	2236 94.4%	3803 93.2%	7663 97.2%	1424 95.8%	263 98.1%
John Dory															
Seabass Family															
European seabass															
Perch family															
Atlantic horse-mackerel													1 0%		
Sea beam family												1 0%			
Red sea bream															
Black sea bream															
Wrasse family									3 0.5%	2 0.2%		2 0%	1 0%	6 0.4%	
Goldsinny wrasse															
Ballan wrasse									6 1%						

Appendix Table 5.1: Fish NISP

Cuckoo wrasse																														
Corkwing wrasse																														
Sand-eel family																														
Greater sand-eel																														
Tuna																														
Atlantic mackerel																														
Goby family																					1	0%	1	0%			1	0.1%		
Black goby																														
Dragonet																														
Shanny																									1	0%				
Wolf-fish																														
Yarrell's/ Snake blenny																														
Yarrell's blenny																														
Snake blenny																														
Butterfish																														
Eelpout Family																	1	0.2%					15	0.4%	9	0.1%	1	0.1%		
Viviparous eelpout																														
Thick-lipped grey mullet																							1	0%						
Gurnard family																														
Red gurnard																			1	0.1%			1	0%	11	0.1%	3	0.2%		
Grey gurnard																									2	0%				
Tub gurnard																														
Sea scorpion family																														
Bull-rout																			1	0.1%	1	0%			1	0%				
Sea scorpion																											1	0.1%		
Bullhead																									1	0%				
Hooknose																														
Lumpsucker																														
Flatfish order																														
Turbot family																									3	0%				
Megrim																							1	0%						
Turbot																					1	0%								
Topknot																														
Halibut family					1	0.3%																								
Witch																	0.2%		0.1%				0.1%		0.1%		0.2%		0.4%	
Halibut																														
Dab																														
Lemon sole																														
Flounder or plaice																									0%					
Flounder																														
Plaice																														
Sole																									0.1%					
Angler																							0%							
Total identified fish	37	100%	207	100%	293	100%	57	100%	112	100%	429	100%	26		297	100%	623	100%	867	100%	2369	100%	4079	100%	7887	100%	1487	100%	268	100%
Unidentified fish	105		411		602		115		334		900		128		993		1857		1537		6418		10055		16366		3893		726	
Total fish	142		618		895		172		446		1329		154		1290		2480		2404		8787		14134		24253		5380		994	
Sources	Chapter Four										Chapter Four																			
											>4mm. plus vertebrae, dentaries and premaxillae from >2mm																			

Appendix Table 5.1: Fish NISP

Site	Robert's Haven								Freswick									
Dates	11th to 13th c.		Viking Age to med		14th to 16th c.		Viking Age to med		?late Iron Age to med		Med		late Iron-Age to Viking Age		early 11th c. to late 14th		12th c. to early 14th	
Context types	Fish midden		Midden, associated with structure		Midden		Midden		Mostly midden		Mostly midden		Mixed, cultivation layers and deflated middens		Midden		Midden	
Recovery	>4mm		>4mm		>4mm		>4mm		>2mm		>2mm		>2mm		>2mm		>2mm	
Phase or area	Phase 1, area A		Phase 1, area B		Area E		Phase 2, area B		Inland, Area 3		Inland, Area 9		SCA, Area 11-14		NCA, Area 4, Phases T, U, V		NCA, Area 4, Phase X	
Shark, skate, ray & chimaera	5	0%							1	0.1%			2	0.7%				
Shark order																		
Shark, skate & ray orders																		
Basking shark																		
Dogfish family																		
Dogfish families	7	0%																
Smallspotted catshark																		
Tope shark																		
Spurdog	p																	
Ray family	p																	
Thornback ray													1	0.3%				
Atlantic herrings	32	0.2%							2	0.1%			9	3.1%	6	0.4%	2	0.9%
Allis Shad/Twaite Shad																		
Salmon & trout family									3	0.2%	1	0.6%						
Salmon/trout																		
Atlantic salmon																		
Trout																		
Eel	1	0%									1	0.6%	1	0.3%	3	0.2%	2	0.9%
Conger eel	6	0%											1	0.3%	28	1.9%	2	0.9%
Needlefishes/Sauries																		
Garfish	2	0%													5	0.3%		
Stickleback family																		
Three-spined stickleback																		
Hake	15	0.1%																
Gadid	15140	95%	52	96.3%	295	98%	74	86%	1429	98.2%	169	96.6%	252	87.2%	1324	88.9%	199	91.7%
John Dory	p																	
Seabass Family																		
European seabass															1	0.1%		
Perch family																		
Atlantic horse-mackerel	3	0%							9	0.6%			1	0.3%	4	0.3%		
Sea beam family																		
Red sea bream	1	0%																
Black sea bream															2	0.1%		
Wrasse family	1	0%							1	0.1%			1	0.3%	2	0.1%		
Goldsinny wrasse																		
Ballan wrasse															1	0.1%		

Appendix Table 5.1: Fish NISP

Cuckoo wrasse															1	0.1%		
Corkwing wrasse																		
Sand-eel family																		
Greater sand-eel											2	1.1%						
Tuna																		
Atlantic mackerel	4	0%							1	0.1%					1	0.1%		
Goby family																		
Black goby																		
Dragonet	p																	
Shanny																		
Wolf-fish	1	0%											5	1.7%	21	1.4%		
Yarrell's/ Snake blenny																		
Yarrell's blenny																		
Snake blenny																		
Butterfish	p																	
Eelpout Family																		
Viviparous eelpout																		
Thick-lipped grey mullet																		
Gurnard family	479	3%			2	0.7%	3	3.5%	1	0.1%			9	3.1%	1	0.1%	2	0.9%
Red gurnard																		
Grey gurnard	166	1%											4	1.4%			1	0.5%
Tub gurnard																		
Sea scorpion family	22	0.1%					1	1.2%										
Bull-rout																		
Sea scorpion									1	0.1%			1	0.3%	2	0.1%		
Bullhead																		
Hooknose																		
Lumpsucker																		
Flatfish order	1	0%																
Turbot family																		
Megrim	3	0%													5	0.3%	1	0.5%
Turbot																		
Topknot															4	0.3%		
Halibut family	24	0.2%							7	0.5%	2	1.1%	2	0.7%	70	4.7%	7	3.2%
Witch	18	0.1%																
Halibut	2	0%																
Dab	1	0%																
Lemon sole	1	0%																
Flounder or plaice	3	0%																
Flounder	1	0%																
Plaice	1	0%					1	1.2%										
Sole																		
Angler	5	0%	2	3.7%	4	1.3%	7	8.1%							8	0.5%	1	0.5%
Total identified fish	15945	100%	54	100%	301	100%	86	100%	1455	100%	175	100%	289	100%	1489	100%	217	100%
Unidentified fish	33667		322		1431		840											
Total fish	49612		376		1732		926		1455		175		289		1489		217	
Sources	Barrett 1997, Appendix 3		RL Parks pers comm				RL Parks pers comm		Jones 1995, Tables 17, 21, 27, 29, 31									
Notes	Data only available for >4mm, and for gadids these are counts of only 9 cranial elements, not vertebrae		These data only include the 9 cranial elements to match Phase 1, Area A		These data only include the 9 cranial elements to match Phase 1, Area A		These data only include the 9 cranial elements to match Phase 1 Area A		This is all fish bones except ui		This is all fish bones except ui		Only cleithra, dentaries, premaxillae and otoliths for main gadids, otherwise all fish bone except ui		Only cleithra, dentaries, premaxillae and otoliths for main gadids, otherwise all fish bone except ui		Only cleithra, dentaries, premaxillae and otoliths for main gadids, otherwise all fish bone except ui	

Appendix Table 5.2: Gadid NISP

Site	Sandwick North						Sandwick						
Dates	Med?	11-12th c.	11-12th c.	12-13th c.	12-13th c.	13-14th c.	Late 12th c.	Late 12th c.	13th c.	13th c.	13th c.	Late 13th to 14th c.	Late 13th to 14th c.
Context types	?Midden	Midden	Midden	Midden associated with structure	Midden associated with structure	Midden associated with structure	Midden	Midden	Midden	Midden	Midden	Midden	Midden
Recovery	Hc	>2mm	Hc	>2mm	Hc	Hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc
Phase or area	Phase 1	Phase 2	Phase 2	Phase 3	Phase 3	Phase 4	Early phase, area 3	Early phase, area 4	Middle phase, area 2	Middle phase, area 3	Middle phase, area 4	Late phase, area 3	Late phase, area 4
Cod/saithe/pollack		1 2.2%	1 0.2%		1 0.4%	1 0.6%							
Cod	13	30 65.2%	538 81.9%	5	150 63.3%	57 37%	61 57.5%	17 47.2%	61 6.7%	61 55%	13 44.8%	250 31%	87 26.9%
Haddock		6 13%	1 0.2%		2 0.8%			1 2.8%			1 3.4%	2 0.2%	
Whiting			1 0.2%	1		1 0.6%						1 0.1%	
Saithe/pollack						1 0.6%	26 24.5%	15 41.7%	749 82.7%	21 18.9%	12 41.4%	438 54.3%	200 61.7%
Pollack			1 0.2%		1 0.4%		1 0.9%		3 0.3%			4 0.5%	
Saithe	2	3 6.5%	44 6.7%	13	49 20.7%	67 43.5%							
Norway pout/bib/poor-cod													
Norway pout													
Bib												1 0.1%	
Poor-cod													
Torsk		2 4.3%	5 0.8%		4 1.7%	7 4.5%	2 1.9%	3 8.3%	13 1.4%	16 14.4%	2 6.9%	20 2.5%	12 3.7%
Rockling													
Five-bearded/northern rockling													
Five-bearded rockling													
Four-bearded rockling													
Shore rockling													
Three-bearded rockling													
Tadpole fish													
Ling	2	4 8.7%	66 10%		30 12.7%	20 13%	16 15.1%		80 8.8%	13 11.7%	1 3.4%	90 11.2%	25 7.7%
Greater fork-beard													
Total gadid id'd to species	17	46 100%	657 100%	19	237 100%	154 100%	106 100%	36 100%	906 100%	111 100%	29 100%	806 100%	324 100%
Sources	Barrett and Oltmann 2000, Tables 11, 12						Bigelow 1984, Tables 11, 12, 13						
Notes							Only 6 cranial elements and vertebrae identified and counted						

Appendix Table 5.2: Gadid NISP

Site	Scalloway			Jarlshof	St. Boniface						Quoygrew										
Dates	Late Iron Age to Viking Age	9-10th c.		Early 9th c. to med	250 to 750		1100-1250		Med?		676-896		1066-1294		Med	Viking Age		779-981		1035-1261	
Context types	Mixed including midden infill, ditch fills	Midden in disused and collapsing broch		Mostly midden	Plaggen soils, ?midden		?Midden		?Midden		Fish midden		Fish midden		Fish midden	Farm mound midden		Farm mound midden		Farm mound midden	
Recovery	Hc and sieving, MNI only	Hc and sieving, MNI only		Selective hc	>1mm		>1mm		>1mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm	>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm	
Phase or area	Late phase 3	Block 7.1		Viking and medieval	Phase 7		Phase 8		Phase 9		Phase 1.2		Phase 2		Phase 7	Phase i		Phase ii		Phase iii	
Cod/saithe/pollack											6	4%	102	4.2%	3	9	8.8%	270	7.8%	147	4.9%
Cod	13	37	42%	P	35	24.3%	362	36.9%	20	5.8%	68	45%	1056	43.7%	2	36	35.3%	1019	29.4%	1725	57.5%
Haddock													5	0.2%		1	1%	2	0.1%	2	0.1%
Whiting		4	4.5%				6	0.6%					1	0%				2	0.1%	3	0.1%
Saithe/pollack																		13	0.4%		
Pollack		3	3.4%		21	14.6%	161	16.4%	15	4.3%			1	0%				66	1.9%	15	0.5%
Saithe	5	38	43.2%	P	87	60.4%	448	45.7%	311	89.6%	72	47.7%	1176	48.6%	24	55	53.9%	2069	59.6%	1002	33.4%
Norway pout/bib/poor-cod																					
Norway pout																					
Bib																		1	0%		
Poor-cod																		2	0.1%		
Torsk											2	1.3%						3	0.1%	4	0.1%
Rockling	2	1	1.1%										8	0.3%				1	0%	10	0.3%
Five-bearded/northern rockling																					
Five-bearded rockling													9	0.4%				4	0.1%	10	0.3%
Four-bearded rockling											1	0.7%	3	0.1%				4	0.1%	7	0.2%
Shore rockling					1	0.7%	3	0.3%	1	0.3%											
Three-bearded rockling													5	0.2%				3	0.1%	11	0.4%
Tadpole fish																					
Ling	5	5	5.7%	P			1	0.1%			2	1.3%	53	2.2%		1	1%	10	0.3%	65	2.2%
Greater fork-beard																					
Total gadid id'd to species	25	88	100%		144	100%	981	100%	347	100%	151	100%	2419	100%	29	102	100%	3469	100%	3001	100%
Sources	Cerón-Carrasco 1998a, Tables 50. 53			Platt 1956	Cerón-Carrasco 1998b, Table 32						Chapter Six										

Appendix Table 5.2: Gadid NISP

Site	Tuquoy													
Dates	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med
Context types	Sandy, mixed	Construction	Wall fills	Floor deposits and ash layers	Floor deposits, debris associated with interior building work	Floor deposits, debris associated with interior building work	Floor deposits, debris associated with interior building work	External to structure 1, including pit fills, ash, flagstone paving	Destruction and rubble	Construction and wall cores	Occupation, floor deposits, possible industrial fuction	Unknown	Destruction and construct-on	Wall cores
Recovery	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc
Phase or area	Phase I	Phase IIa	Phase IIb	Phase IIIb	Phase IV	Phase V	Phase VI	Phase III-VI	Phase VII	Phase VIII	Phase IX internal	Phase IX external	Phase Xa	Phase Xb
Cod/saithe/pollack														
Cod	59 81.9%	8	101 75.9%	125 76.7%	100 76.7%	95 90.5%	65 79.3%	54 74%	19	35 64.8%	108 63.5%	6	367 74.6%	31 40.8%
Haddock						1 1%			1	1 1.9%			2 0.4%	3 3.9%
Whiting														
Saithe/pollack														
Pollack														
Saithe	5 6.9%		27 20.3%	13 8%	7 8%	4 3.8%	12 14.6%	15 20.5%	3	9 16.7%	42 24.7%	3	57 11.6%	32 42.1%
Norway pout/bib/poor-cod														
Norway pout														
Bib														
Poor-cod														
Torsk														
Rockling														
Five-bearded/northern rockling														
Five-bearded rockling														
Four-bearded rockling														
Shore rockling														
Three-bearded rockling														
Tadpole fish														
Ling	8 11.1%	1	5 3.8%	25 15.3%	6 15.3%	5 4.8%	5 6.1%	4 5.5%	1	9 16.7%	20 11.8%		66 13.4%	10 13.2%
Greater fork-beard														
Total gadid id'd to species	72 100%	9	133 100%	163 100%	113 100%	105 100%	82 100%	73 100%	24	54 100%	170 100%	9	492 100%	76 100%
Sources	Colley 1988													

Appendix Table 5.2: Gadid NISP

Site	Tuquoy (continued)												
Dates	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med	Viking Age to med
Context types	Occupation, floor deposits, ash	Unknown	Wall core, floor layers, rubble	Midden, rubble, collapse, wall fill etc.	Midden	Unknown	Midden, rubble	Midden	Unknown	Midden	Unknown	Midden	Sand, soil, stony fill
Recovery	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc	>1mm, >5mm, coarse and hc
Phase or area	Phase XI internal	Phase XIa exterior	Phase XIa exterior S3	Phase XIb exterior	Phase XIb exterior midden only	Phase XIb exterior S3	Phase XIc exterior	Phase XIc exterior midden only	Phase XIIa	Phase XIIa midden only	Phase XIIb	Phase XIIb midden only	Phase XIIa/b
Cod/saithe/pollack													
Cod	46 44.7%	141 66.2%	4	444 64%	159 70.7%	4	875 63.8%	678 61.4%	2622 59%	2424 60.4%	1591 59%	1360 56.9%	80 34.5%
Haddock	2 1.9%	1 0.5%		7 1%			3 0.2%	3 0.3%	7 0.2%	6 0.1%	37 1.4%	36 1.5%	
Whiting													
Saithe/pollack													
Pollack									2 0%	2 0%	12 0.4%	12 0.5%	
Saithe	48 46.6%	23 10.8%	2	150 21.6%	35 15.6%	8	234 17.1%	200 18.1%	908 20.4%	757 18.9%	789 29.3%	753 31.5%	134 57.8%
Norway pout/bib/poor-cod													
Norway pout													
Bib													
Poor-cod													
Torsk													
Rockling				1 0.1%					10 0.2%	9 0.2%	13 0.5%	13 0.5%	
Five-bearded/northern rockling													
Five-bearded rockling									1 0%	1 0%			
Four-bearded rockling													
Shore rockling									1 0%	1 0%			
Three-bearded rockling													
Tadpole fish													
Ling	7 6.8%	48 22.5%		92 13.3%	31 13.8%		260 19%	223 20.2%	890 20%	813 20.3%	255 9.5%	218 9.1%	18 7.8%
Greater fork-beard													
Total gadid id'd to species	103 100%	213 100%	6	694 100%	225 100%	12	1372 100%	1104 100%	4441 100%	4013 100%	2697 100%	2392 100%	232 100%
Sources	Colley 1988												

Appendix Table 5.2: Gadid NISP

Site	Tuquoy (continued)														Pool													
Dates	Med		Med		Med		Med		Med		Med		Med		Late Iron Age - Viking Age interface		Late Iron Age - Viking Age interface		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Viking Age to mid 11th c.	
Context types	Wall cores, floor surface, midden		Midden		Wall fill, soil, rubble, midden		Sand		Disuse, rubble, wall fill, middens		Midden		Sand		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mostly midden	
Recovery	>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		>1mm, >5mm, coarse and hc		Hc		Hc and >3mm		Hc, >3mm and >100mm		Hc		Hc		Hc and >3mm		Hc and >3mm	
Phase or area	Phase XIIIa		Phase XIIIa midden only		Phase XIIIb		Phase XIIIa/b		Phase XIVa		Phase XIVa midden only		Phase XIVb		Pool 7.1		Pool 7.2		Pool 8.1		Pool 8.2		Pool 8.2.1		Pool 8.2.2		Pool 8.2.3	
Cod/saithe/pollack															4	5.3%	815	30.5%	74	17.6%	23	15.6%	21	13%	106	14.8%	340	20.7%
Cod	697	66.3%	583	68.8%	120	50.6%			67	5.3%	51	4.2%	3	5.8%	17	22.7%	1364	51%	221	52.6%	106	72.1%	89	55.3%	340	47.6%	903	55%
Haddock	9	0.9%	6	0.7%	2	0.8%			70	5.5%	70	5.7%	7	13.5%			4	0.1%	42	10%	11	7.5%	1	0.6%	4	0.6%	8	0.5%
Whiting									1	0.1%	1	0.1%			1	1.3%	1	0%									1	0.1%
Saithe/pollack															7	9.3%	79	3%	14	3.3%			2	1.2%	9	1.3%	22	1.3%
Pollack	1	0.1%	1	0.1%	5	2.1%			4	0.3%	2	0.2%			6	8%	33	1.2%	22	5.2%							2	0.1%
Saithe	268	25.5%	195	23%	99	41.8%	1		1040	81.5%	1013	82.6%	41	78.8%	7	9.3%	336	12.6%	30	7.1%	2	1.4%	2	1.2%	42	5.9%	132	8%
Norway pout/bib/poor-cod																												
Norway pout																												
Bib																												
Poor-cod																												
Torsk																												
Rockling					2	0.8%			29	2.3%	28	2.3%																
Five-bearded/northern rockling																												
Five-bearded rockling					3	1.3%			58	4.5%	58	4.7%																
Four-bearded rockling																												
Shore rockling									3	0.2%	3	0.2%																
Three-bearded rockling																												
Tadpole fish																												
Ling	76	7.2%	63	7.4%	6	2.5%			4	0.3%			1	1.9%	33	44%	41	1.5%	17	4%	5	3.4%	46	28.6%	214	29.9%	235	14.3%
Greater fork-beard																												
Total gadid id'd to species	1051	100%	848	100%	237	100%	1		1276	100%	1226	100%	52	100%	75	100%	2673	100%	420	100%	147	100%	161	100%	715	100%	1643	100%
Sources	Colley 1988														Nicholson 1998, Table 5													

Appendix Table 5.2: Gadid NISP

Site	Brough of Birsay Rescue Exc.			Brough of Birsay Room 5						Brough Road				
Dates	Late Iron Age to early Viking Age	Late Viking Age	Late Viking-Age to early med	Late Iron Age - Viking Age	640-880	890-1190	Viking Age-Med	Viking Age-Med	890-1190		7-11th c.	7-12th c.	7-11th c.	7-11th c.
Context types	Industrial spreads	Gullies, pits, drainage ditch	Floor, wall fill, hearth, pits, some industrial fuction	Floor deposits	Floor surface, levelling	Occupation layers	Abandonment, general rubbish	Levelling, floor deposits	Abandonment period	Sand	Midden	Cist graves and associated midden	Midden	Disturbed midden
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc, sieved to 1cm and some sieved to >1mm	Hc and sieved to 1cm
Phase or area	Phase 1, site VII	Phase 2.2, site VII	Phase 3, site VII	Phase 1	Phase 2	Phase 3a	Phase 3b	Phase 4	Drain fill	Area 1, phase C	Area 1, phase D	Area 1, phase E	Area 1, phase F1	Area 1, phase F2
Cod/saithe/pollack														
Cod	p	p	p	5	3	32	36	438	22		87 74.4%	1	68 79.1%	9
Haddock														
Whiting														
Saithe/pollack											3 2.6%			
Pollack											1 0.9%			
Saithe		p	p							1	15 12.8%		11 12.8%	1
Norway pout/bib/poor-cod														
Norway pout														
Bib														
Poor-cod														
Torsk											2 1.7%		1 1.2%	
Rockling												1		
Five-bearded/northern rockling														
Five-bearded rockling														
Four-bearded rockling														
Shore rockling														
Three-bearded rockling														
Tadpole fish														
Ling			p								9 7.7%		6 7%	
Greater fork-beard														
Total gadid id'd to species				5	3	32	36	438	22	1	117 100%	2	86 100%	10
Sources	Sellar *et al.* 1986, Table 11			Sellar 1982, Tables 1, 2						Rackham 1989, Table 18				

Appendix Table 5.2: Gadid NISP

Site	Brough Road (continued)														
Dates	7-9th c.				9-13th c.		9-11th c.		7-11th c.				7-12th c.		7-10th c.
Context types	Sand		Stone spread	Flagstones	Midden		Midden		Cist graves and associated midden	Stone spread with sand		Sand	Floor deposits	Hearth and clay deposits	Organic spreads
Recovery	Hc and sieved to 1cm		Hc and sieved to 1cm	Hc and sieved to 1cm	Hc, sieved to 1cm and some sieved to >1mm		Hc, sieved to 1cm and some sieved to >1mm		Hc and sieved to 1cm	Hc and sieved to 1cm		Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm
Phase or area	Area 2, phase A		Area 2, phase B1	Area 2, phase B2	Area 2, phase C1		Area 2, phase C2		Area 2, phase D	Area 2, phase E1		Area 2, phase E2	Area 3, phase A	Area 3, phase B	Area 3, phase C
Cod/saithe/pollack															
Cod	63	62.4%	5	18	447	69.8%	442	59.4%	1	60	75.9%	4			2
Haddock							2	0.3%							
Whiting															
Saithe/pollack															
Pollack	4	4%		2	1	0.2%	4	0.5%		1	1.3%				2
Saithe	26	25.7%	2	4	132	20.6%	228	30.6%	4	11	13.9%	3	25	2	
Norway pout/bib/poor-cod															
Norway pout															
Bib															
Poor-cod															
Torsk					7	1.1%	9	1.2%							
Rockling					1	0.2%									
Five-bearded/northern rockling															
Five-bearded rockling															
Four-bearded rockling															
Shore rockling															
Three-bearded rockling															
Tadpole fish															
Ling	8	7.9%	1	3	52	8.1%	59	7.9%	1	7	8.9%				
Greater fork-beard															
Total gadid id'd to species	101	100%	8	27	640	100%	744	100%	6	79	100%	7	25	2	4
Sources	Rackham 1989, Tables 19, 20														

Appendix Table 5.2: Gadid NISP

Site	Beachview (Burnside)																							
Dates	1020-1320	1020-1320		1020-1280	1020-1280	1020-1280		1020-1280		1020-1280	1020-1280	1020-1280		1020-1280	1020-1280		1020-1280	1020-1280	1020-1280		1020-1280		1020-1280	
Context types	Midden	Midden		Midden	Midden	Midden		Midden		Midden	Midden	Midden		Midden	Midden		Midden	Midden	Midden		Midden		Midden	
Recovery	Hc	>2mm		Hc	Hc	Hc		Hc		>2mm	>2mm	>2mm		Hc	Hc		Hc	Hc	Hc		Hc		Hc	
Phase or area	Area 3 phase X	Area 3 phase X		Area 2, phase W, episode 3 PL	Area 2, phase W, episode 3 PT	Area 2, phase W, episode 5		Area 2, phase W total		Area 2, phase W, episode 3	Area 2, phase W, episode 5	Area 2, phase W total		Area 2, phase X, episode 6 PN	Area 2, phase X, episode 6 PK		Area 2, phase X, episode 7 PM	Area 2, phase X, episode 7 PU	Area 2, phase X, episode 7 PW		Area 2, phase X, episode 8		Area 2, phase X total	
Cod/saithe/pollack				1		1	3.2%	2	5.6%	4	1	5	11.4%	2	45	11.7%			4	9.8%	31	12%	82	11.7%
Cod	13	16	10.8%		4	29	93.5%	33	91.7%	3	2	5	11.4%	13	323	84.3%	2	2	37	90.2%	195	75.3%	572	81.4%
Haddock										1		1	2.3%		1	0.3%							1	0.1%
Whiting																								
Saithe/pollack																								
Pollack															1	0.3%							1	0.1%
Saithe		125	84.5%			1	3.2%	1	2.8%	19	14	33	75%	1	4	1%					2	0.8%	7	1%
Norway pout/bib/poor-cod																								
Norway pout																								
Bib																								
Poor-cod																								
Torsk																								
Rockling		6	4.1%																					
Five-bearded/northern rockling																								
Five-bearded rockling																								
Four-bearded rockling																								
Shore rockling																								
Three-bearded rockling																								
Tadpole fish																								
Ling		1	0.7%												9	2.3%					31	12%	40	5.7%
Greater fork-beard																								
Total gadid id'd to species	13	148	100%	1	4	31	100%	36	100%	27	17	44	100%	16	383	100%	2	2	41	100%	259	100%	703	100%
Sources	Colley and Rackham 1996, Tables M8, M26, M27																							

Appendix Table 5.2: Gadid NISP

Site	Beachview (Burnside) (continued)							Beachview Studio						
Dates	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	Med	1020-1320	980-1206	1030-1280		1001-1410		1020-1280	
Context types	Midden	Midden	Midden	Midden	Midden	Interface of midden and sand	Midden	Sand overlying rubble	Ash dump, sandy deposits	Midden	Midden	Sand blow, wall	Sands, burnt peat	Wall fill and rubble
Recovery	>2mm	>2mm	>2mm	>2mm	>2mm	Hc	>2mm	Hc	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Area 2, Phase X, Episode 6	Area 2, Phase X, Episode 7 PG	Area 2, Phase X, Episode 7 PW	Area 2, Phase X, Episode 8	Area 2, Phase X total	Area 2, Phase Y, Episode 9	Total Areas 2 and 3	Area 1D/E, Phase Q	Area 1D/E, Phase S	Area 1D/E, Phase T	Area 1D/E, Phase U	Area 1D/E, Phase V	Area 1D/E, Phase W	Area 1D/E, Phase X
Cod/saithe/pollack		83 61%	1		84 6.4%		89 5.9%		1 1.5%		5 9.6%		1	
Cod	76 24.5%	8 5.9%	5	237 27.7%	326 24.9%	1	347 23.1%	8	59 90.8%	1	45 86.5%	1	5	8
Haddock	1 0.3%				1 0.1%		2 0.1%							
Whiting														
Saithe/pollack														
Pollack														
Saithe	229 73.9%	44 32.4%		581 67.8%	854 65.2%		1012 67.4%		4 6.2%		2 3.8%		1	1
Norway pout/bib/poor-cod														
Norway pout														
Bib														
Poor-cod														
Torsk	1 0.3%				1 0.1%		1 0.1%							
Rockling		1 0.7%		1 0.1%	2 0.2%		8 0.5%							
Five-bearded/northern rockling														
Five-bearded rockling														
Four-bearded rockling														
Shore rockling														
Three-bearded rockling														
Tadpole fish														
Ling	3 1%			38 4.4%	41 3.1%		42 2.8%		1 1.5%					
Greater fork-beard														
Total gadid id'd to species	310 100%	136 100%	6	857 100%	1309 100%	1	1501 100%	8	65 100%	1	52 9.6%	1	7	9
Sources	Colley and Rackham 1996, Table M8, M26, M27							Rackham 1996a, Table 11						

Appendix Table 5.2: Gadid NISP

Site	Beachview Studio (continued)														
Dates									1134-1280	1134-1280	990-1220	990-1220			1163-1300
Context types	Mixed, including midden	Mixed, including midden	Peat ash, sandy layers	Wall fill, sandy layer	Hearth deposits	Hearth deposits	Sandy deposits in structure	Sandy deposits in structure	Pit fill and midden in structure	Pit fill and midden in structure	Midden, sand and clay layers	Midden, sand and clay layers	Wall dug into midden	Peat ash, clay layers built up to exterior of structure	Rubble collapse layers
Recovery	Hc	>3.5	>2mm	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm	Hc	Hc	Hc
Phase or area	Area 1D/E, phase Y	Area 1D/E, phase Y	Area 1, phase L	Area 1, phase N	Area 1, phase P	Area 1, phase P	Area 1, phase Q	Area 1, phase Q	Area 1, phase R	Area 1, phase R	Area 1, phase S	Area 1, phase S	Area 1, phase T	Area 1, phase U	Area 1, phase V
Cod/saithe/pollack	37 10.1%		26 28.9%	1		2		51 36.4%	1	273 39.8%	6	221 34.4%		12	4 3.9%
Cod	301 82.5%	14	8 8.9%	2	6		2	3 2.1%		85 12.4%	6	53 8.3%	24		92 90.2%
Haddock												1 0.2%			
Whiting															
Saithe/pollack															
Pollack	1 0.3%														
Saithe	1 0.3%		56 62.2%	1		3		85 60.7%		318 46.4%	5	352 54.8%		5	1 1%
Norway pout/bib/poor-cod															
Norway pout															
Bib															
Poor-cod															
Torsk								1 0.7%		7 1%		1 0.2%			
Rockling															
Five-bearded/northern rockling															
Five-bearded rockling															
Four-bearded rockling															
Shore rockling												2 0.3%			
Three-bearded rockling															
Tadpole fish															
Ling	25 6.8%	1								3 0.4%	3	12 1.9%		3	5 4.9%
Greater fork-beard															
Total gadid id'd to species	365 100%	15	90 100%	4	6	5	2	140 36.4%	1	686 100%	20	642 100%	24	20	102 100%
Sources	Rackham 1996a, Tables 11, 13, 14														

Appendix Table 5.2: Gadid NISP

Site	Beachview Studio (continued)				Buckquoy				Saevar Howe				
Dates			990-1210	990-1210	Pictish	Pictish	Viking Age	Viking Age	Iron Age	9th c. +/-	9th c. +/-	9th c. +/-	9th c. +/-
Context types	Drain fill	Wall fill	Sand and ash layers associated with disuse of structure	Sand and ash layers associated with disuse of structure	Mixed, including ?ritual	Mixed, including ?ritual	?Entirely midden	?Entirely midden	Mostly midden	Constr-uction, midden	Constru-ction, midden	Constru-ction, midden	Constru-ction, midden, abandonment
Recovery	Hc	Hc	Hc	>2mm	Hc	Hc	Hc	Hc	>5mm	>5mm	>5mm	>5mm	>5mm
Phase or area	Area 1, phase W	Area 1, phase X	Area 1, phase Y	Area 1, phase Y	Phase I all	Phase II all	Phase IV	Phase V	Phase I all	Phase IIa	Phase IIb	Phase IIb/c	Phase IIc
Cod/saithe/pollack			107 19.9%	257 30.2%					10 23.3%	9	97 43.5%	32 61.5%	28 65.1%
Cod	23		357 66.4%	76 8.9%			6	2	5 11.6%	5	105 47.1%	10 19.2%	10 23.3%
Haddock		1	2 0.4%	1 0.1%			?p	2					
Whiting													
Saithe/pollack					2		10	3					
Pollack			1 0.2%										
Saithe			27 5%	504 59.2%					16 37.2%	2	17 7.6%	3 5.8%	4 9.3%
Norway pout/bib/poor-cod													
Norway pout													
Bib													
Poor-cod													
Torsk				1 0.1%							1 0.4%		
Rockling			1 0.2%										
Five-bearded/northern rockling													
Five-bearded rockling													
Four-bearded rockling													
Shore rockling											1 0.4%		
Three-bearded rockling													
Tadpole fish													
Ling			43 8%	13 1.5%		1	4	5	12 27.9%	7	2 0.9%	7 13.5%	1 2.3%
Greater fork-beard													
Total gadid id'd to species	23	1	538 100%	852 30.2%	2	1	20	12	43 100%	23	223 100%	52 100%	43 100%
Sources	Rackham 1996a, Tables 13, 14				Wheeler 1976-77, Table 12				Colley 1983a, Table 13				

Appendix Table 5.2: Gadid NISP

Site	Brough of Deerness			Skaill	Newark Bay				Earl's Bu									
Dates	Med	Med and ?later	late Iron Age	?Viking Age and ?med	?Late Iron Age	Med	?Med	Med	Viking Age-med	Med	970-1220	880-1160	Med	Med	990-1190	890-1160	Viking Age-med	Med
Context types	Construction and use	Decay and collapse, possibly non-anthropogenic	Construction	Probably all midden	Souterrains	Assoc. with burials	Floor fill	Below drain	Construction and use of mill	Collapse features of mill	Mill features	Midden	Midden	Midden	Midden	Midden	Redeposited midden	Redeposited midden
Recovery	Mixed	Mixed	Mixed	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Chapel interior phase C	Chapel interior phase D	Enclosure phase A	Site 2 'Norse'	Souterrains	Assoc. with burials	Floor fill	Below drain	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3
Cod/saithe/pollack				220 13.8%					1				20 21.1%	5	83 57.6%	60 29%	6 14.3%	13 14.6%
Cod		2		780 48.9%	1	11	6	2	3	17	6	10	32 33.7%	18	38 26.4%	86 41.5%	25 59.5%	54 60.7%
Haddock				p p			2		1	1		1	20 21.1%	3	19 13.2%	31 15%	4 9.5%	16 18%
Whiting																		
Saithe/pollack				83 5.2%														
Pollack				165 10.3%														
Saithe	1	1	1	250 15.7%		4	4			3			2 2.1%			3 1.4%		2 2.2%
Norway pout/bib/poor-cod																		
Norway pout																		
Bib																		
Poor-cod																		
Torsk																		
Rockling																		
Five-bearded/northern rockling																		
Five-bearded rockling																		
Four-bearded rockling																		
Shore rockling																		
Three-bearded rockling																		
Tadpole fish																		
Ling		4		98 6.1%		5	1		1	4			21 22.1%	1	4 2.8%	27 13%	7 16.7%	4 4.5%
Greater fork-beard																		
Total gadid id'd to species	1	7	1	1596 100%	1	20	13	2	6	25	6	11	95 100%	27	144 100%	207 100%	42 100%	89 100%
Sources	Rackham 1986, Tables 6, 7			Nicholson 1997, Table 18.1	Harland 2001b				Chapter Five									

Appendix Table 5.2: Gadid NISP

Site	Earl's Bu (continued)																
Dates	Viking Age-med		Med	970-1220		880-1160		Med		Med		990-1190		890-1160		Viking Age-Med		Med	
Context types	Construction and use of mill		Collapse features of mill	Mill features		Midden		Midden		Midden		Midden		Midden		Redepos-ited midden		Redeposited midden	
Recovery	>4mm and 2-4mm		>4mm and 2-4mm	>4mm and 2-4mm		>4mm and 2-4mm		>4mm and 2-4mm		>4mm and 2-4mm		>4mm and 2-4mm		>4mm and 2-4mm		>4mm and 2-4mm		>4mm and 2-4mm	
Phase or area	C2		C3	F2		M1		M3		M3a		M3b		M3c		R1		R3	
Cod/saithe/pollack	28	19.6%	8	59	35.3%	100	24.8%	226	39.3%	412	24.6%	855	32.1%	2514	48%	284	25.6%	32	15.4%
Cod	75	52.4%	9	78	46.7%	200	49.5%	111	19.3%	660	39.4%	816	30.6%	913	17.4%	435	39.2%	55	26.4%
Haddock	34	23.8%	3	23	13.8%	73	18.1%	198	34.4%	428	25.6%	782	29.3%	1487	28.4%	315	28.4%	102	49%
Whiting														10	0.2%				
Saithe/pollack																			
Pollack												10	0.4%						
Saithe	3	2.1%		2	1.2%	30	7.4%	12	2.1%	143	8.5%	152	5.7%	90	1.7%	59	5.3%	7	3.4%
Norway pout/bib/poor-cod	1	0.7%								1	0.1%	1	0%	1	0%				
Norway pout														1	0%				
Bib																			
Poor-cod																			
Torsk																			
Rockling										3	0.2%	5	0.2%	5	0.1%	2	0.2%		
Five-bearded/northern rockling																			
Five-bearded rockling										1	0.1%			3	0.1%				
Four-bearded rockling																			
Shore rockling																			
Three-bearded rockling								1	0.2%					1	0%				
Tadpole fish																			
Ling	2	1.4%	1	5	3%	1	0.2%	26	4.5%	27	1.6%	45	1.7%	208	4%	14	1.3%	12	5.8%
Greater fork-beard								1	0.2%										
Total gadid id'd to species	143	100%	21	167	100%	404	100%	575	100%	1675	100%	2666	100%	5233	100%	1109	100%	208	100%
Sources	Chapter Four																		
Notes	Sieved to >4mm, and also includes vertebrae, dentaries and premaxillae from 2-4mm																		

Appendix Table 5.2: Gadid NISP

Site	Robert's Haven								Freswick									
Dates	11th to 13th c.		Viking Age to med		14th to 16th c.		Viking Age to med		?late Iron Age to med		Med		late Iron-Age to Viking Age		early 11th c. to late 14th		12th c. to early 14th	
Context types	Fish midden		Midden, associated with structure		Midden		Midden		Mostly midden		Mostly midden		Mixed, cultivation layers and deflated middens		Midden		Midden	
Recovery	>4mm		>4mm		>4mm		>4mm		>2mm		>2mm		>2mm		>2mm		>2mm	
Phase or area	Phase 1, area A		Phase 1, area B		Area E		Phase 2, area B		Inland, area 3		Inland, area 9		SCA, area 11-14		NCA, area 4, phases T, U, V		NCA, area 4, phase X	
Cod/saithe/pollack	15	0.7%	3	6.8%	7	2.8%	2	3.4%	1	0.2%					21	1.8%	2	1.1%
Cod	980	43%	5	11.4%	12	4.7%	8	13.8%	445	85.7%	29	28.4%	80	36.5%	415	35.8%	59	31.7%
Haddock	35	1.5%			4	1.6%	2	3.4%	4	0.8%	14	13.7%	2	0.9%	37	3.2%	6	3.2%
Whiting	4	0.2%													1	0.1%		
Saithe/pollack	53	2.3%	2	4.5%	2	0.8%	2	3.4%			1	1%			5	0.4%		
Pollack	88	3.9%	2	4.5%	4	1.6%							2	0.9%	18	1.6%	5	2.7%
Saithe	826	36.2%	32	72.7%	222	87.7%	42	72.4%	63	12.1%	30	29.4%	114	52.1%	360	31.1%	79	42.5%
Norway pout/bib/poor-cod	p	p							3	0.6%	1	1%	2	0.9%	6	0.5%	1	0.5%
Norway pout																		
Bib													1	0.5%				
Poor-cod																		
Torsk	8	0.4%													6	0.5%		
Rockling	p	p											1	0.5%	32	2.8%		
Five-bearded/northern rockling															2	0.2%	1	0.5%
Five-bearded rockling																		
Four-bearded rockling																		
Shore rockling																		
Three-bearded rockling																		
Tadpole fish															4	0.3%		
Ling	270	11.8%			2	0.8%	2	3.4%	3	0.6%	27	26.5%	17	7.8%	251	21.7%	33	17.7%
Greater fork-beard																		
Total gadid id'd to species	2279	100%	44	100%	253	100%	58	100%	519	100%	102	100%	219	100%	1158	100%	186	100%
Sources	Barrett 1997, Appendix 3		RL Parks pers. comm.		RL Parks pers. comm.		RL Parks pers. comm.		Jones 1995, Tables 17, 21, 27, 29, 31									
Notes	Data only available for >4mm, and for gadids these are counts of only 9 cranial elements, NOT vertebrae		These data only include the 9 cranial elements to match Phase 1, Area A		These data only include the 9 cranial elements to match Phase 1, Area A		These data only include the 9 cranial elements to match Phase 1, Area A		This is all fish bones except ui		This is all fish bones except ui		Only cleithra, dentaries, premaxillae and otoliths for main gadids, otherwise all fish bone except ui		Only cleithra, dentaries, premaxillae and otoliths for main gadids, otherwise all fish bone except ui		Only cleithra, dentaries, premaxillae and otoliths for main gadids, otherwise all fish bone except ui	

Appendix Table 5.3: Mammal NISP

Site	Sandwick North												Sandwick													
Dates	Med		11-12th c.		11-12th c.		12-13th c.		12-13th c.		13-14th c.		late 12th c.		late 12th c.		13th c.		13th c.		13th c.		late 13th to 14th c.		late 13th to 14th c.	
Context types	?Midden		Midden		Midden		Midden associated with structure		Midden associated with structure		Midden associated with structure		Midden		Midden		Midden		Midden		Midden		Midden		Midden	
Recovery	Hc		Hc		>4mm		Hc		>4mm		Hc		>1.5 to >3mm sieving and hc		>1.5 to >3mm sieving and hc		>1.5 to >3mm sieving and hc		>1.5 to >3mm sieving and hc		>1.5 to >3mm sieving and hc		>1.5 to >3mm sieving and hc		>1.5 to >3mm sieving and hc	
Phase or area	Phase 1		Phase 2		Phase 2		Phase 3		Phase 3		Phase 4		Early Phase, Area 3		Early Phase, Area 4		Middle Phase, Area 2		Middle Phase, Area 3		Middle Phase, Area 4		Late Phase, Area 3		Late Phase, Area 4	
Seal			p				p																			
Pigmy shrew																										
Common shrew																										
Mole																										
Whale sp.			p				p				p		1	0.4%			1		1	0.7%			4	0.5%	1	0.3%
Dog/Fox																										
Dog							3	0.8%					1	0.4%					1	0.7%			5	0.6%	6	1.7%
Stoat																										
Otter																							1	0.1%		
Cat			2	0.5%			23	5.8%			1	2.4%	3	1.1%			1						4	0.5%	2	0.6%
Horse			1	0.3%			12	3%					2	0.7%									7	0.8%	6	1.7%
Pig			6	1.5%	1		8	2%			p		6	2.2%	1	1.1%			4	2.7%	1	1.2%	6	0.7%	5	1.4%
Deer family																										
Red deer																										
Roe deer																										
Cattle	13		205	52.3%	2		161	40.4%			11	26.2%	91	33.3%	25	28.7%	7		48	32.7%	25	29.8%	380	43.9%	117	33.1%
Caprine	3		177	45.2%	6		192	48.1%			25	59.5%	64	23.4%	21	24.1%	4		25	17%	16	19%	136	15.7%	49	13.8%
(of which sheep)			14	3.6%			33	8.3%			3	7.1%	13	4.8%	3	3.4%			4	2.7%			14	1.6%	3	0.8%
(of which goat)																										
Rodent																										
Vole or mouse																										
Vole species																										
Bank vole																										
Orkney vole																										
Water vole																										
Mouse sp.																										
Wood Mouse																										
House Mouse																										
Ship/Common rat																										
Common rat																										
Rabbit																										
Brown/Mountain hare																										
Small mammal											5	11.9%														
Medium mammal 2																										
Medium mammal 1													77	28.2%	31	35.6%	5		48	32.7%	4	4.8%	229	26.5%	129	36.4%
Large mammal													28	10.3%	9	10.3%	4		20	13.6%	38	45.2%	93	10.8%	39	11%
Sea mammal																										
Other			1	0.3%																						
Total identified	16		392	100%	9		399	100%	0		42	100%	273	100%	87	100%	22		147	100%	84	100%	865	100%	354	100%
Unidentified	65		2487		590		1379		20		172		276		86		13		232		123		1253		590	
Total	81		2879		599		1778		20		214		549		173		35		379		207		2118		944	
Source	Barrett and Oltmann 2000, Tables 10, 11a, 12												Bigelow 1984, Tables 11, 12, 13													

Appendix Table 5.3: Mammal NISP

Site	Sandwick North						Sandwick						
Dates	Med	11-12th c.	11-12th c.	12-13th c.	12-13th c.	13-14th c.	late 12th c.	late 12th c.	13th c.	13th c.	13th c.	late 13th to 14th c.	late 13th to 14th c.
Context types	?Midden	Midden	Midden	Midden associated with structure	Midden associated with structure	Midden associated with structure	Midden	Midden	Midden	Midden	Midden	Midden	Midden
Recovery	Hc	Hc	>4mm	Hc	>4mm	Hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc	>1.5 to >3mm sieving and hc
Phase or area	Phase 1	Phase 2	Phase 2	Phase 3	Phase 3	Phase 4	Early phase, area 3	Early phase, area 4	Middle phase, area 2	Middle phase, area 3	Middle phase, area 4	Late phase, area 3	Late phase, area 4
Dog				0.8%			0.6%			1.3%		0.9%	3.2%
Cat		0.5%		5.8%		2.7%	1.8%		8.3%			0.7%	1.1%
Horse		0.3%		3%			1.2%					1.3%	3.2%
Pig		1.5%	11.1%	2%		p	3.6%	2.1%		5.1%	2.4%	1.1%	2.7%
Cattle	81.3%	52.4%	22.2%	40.4%		29.7%	54.5%	53.2%	58.3%	61.5%	59.5%	70.6%	63.2%
Caprine	18.8%	45.3%	66.7%	48.1%		67.6%	38.3%	44.7%	33.3%	32.1%	38.1%	25.3%	26.5%
(of which sheep)		3.6%		8.3%		8.1%	7.8%	6.4%		5.1%		2.6%	1.6%
(of which goat)													
Total domestic identifications	100% 16	100% 391	100% 9	100% 399	0	100% 37	100% 167	100% 47	100% 12	100% 78	100% 42	100% 538	100% 185

Appendix Table 5.3: Mammal NISP

Site	Scalloway				Jarlshof	St. Boniface		Quoygrew														
Dates	late Iron Age to Viking Age		9-10th c.		early 9th c. to med	250-750	1100-1250	676-896	1066-1294		Med	Viking Age		Viking Age	779-981		779-981		1035-1261		1035-1261	
Context types	Mixed including midden infill, ditch fills		Midden in disused and collapsing broch		Mostly midden	Plaggen soils, ?midden	?Midden	Fish midden	Fish midden		Fish midden	Farm mound midden		Farm mound midden	Farm mound midden		Farm mound midden		Farm mound midden		Farm mound midden	
Recovery	Hc and sieved		Hc and sieved		Selective hc	>1mm	>1mm	>2mm, ui only counted for >4mm	>2mm, ui only counted for >4mm		>2mm, ui only counted for >4mm	>2mm, ui only counted for >4mm		Hc	>2mm, ui only counted for >4mm		Hc		>2mm, ui only counted for >4mm		Hc	
Phase or area	Late phase 3		Block 7.1		Viking Age and medieval	Phase 7	Phase 8	Phase 1.2	Phase 2		Phase 7	Phase i		Phase i	Phase ii		Phase ii		Phase iii		Phase iii	
Seal			1	0.1%	p							3	6.8%		1	0.2%	3	0.2%	6	0.8%	20	0.6%
Pigmy shrew																						
Common shrew																						
Mole																						
Whale sp	6	0.4%	3	0.2%	p										2	0.3%	2	0.1%	2	0.3%	9	0.3%
Dog/Fox																						
Dog			2	0.1%	p												2	0.1%	2	0.3%	3	0.1%
Stoat																						
Otter																						
Cat	1	0.1%	9	0.6%					1	1.1%							9	0.6%	6	0.8%	16	0.5%
Horse	18	1.1%	21	1.5%	p												4	0.3%	1	0.1%	7	0.2%
Pig	277	16.6%	179	12.4%	p	3	5	1	6	6.6%	1	2	4.5%	1	19	3%	124	8.3%	57	7.5%	74	2.2%
Deer family																						
Red deer					p												2	0.1%				
Roe deer																						
Cattle	782	46.7%	499	34.5%	p	6	11		4	4.4%		10	22.7%	5	68	10.6%	301	20%	126	16.7%	1048	31.1%
Caprine	589	35.2%	728	50.3%	p	10	17	1	33	36.3%		6	13.6%	2	193	30.2%	292	19.4%	167	22.1%	800	23.8%
(of which sheep)																			6	0.8%	25	0.7%
(of which goat)																					1	0%
Rodent																						
Vole or mouse									4	4.4%		2	4.5%		6	0.9%			10	1.3%		
Vole species															8	1.3%	1	0.1%	8	1.1%	1	0%
Bank vole																						
Orkney vole												1	2.3%		87	13.6%			20	2.6%		
Water vole																						
Mouse sp.																			2	0.3%		
Wood Mouse									1	1.1%					4	0.6%			5	0.7%		
House Mouse																			1	0.1%		
Ship/Common rat																						
Common rat																						
Rabbit			6	0.4%					1	1.1%	2								2	0.3%	2	0.1%
Brown/Mountain hare																						
Small mammal									7	7.7%	1				26	4.1%			2	0.3%		
Medium mammal 2												2	4.5%		8	1.3%	4	0.3%	3	0.4%	2	0.1%
Medium mammal 1								6	29	31.9%	3	13	29.5%	12	172	26.9%	494	32.9%	234	31%	1057	31.4%
Large mammal									5	5.5%		5	11.4%	1	45	7%	260	17.3%	100	13.2%	327	9.7%
Sea mammal																	5	0.3%			1	0%
Other																			2	0.3%		
Total identified	1673	100%	1448	100%	0	19	33	8	91	100%	7	44	100%	21	639	100%	1503	100%	756	100%	3367	100%
Unidentified								121	1099		59	352		14	7681		2451		5934		3152	
Total	1673		1448		0	19	33	129	1190		66	396		35	8320		3954		6690		6519	
Source	Sharples 1998, Tables 16, 17, 18, 19, 21, 22, 23				Platt 1956	McCormick 1998b, Table 26		Chapter Six														

Appendix Table 5.3: Mammal NISP

Site	Scalloway		Jarlshof	St. Boniface		Quoygrew								
Dates	late Iron Age to Viking Age	9-10th c.	early 9th c. to med	250-750	1100-1250	676-896	1066-1294	Med	Viking Age	Viking Age	779-981	779-981	1035-1261	1035-1261
Context types	Mixed including midden infill, ditch fills	Midden in disused and collapsing broch	Mostly midden	Plaggen soils, ?midden	?Midden	Fish midden	Fish midden	Fish midden	Farm mound midden	Farm mound midden	Farm mound midden	Farm mound midden	Farm mound midden	Farm mound midden
Recovery	Hc and sieved	Hc and sieved	Selective hc	>1mm	>1mm	>2mm, ui only counted for >4mm	>2mm, ui only counted for >4mm	>2mm, ui only counted for >4mm	>2mm, ui only counted for >4mm	Hc	>2mm, ui only counted for >4mm	Hc	>2mm, ui only counted for >4mm	Hc
Phase or area	Late Phase 3	Block 7.1	Viking Age and medieval	Phase 7	Phase 8	Phase 1.2	Phase 2	Phase 7	Phase i	Phase i	Phase ii	Phase ii	Phase iii	Phase iii
Dog		0.1%	p									0.3%	0.6%	0.2%
Cat	0.1%	0.6%					2.3%					1.2%	1.7%	0.8%
Horse	1.1%	1.5%	p									0.5%	0.3%	0.4%
Pig	16.6%	12.4%	p	15.8%	15.2%	50%	13.6%	100%	11.1%	12.5%	6.8%	16.9%	15.9%	3.8%
Cattle	46.9%	34.7%	p	31.6%	33.3%		9.1%		55.6%	62.5%	24.3%	41.1%	35.1%	53.8%
Caprine	35.3%	50.6%	p	52.6%	51.5%	50%	75%		33.3%	25%	68.9%	39.9%	46.5%	41.1%
(of which sheep)													1.7%	1.3%
(of which goat)														0.1%
Total domestic identifications	100% 1667	100% 1438	p	100% 19	100% 33	100% 2	100% 44	100% 1	100% 18	100% 8	100% 280	100% 732	100% 359	100% 1948

Appendix Table 5.3: Mammal NISP

Site	Pool														Brough of Birsay Rescue Excavations													
Dates	late Iron Age - Viking Age interface		late Iron Age - Viking Age interface		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Viking Age to mid 11th c.		Late Iron Age to early Viking Age		Late Iron Age to early Viking Age		Late Iron Age to early Viking Age		Late Viking Age		Late Viking Age		Late Viking Age		Late Viking Age	
Context types	Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Industrial spreads		Ditch fill, stake hole, industrial *function*		Gullies, slots, burnt areas, hearths, walling, possible *industrial function*		Levelling of earlier structures		Gullies, pits, drainage ditch		Floor, drainage, wall fill, agricultural *function*		Drainage, wall foundations, hearth	
Recovery	>3mm, >1cm and hc		>3mm, >1cm and hc		>3mm, >1cm and hc		>3mm, >1cm and hc		>3mm, >1cm and hc		>3mm, >1cm and hc		>3mm, >1cm and hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc	
Phase or area	Phase 7.1		Phase 7.2		Phase 8.1		Phase 8.2		Phase 8.2.1		Phase 8.2.2		Phase 8.2.3		Phase 1, site VII		Phase 1, site VIII		Phase 1, site IX		Phase 2.1, site IX		Phase 2.2, site VII		Phase 2.2, site VIII		Phase 2.2, site IX	
Seal	24	0.5%	2	0%							3	0.2%	3	0.2%														
Pigmy shrew																												
Common shrew																												
Mole																												
Whale sp.	48	1.1%	31	0.5%	8	0.6%			5	2.5%	23	1.4%	9	0.5%														
Dog/Fox																												
Dog											2	0.1%	10	0.6%														
Stoat																												
Otter	3	0.1%	21	0.3%	2	0.2%							2	0.1%														
Cat	9	0.2%	30	0.5%	1	0.1%			1	0.5%	85	5.1%	76	4.2%														
Horse	39	0.9%	220	3.4%	56	4.2%	1	0.4%	4	2%	21	1.3%	52	2.9%														
Pig	459	10.3%	512	8%	110	8.3%	17	7.3%	15	7.4%	122	7.3%	103	5.7%	1	0.1%	8	2.7%	29	16.3%	20	5.1%	1	0.2%	51	7%	83	7.9%
Deer family																	1	0.3%					6	1.3%	9	1.2%		
Red deer	83	1.9%	53	0.8%	8	0.6%					18	1.1%	5	0.3%														
Roe deer																												
Cattle	1459	32.9%	2051	31.9%	434	32.9%	65	28%	35	17.2%	611	36.6%	510	28.2%	330	35.9%	154	51.9%	86	48.3%	165	42.4%	266	58.3%	402	55%	542	51.4%
Caprine	2205	49.7%	2681	41.7%	605	45.8%	69	29.7%	76	37.3%	533	31.9%	696	38.5%	583	63.4%	86	29%	63	35.4%	204	52.4%	180	39.5%	257	35.2%	429	40.7%
(of which sheep)																												
(of which goat)			p		p		p																					
Rodent																												
Vole or mouse																												
Vole species																												
Bank vole																												
Orkney vole																												
Water vole																												
Mouse sp																												
Wood Mouse																												
House Mouse																												
Ship/Common rat															5	0.5%							3	0.7%	1	0.1%		
Common rat																												
Rabbit																												
Brown/Mountain hare															1	0.1%	48	16.2%							11	1.5%		
Small mammal	2	0%	4	0.1%	2	0.2%	2	0.9%					2	0.1%														
Medium mammal 2																												
Medium mammal 1	37	0.8%	598	9.3%	50	3.8%	47	20.3%	47	23%	118	7.1%	198	10.9%														
Large mammal	68	1.5%	231	3.6%	44	3.3%	31	13.4%	21	10.3%	133	8%	144	8%														
Sea mammal																												
Other																												
Total identified	4436	100%	6434	100%	1320	100%	232	100%	204	100%	1669	100%	1810	100%	920	100%	297	100%	178	100%	389	100%	456	100%	731	100%	1054	100%
Unidentified	2975		3543		655		70		61		622		934															
Total	7411		9977		1975		302		265		2291		2744		920		297		178		389		456		731		1054	
Source	Bond 1994														Sellar *et al.* 1986, Tables 11, 18, 25, see note regarding recovery in Appendix One													

Appendix Table 5.3: Mammal NISP

Site	Pool							Brough of Birsay Rescue Excavations						
Dates	late Iron Age - Viking Age interface	late Iron Age - Viking Age interface	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Viking Age to mid 11th c.	Late Iron Age to early Viking Age	Late Iron Age to early Viking Age	Late Iron Age to early Viking Age	Late Viking Age	Late Viking Age	Late Viking Age	Late Viking Age
Context types	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Industrial spreads	Ditch fill, stake hole, industrial function	Gullies, slots, burnt areas, hearths, walling, possible industrial function	Levelling of earlier structures	Gullies, pits, drainage ditch	Floor, drainage, wall fill, agricultural function	Drainage, wall foundations, hearth
Recovery	>3mm, >1cm and hc	>3mm, >1cm and hc	>3mm, >1cm and hc	>3mm, >1cm and hc	>3mm, >1cm and hc	>3mm, >1cm and hc	>3mm, >1cm and hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Phase 7.1	Phase 7.2	Phase 8.1	Phase 8.2	Phase 8.2.1	Phase 8.2.2	Phase 8.2.3	Phase 1, site VII	Phase 1, site VIII	Phase 1, site IX	Phase 2.1, site IX	Phase 2.2, site VII	Phase 2.2, site VIII	Phase 2.2, site IX
Dog						0.1%	0.7%							
Cat	0.2%	0.5%	0.1%		0.8%	6.2%	5.3%							
Horse	0.9%	4%	4.6%	0.7%	3.1%	1.5%	3.6%							
Pig	11%	9.3%	9.1%	11.2%	11.5%	8.9%	7.1%	0.1%	3.2%	16.3%	5.1%	0.2%	7.2%	7.9%
Cattle	35%	37.3%	36%	42.8%	26.7%	44.5%	35.2%	36.1%	62.1%	48.3%	42.4%	59.5%	56.6%	51.4%
Caprine	52.9%	48.8%	50.2%	45.4%	58%	38.8%	48.1%	63.8%	34.7%	35.4%	52.4%	40.3%	36.2%	40.7%
(of which sheep)														
(of which goat)		p	p	p										
Total domestic identifications	100% 4171	100% 5494	100% 1206	100% 152	100% 131	100% 1374	100% 1447	100% 914	100% 248	100% 178	100% 389	100% 447	100% 710	100% 1054

Appendix Table 5.3: Mammal NISP

Site	Brough of Birsay Rescue Exc. (continued)				Brough of Birsay Room 5												Brough Road									
Dates	Late Viking Age to early med		Late Viking Age to early med		late Iron Age - Viking Age		640-880		890-1190		Viking Age - med		Viking Age - med		890-1190				7-11th c.		7-12th c.		7-11th c.		7-11th c.	
Context types	Floor, wall fill, hearth, pits, some industrial fuction		Floor deposits, domestic		Floor deposits		Floor surface, levelling		Occupation layers		Abandonment, general rubbish		Levelling, floor deposits		Abandonment period		Sand		Midden		Cist graves and associated midden		Midden		Disturbed midden	
Recovery	Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc, sieved to 1cm and some sieved to >1mm		Hc and sieved to 1cm	
Phase or area	Phase 3, site VII		Phase 3, site VIII		Phase 1		Phase 2		Phase 3a		Phase 3b		Phase 4		Drain fill		Area 1, phase C		Area 1, phase D		Area 1, phase E		Area 1, phase F1		Area 1, phase F2	
Seal																							3	0.2%	3	0.9%
Pigmy shrew																										
Common shrew																										
Mole																										
Whale sp																			5	1.2%						
Dog/Fox																										
Dog																										
Stoat																										
Otter					6	0.5%	1	0.3%	1	0.4%	0	0%	5	0.4%	44	9.1%										
Cat																										
Horse																							4	0.3%	1	0.3%
Pig	7	0.5%	75	11.8%	18	1.6%		0%	7	2.9%	15	4.4%	63	5%	20	4.1%			22	5.4%	2	5.1%	35	2.7%	4	1.2%
Deer family	6	0.4%	4	0.6%																						
Red deer																			8	2%			11	0.8%	4	1.2%
Roe deer																										
Cattle	501	35.1%	419	66.1%	523	47.8%	137	35%	96	39.3%	135	39.9%	442	34.8%	166	34.2%	7	17.1%	27	6.7%	2	5.1%	42	3.2%	3	0.9%
Caprine	856	60%	130	20.5%	525	48%	242	61.9%	125	51.2%	170	50.3%	672	53%	237	48.9%	1	2.4%	18	4.5%	2	5.1%	41	3.1%	5	1.5%
(of which sheep)																										
(of which goat)																										
Rodent																			3	0.7%						
Vole or mouse																										
Vole species						0%		0%		0%		0%	3	0.2%		0%							14	1.1%	24	7.3%
Bank vole																							1	0.1%		
Orkney vole	6	0.4%																					11	0.8%	1	0.3%
Water vole																										
Mouse sp.																										
Wood Mouse																										
House Mouse																										
Ship/Common rat	7	0.5%	2	0.3%	6	0.5%	3	0.8%		0%		0%	16	1.3%		0%										
Common rat																										
Rabbit					16	1.5%	8	2%	15	6.1%	18	5.3%	68	5.4%	18	3.7%	5	12.2%	31	7.7%	24	61.5%	422	32.4%	98	30%
Brown/Mountain hare	43	3%	4	0.6%																						
Small mammal																										
Medium mammal 2																			2	0.5%			2	0.2%	4	1.2%
Medium mammal 1																	3	7.3%	151	37.4%	7	17.9%	425	32.6%	50	15.3%
Large mammal																	25	61%	137	33.9%	2	5.1%	293	22.5%	130	39.8%
Sea mammal																										
Other																										
Total identified	1426	100%	634	100%	1094	100%	391	100%	244	100%	338	100%	1269	100%	485	100%	41	100%	404	100%	39	100%	1304	100%	327	100%
Unidentified																			63				2		1	
Total	1426		634		1094		391		244		338		1269		485		41		467		39		1306		328	
Source	Sellar *et al.* 1986, Tables 11, 18				Sellar 1982, Tables 1, 2												Rackham 1989, Table 18									

Appendix Table 5.3: Mammal NISP

Site	Brough of Birsay Rescue Exc. (continued)		Brough of Birsay Room 5						Brough Road				
Dates	Late Viking Age to early med	Late Viking Age to early med	late Iron Age - Viking Age	640-880	890-1190	Viking Age - med	Viking Age - med	890-1190		7-11th c.	7-12th c.	7-11th c.	7-11th c.
Context types	Floor, wall fill, hearth, pits, some industrial fuction	Floor deposits, domestic	Floor deposits	Floor surface, levelling	Occupation layers	Abandon-ment, general rubbish	Levelling, floor deposits	Abandon-ment period	Sand	Midden	Cist graves and associated midden	Midden	Disturbed midden
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc, sieved to 1cm and some sieved to >1mm	Hc and sieved to 1cm
Phase or area	Phase 3, site VII	Phase 3, site VIII	Phase 1	Phase 2	Phase 3a	Phase 3b	Phase 4	Drain fill	Area 1, phase C	Area 1, phase D	Area 1, phase E	Area 1, phase F1	Area 1, phase F2
Dog													
Cat													
Horse												3.3%	7.7%
Pig	0.5%	12%	1.7%	0%	3.1%	4.7%	5.4%	4.7%		32.8%	33.3%	28.7%	30.8%
Cattle	36.7%	67.1%	49.1%	36.1%	42.1%	42.2%	37.6%	39.2%	87.5%	40.3%	33.3%	34.4%	23.1%
Caprine	62.8%	20.8%	49.2%	63.9%	54.8%	53.1%	57.1%	56%	12.5%	26.9%	33.3%	33.6%	38.5%
(of which sheep)													
(of which goat)													
Total domestic identifications	100% 1364	100% 624	100% 1066	100% 379	100% 228	100% 320	100% 1177	100% 423	100% 8	100% 67	100% 6	100% 122	100% 13

Appendix Table 5.3: Mammal NISP

Site	Brough Road (continued)																							
Dates	7-9th c.						9-13th c.		9-11th c.		7-11th c.						7-12th c.							
Context types	Sand		Stone spread		Flagstones		Midden		Midden		Cist graves and associated midden		Stone spread with sand		Sand		Floor deposits		Hearth and clay deposits		Organic spreads			
Recovery	Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc, sieved to 1cm and some sieved to >1mm		Hc, sieved to 1cm and some sieved to >1mm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved to 1cm		Hc and sieved	
Phase or area	Area 2, phase A		Area 2, phase B1		Area 2, phase B2		Area 2, phase C1		Area 2, phase C2		Area 2, phase D		Area 2, phase E1		Area 2, phase E2		Area 3, phase A		Area 3, phase B		Area 3, phase C		All areas 1, 2 and 3	
Seal	9	2%	2	2.9%	2	4.4%	2	0.2%	7	0.7%			1	0.3%	1	0.4%					1	2%	31	0.6%
Pigmy shrew																								
Common shrew																								
Mole																								
Whale sp.																							5	0.1%
Dog/Fox	1	0.2%																					1	0%
Dog																								
Stoat																								
Otter									2	0.2%													2	0%
Cat									1	0.1%													1	0%
Horse	4	0.9%	1	1.4%			4	0.4%	6	0.6%			4	1.2%									24	0.5%
Pig	21	4.8%	4	5.7%	4	8.9%	41	4.6%	52	5.1%	2	6.7%	15	4.4%	12	4.7%					4	8.2%	218	4.1%
Deer family																								
Red deer	8	1.8%	1	1.4%	3	6.7%	10	1.1%	23	2.3%			6	1.8%	2	0.8%							76	1.4%
Roe deer																								
Cattle	29	6.6%	4	5.7%	2	4.4%	72	8%	46	4.5%	2	6.7%	8	2.4%	7	2.7%					7	14.3%	258	4.9%
Caprine	22	5%	9	12.9%			39	4.3%	39	3.8%	2	6.7%	11	3.2%	6	2.3%	2		1		3	6.1%	201	3.8%
(of which sheep)																								
(of which goat)																								
Rodent									1	0.1%			1	0.3%	2	0.8%							7	0.1%
Vole or mouse																								
Vole species							2	0.2%	10	1%			4	1.2%	2	0.8%							56	1.1%
Bank vole																							1	0%
Orkney vole															1	0.4%							13	0.2%
Water vole																								
Mouse sp.																								
Wood Mouse																								
House Mouse																								
Ship/Common rat																								
Common rat																								
Rabbit	12	2.7%			1	2.2%	8	0.9%	20	2%			120	35.3%	126	49%							867	16.4%
Brown/Mountain hare																								
Small mammal																								
Medium mammal 2	3	0.7%	2	2.9%	1	2.2%	2	0.2%	13	1.3%			2	0.6%	1	0.4%							32	0.6%
Medium mammal 1	146	33%	35	50%	19	42.2%	335	37.3%	322	31.5%	7	23.3%	100	29.4%	50	19.5%	2		2		11	22.4%	1665	31.5%
Large mammal	187	42.3%	12	17.1%	13	28.9%	384	42.7%	479	46.9%	17	56.7%	68	20%	47	18.3%	5				23	46.9%	1822	34.5%
Sea mammal																								
Other																								
Total identified	442	100%	70	100%	45	100%	899	100%	1021	100%	30	100%	340	100%	257	100%	9		3		49	100%	5280	100%
Unidentified	28				5		90		97				57										343	
Total	470		70		50		989		1118		30		397		257		9		3		49		5623	
Source	Rackham 1989, Tables 19, 20																							

Appendix Table 5.3: Mammal NISP

Site	Brough Road (continued)											
Dates	7-9th c.			9-13th c.	9-11th c.	7-11th c.			7-12th c.			
Context types	Sand	Stone spread	Flagstones	Midden	Midden	Cist graves and associated midden	Stone spread with sand	Sand	Floor deposits	Hearth and clay deposits	Organic spreads	
Recovery	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc, sieved to 1cm and some sieved to >1mm	Hc, sieved to 1cm and some sieved to >1mm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved to 1cm	Hc and sieved
Phase or area	Area 2, phase A	Area 2, phase B1	Area 2, phase B2	Area 2, phase C1	Area 2, phase C2	Area 2, phase D	Area 2, phase E1	Area 2, phase E2	Area 3, phase A	Area 3, phase B	Area 3, phase C	All areas 1, 2 and 3
Dog												
Cat					0.7%							0.1%
Horse	5.3%	5.6%		2.6%	4.2%		10.5%					3.4%
Pig	27.6%	22.2%	66.7%	26.3%	36.1%	33.3%	39.5%	48%			28.6%	31.1%
Cattle	38.2%	22.2%	33.3%	46.2%	31.9%	33.3%	21.1%	28%			50%	36.8%
Caprine	28.9%	50%		25%	27.1%	33.3%	28.9%	24%	100%	100%	21.4%	28.6%
(of which sheep)												
(of which goat)												
Total domestic identifications	100% 76	100% 18	100% 6	100% 156	100% 144	100% 6	100% 38	100% 25	100% 2	100% 1	100% 14	100% 702

Appendix Table 5.3: Mammal NISP

Site	Beachview (Burnside)													
Dates	1020-1320	1020-1320	Med	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1030-1280	1030-1280	1030-1280	1030-1280
Context types	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden
Recovery	Hc	>2mm	Hc	Hc	Hc	Hc	Hc	>2mm	>2mm	>2mm	Hc	Hc	Hc	Hc
Phase or area	Area 3, phase X	Area 3, phase X	Area 3, phase Y	Area 2, phase W, episode 3	Area 2, phase W, episode 4	Area 2, phase W, episode 5	Area 2, phase W total	Area 2, phase W, episode 3	Area 2, phase W, episode 5	Area 2, phase W total	Area 2, phase X, episode 6	Area 2, phase X, episode 7	Area 2, phase X, episode 8	Area 2, phase X total
Seal	1 0.3%										1 0.1%			1 0.1%
Pigmy shrew		1 0.4%						1 0.7%	4 6.9%	5 2.5%				
Common shrew														
Mole														
Whale sp.														
Dog/Fox											1 0.1%			1 0.1%
Dog		1 0.4%									1 0.1%			1 0.1%
Stoat														
Otter														
Cat	1 0.3%										5 0.7%			5 0.4%
Horse	1 0.3%			1 2.9%			1 0.7%				6 0.8%	1 1.2%	6 1.3%	13 1%
Pig	13 4.2%	4 1.6%	2	3 8.6%		7 6.9%	10 7.2%	2 1.4%		2 1%	55 7.2%	7 8.1%	27 5.7%	89 6.7%
Deer family									1 1.7%	1 0.5%				
Red deer									1 1.7%	1 0.5%			1 0.2%	1 0.1%
Roe deer														
Cattle	49 15.9%	9 3.6%	2		1	11 10.8%	12 8.6%	1 0.7%	4 6.9%	5 2.5%	75 9.8%	13 15.1%	64 13.4%	152 11.5%
Caprine	20 6.5%	9 3.6%	2	4 11.4%		19 18.6%	23 16.5%	4 2.7%	3 5.2%	7 3.4%	65 8.5%	5 5.8%	30 6.3%	100 7.5%
(of which sheep)											1 0.1%			1 0.1%
(of which goat)														
Rodent		49 19.4%						30 20.5%	5 8.6%	35 17.2%				
Vole or mouse														
Vole species		27 10.7%						33 22.6%	10 17.2%	43 21.1%				
Bank vole														
Orkney vole		1 0.4%						1 0.7%	1 1.7%	2 1%				
Water vole														
Mouse sp.								12 8.2%	1 1.7%	13 6.4%				
Wood Mouse		2 0.8%						1 0.7%	1 1.7%	2 1%				
House Mouse		9 3.6%						8 5.5%	5 8.6%	13 6.4%				
Ship/Common rat														
Common rat														
Rabbit		20 7.9%	1											
Brown/Mountain hare														
Small mammal		24 9.5%				1 1%	1 0.7%	31 21.2%	9 15.5%	40 19.6%			1 0.2%	1 0.1%
Medium mammal 2	1 0.3%	3 1.2%									4 0.5%	1 1.2%	6 1.3%	11 0.8%
Medium mammal 1	145 46.9%	84 33.2%	12	18 51.4%		53 52%	71 51.1%	16 11%	12 20.7%	28 13.7%	410 53.7%	46 53.5%	242 50.7%	698 52.6%
Large mammal	78 25.2%	10 4%	1	9 25.7%	1	11 10.8%	21 15.1%	6 4.1%	1 1.7%	7 3.4%	141 18.5%	13 15.1%	100 21%	254 19.1%
Sea mammal														
Other														
Total identified	309 100%	253 100%	20	35 100%	2	102 100%	139 100%	146 100%	58 100%	204 100%	764 100%	86 100%	477 100%	1327 100%
Unidentified	4	2303				1	1	297	197	494	4	2	1	7
Total	313	2556	20	35	2	103	140	443	255	698	768	88	478	1334
Source	Rackham 1989, Tables M5, M12, M13													

Appendix Table 5.3: Mammal NISP

Site	Beachview (Burnside)													
Dates	1020-1320	1020-1320	Med	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1030-1280	1030-1280	1030-1280	1030-1280
Context types	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden
Recovery	Hc	>2mm	Hc	Hc	Hc	Hc	Hc	>2mm	>2mm	>2mm	Hc	Hc	Hc	Hc
Phase or area	Area 3, phase X	Area 3, phase X	Area 3, phase Y	Area 2, phase W, episode 3	Area 2, phase W, episode 4	Area 2, phase W, episode 5	Area 2, phase W total	Area 2, phase W, episode 3	Area 2, phase W, episode 5	Area 2, phase W total	Area 2, phase X, episode 6	Area 2, phase X, episode 7	Area 2, phase X, episode 8	Area 2, phase X total
Dog		4.3%									0.5%			0.3%
Cat	1.2%										2.4%			1.4%
Horse	1.2%			12.5%			2.2%				2.9%	3.8%	4.7%	3.6%
Pig	15.5%	17.4%	33.3%	37.5%		18.9%	21.7%	28.6%		14.3%	26.6%	26.9%	21.3%	24.7%
Cattle	58.3%	39.1%	33.3%		100%	29.7%	26.1%	14.3%	57.1%	35.7%	36.2%	50%	50.4%	42.2%
Caprine	23.8%	39.1%	33.3%	50%		51.4%	50%	57.1%	42.9%	50%	31.4%	19.2%	23.6%	27.8%
(of which sheep)											0.5%			0.3%
(of which goat)														
Total domestic identifications	100% 84	100% 23	100% 6	100% 8	100% 1	100% 37	100% 46	100% 7	100% 7	100% 14	100% 207	100% 26	100% 127	100% 360

Appendix Table 5.3: Mammal NISP

Site	Beachview (Burnside) (continued)																		Beachview Studio											
Dates	1030-1280		1030-1280		1030-1280		1030-1280		1030-1280		Med		Med		Med		Med		980-1206				1030-1280				1001-1410			
Context types	Midden		Midden		Midden		Midden		Midden		Interface of midden and sand		Interface of midden and sand		Interface of midden and sand		Interface of midden and sand		Sand overlying rubble		Wall core		Ash dump, sandy deposits		Midden		Midden		Sand blow, wall	
Recovery	>2mm		>2mm		>2mm		>2mm		>2mm		Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc	
Phase or area	Area 2, phase X, episode 6		Area 2, phase X, episode 7 PG		Area 2, phase X, episode 7 PW		Area 2, phase X, episode 8		Area 2, phase X total		Area 2, phase Y, episode 9		Area 2, phase Y, episode 10		Area 2, phase Y, episode 11		Area 2, phase Y total		Area 1D/E, phase Q		Area 1D/E, phase R		Area 1D/E, phase S		Area 1D/E, phase T		Area 1D/E, phase U		Area 1D/E, phase V	
Seal							1	0.1%	1	0%															6	16.7%	8	0.5%		
Pigmy shrew	1	0.1%							1	0%																				
Common shrew																														
Mole																														
Whale sp																														
Dog/Fox																														
Dog			1	0.7%					1	0%			2				2	2.8%					1	0.3%						
Stoat																														
Otter																														
Cat	13	1.2%	1	0.7%					14	0.5%																				
Horse																			1	0.8%			1	0.3%						
Pig	9	0.8%	5	3.5%			16	0.9%	30	1%	4	9.8%					4	5.6%	3	2.4%			25	6.7%	1	2.8%	42	2.7%		
Deer family																														
Red deer																														
Roe deer																														
Cattle	22	1.9%	5	3.5%			30	1.7%	57	1.9%	6	14.6%	1		2		9	12.7%	12	9.7%			55	14.7%	4	11.1%	68	4.4%	4	4.1%
Caprine	28	2.5%	7	4.9%			30	1.7%	65	2.1%	3	7.3%	3		1		7	9.9%	16	12.9%			70	18.7%	6	16.7%	283	18.4%	19	19.4%
(of which sheep)																														
(of which goat)																														
Rodent	272	24.1%	4	2.8%	2		420	23.5%	698	22.8%																	8	0.5%		
Vole or mouse																														
Vole species	125	11.1%	23	16.2%			299	16.7%	447	14.6%																				
Bank vole																														
Orkney vole	16	1.4%	9	6.3%	1		24	1.3%	50	1.6%																				
Water vole																														
Mouse sp	49	4.3%					179	10%	228	7.4%																	6	0.4%		
Wood Mouse	7	0.6%					89	5%	96	3.1%																	8	0.5%		
House Mouse	26	2.3%	20	14.1%			101	5.6%	147	4.8%																	2	0.1%		
Ship/Common rat																														
Common rat																														
Rabbit																														
Brown/Mountain hare																														
Small mammal	242	21.4%	5	3.5%			409	22.8%	656	21.4%	1	2.4%	1		1		3	4.2%									12	0.8%		
Medium mammal 2	14	1.2%					1	0.1%	15	0.5%									3	2.4%							10	0.6%		
Medium mammal 1	275	24.4%	46	32.4%			161	9%	482	15.7%	15	36.6%	10		2		27	38%	72	58.1%			173	46.3%	15	41.7%	984	63.9%	73	74.5%
Large mammal	30	2.7%	16	11.3%			31	1.7%	77	2.5%	12	29.3%	5		2		19	26.8%	17	13.7%	1		49	13.1%	4	11.1%	109	7.1%	2	2%
Sea mammal																														
Other																														
Total identified	1129	100%	142	100%	3		1791	100%	3065	100%	41	100%	22		8		71	100%	124	100%	1		374	100%	36	100%	1540	100%	98	100%
Unidentified	4573		1		50		3540		8164														3		1		4		2	
Total	5702		143		53		5331		11229		41		22		8		71		124		1		377		37		1544		100	
Source	Rackham 1996a, Tables M12, M13																		Rackham 1996a, Table 11											

Appendix Table 5.3: Mammal NISP

Site	Beachview (Burnside) (continued)									Beachview Studio					
Dates	1030-1280	1030-1280	1030-1280	1030-1280	1030-1280	Med	Med	Med	Med	980-1206		1030-1280		1001-1410	
Context types	Midden	Midden	Midden	Midden	Midden	Interface of midden and sand	Interface of midden and sand	Interface of midden and sand	Interface of midden and sand	Sand overlying rubble	Wall core	Ash dump, sandy deposits	Midden	Midden	Sand blow, wall
Recovery	>2mm	>2mm	>2mm	>2mm	>2mm	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Area 2, phase X, episode 6	Area 2, phase X, episode 7 PG	Area 2, phase X, episode 7 PW	Area 2, phase X, episode 8	Area 2, phase X total	Area 2, phase Y, episode 9	Area 2, phase Y, episode 10	Area 2, phase Y, episode 11	Area 2, phase Y total	Area 1D/E, phase Q	Area 1D/E, phase R	Area 1D/E, phase S	Area 1D/E, phase T	Area 1D/E, phase U	Area 1D/E, phase V
Dog		5.3%			0.6%		33.3%		9.1%			0.7%			
Cat	18.1%	5.3%			8.4%										
Horse										3.1%		0.7%			
Pig	12.5%	26.3%		21.1%	18%	30.8%			18.2%	9.4%		16.4%	9.1%	10.7%	
Cattle	30.6%	26.3%		39.5%	34.1%	46.2%	16.7%	66.7%	40.9%	37.5%		36.2%	36.4%	17.3%	17.4%
Caprine	38.9%	36.8%		39.5%	38.9%	23.1%	50%	33.3%	31.8%	50%		46.1%	54.5%	72%	82.6%
(of which sheep)															
(of which goat)															
Total domestic identifications	100% 72	100% 19	0	100% 76	100% 167	100% 13	100% 6	100% 3	100% 22	100% 32	0	100% 152	100% 11	100% 393	100% 23

Appendix Table 5.3: Mammal NISP

Site	Beachview Studio (continued)																
Dates	1020-1280																1134-1280
Context types	Sands, burnt peat		Sands, burnt peat	Wall fill and rubble	Mixed, including midden		Wall fill	Peat ash, sandy layers	Peat ash, sandy layers	Wall fill, sandy layer		Hearth deposits	Hearth deposits	Sandy deposits in structure	Sandy deposits in structure		Pit fill and midden in structure
Recovery	Hc		>3.5	Hc	Hc		Hc	Hc	>2mm	Hc		Hc	>2mm	Hc	>2mm		Hc
Phase or area	Area 1D/E, phase W		Area 1D/E, phase W	Area 1D/E, phase X	Area 1D/E, phase Y		Area 1, phase K	Area 1, phase L	Area 1, phase L	Area 1, phase N		Area 1, phase P	Area 1, phase P	Area 1, phase Q	Area 1, phase Q		Area 1, phase R
Seal					6	0.3%				1	1.9%						
Pigmy shrew																	
Common shrew																	
Mole																	
Whale sp.																	
Dog/Fox					1	0.1%											
Dog					76	4%											
Stoat																	
Otter																	
Cat					2	0.1%				1	1.9%						
Horse					3	0.2%											
Pig	6	1.8%		3	81	4.2%		1		1	1.9%				1	2.4%	
Deer family					1	0.1%											
Red deer																	
Roe deer																	
Cattle	44	13.4%	1	5	134	7%		1		5	9.4%			1	1	2.4%	
Caprine	19	5.8%		1	131	6.9%	1	3	1	9	17%	2			4	9.8%	3
(of which sheep)																	
(of which goat)																	
Rodent					6	0.3%						1	2		4	9.8%	
Vole or mouse																	
Vole species																	
Bank vole																	
Orkney vole					2	0.1%							1		1	2.4%	
Water vole																	
Mouse sp.																	
Wood Mouse					1	0.1%											
House Mouse									1				2		1	2.4%	
Ship/Common rat																	
Common rat																	
Rabbit					1	0.1%											
Brown/Mountain hare																	
Small mammal																	
Medium mammal 2	1	0.3%			25	1.3%		1	2						1	2.4%	
Medium mammal 1	208	63.4%	13	11	1234	64.7%	1	9	8	28	52.8 %	12			25	61%	
Large mammal	50	15.2%	14	5	204	10.7%			1	8	15.1 %	1			3	7.3%	
Sea mammal																	
Other																	
Total identified	328	100%	28	25	1908	100%	2	15	13	53	100 %	16	5	1	41	100%	3
Unidentified	2				44												
Total	330		28	25	1952		2	15	13	53		16	5	1	41		3
Source	Rackham 1996a, Tables 11, 13, 14																

Appendix Table 5.3: Mammal NISP

Site	Beachview Studio (continued)												
Dates	1020-1280												1134-1280
Context types	Sands, burnt peat	Sands, burnt peat	Wall fill and rubble	Mixed, including midden	Wall fill	Peat ash, sandy layers	Peat ash, sandy layers	Wall fill, sandy layer	Hearth deposits	Hearth deposits	Sandy deposits in structure	Sandy deposits in structure	Pit fill and midden in structure
Recovery	Hc	>3.5	Hc	Hc	Hc	Hc	>2mm	Hc	Hc	>2mm	Hc	>2mm	Hc
Phase or area	Area 1D/E, phase W	Area 1D/E, phase W	Area 1D/E, phase X	Area 1D/E, phase Y	Area 1, phase K	Area 1, phase L	Area 1, phase L	Area 1, phase N	Area 1, phase P	Area 1, phase P	Area 1, phase Q	Area 1, phase Q	Area 1, phase R
Dog				17.8%									
Cat				0.5%				6.3%					
Horse				0.7%									
Pig	8.7%		33.3%	19%		20%		6.3%				16.7%	
Cattle	63.8%	100%	55.6%	31.4%		20%		31.3%			100%	16.7%	
Caprine	27.5%		11.1%	30.7%	100%	60%	100%	56.3%	100%			66.7%	100%
(of which sheep)													
(of which goat)													
Total domestic identifications	100% 69	100% 1	100% 9	100% 427	100% 1	100% 5	100% 1	100% 16	100% 2	0	100% 1	100% 6	100% 3

Appendix Table 5.3: Mammal NISP

Site	Beachview Studio																	Buckquoy									
Dates	1134-1280		990-1220		990-1220					1163-1300		990-1210						late Iron Age		late Iron Age		Viking Age		Viking Age		Viking Age	
Context types	Pit fill and midden in structure		Midden, sand and clay layers		Midden, sand and clay layers		Wall dug into midden	Peat ash, clay layers built up to exterior of structure		Rubble collapse layers		Drain fill	Wall fill	Sand and ash layers associated with disuse of structure		Sand and ash layers associated with disuse of structure		Mixed, including ?ritual		Mixed, including ?ritual		?Entirely midden		?Entirely midden		?Entirely midden	
Recovery	>2mm		Hc		>2mm		Hc	Hc		Hc		Hc	Hc	Hc		>2mm		Hc		Hc		Hc		Hc		Hc	
Phase or area	Area 1, phase R		Area 1, phase S		Area 1, phase S		Area 1, phase T	Area 1, phase U		Area 1, phase V		Area 1, phase W	Area 1, phase X	Area 1, phase Y		Area 1, phase Y		Phase I total		Phase II total		Phase III		Phase IV		Phase V	
Seal	1	0.6%						6	2.6%					3	0.4%			10	0.5%	2	0.2%			4	0.9%	10	0.4%
Pigmy shrew																											
Common shrew																											
Mole																											
Whale sp.																		1	0%	2	0.2%			1	0.2%	7	0.3%
Dog/Fox																											
Dog														1	0.1%					2	0.2%					4	0.2%
Stoat																											
Otter																		3	0.1%								
Cat	1	0.6%												6	0.7%	4	2.4%	2	0.1%	13	1.6%					34	1.5%
Horse										1	0.5%			2	0.2%			60	2.9%	12	1.5%	4	1.4%	18	3.9%	45	2%
Pig	4	2.4%	4	1.1%	3	0.5%		9	3.9%	2	1%		1	50	5.9%	7	4.3%	324	15.9%	162	20.1%	37	13.3%	45	9.8%	382	16.9%
Deer family																											
Red deer																		11	0.5%	2	0.2%					8	0.4%
Roe deer																								1	0.2%		
Cattle	5	3%	12	3.3%	3	0.5%		8	3.5%	6	3%		2	67	7.9%	2	1.2%	1292	63.5%	365	45.2%	146	52.3%	277	60.1%	1044	46.3%
Caprine	24	14.3%	126	35%	107	19.1%	1	20	8.7%	71	35.5%		1	103	12.2%	9	5.5%	328	16.1%	242	30%	90	32.3%	114	24.7%	702	31.1%
(of which sheep)			1	0.3%										2	0.2%												
(of which goat)																				1	0.1%	6	2.2%			30	1.3%
Rodent	1	0.6%	4	1.1%	11	2%								1	0.1%	14	8.5%										
Vole or mouse																											
Vole species																											
Bank vole																											
Orkney vole			3	0.8%	2	0.4%								1	0.1%	1	0.6%									15	0.7%
Water vole																											
Mouse sp.					3	0.5%										4	2.4%							1	0.2%	1	0%
Wood Mouse																											
House Mouse	1	0.6%			6	1.1%										1	0.6%										
Ship/Common rat																		1	0%	2	0.2%	2	0.7%			2	0.1%
Common rat																											
Rabbit					4	0.7%		1	0.4%					5	0.6%			3	0.1%	3	0.4%					2	0.1%
Brown/Mountain hare																											
Small mammal																											
Medium mammal 2	1	0.6%	2	0.6%	6	1.1%				1	0.5%			29	3.4%	12	7.3%										
Medium mammal 1	123	73.2%	199	55.3%	410	73.1%	1	180	78.3%	110	55%	1	4	459	54.2%	99	60.4%										
Large mammal	7	4.2%	10	2.8%	6	1.1%		6	2.6%	9	4.5%		1	120	14.2%	11	6.7%										
Sea mammal																											
Other																											
Total identified	168	100%	360	100%	561	100%	2	230	100%	200	100%	1	9	847	100%	164	100%	2035	100%	807	100%	279	100%	461	100%	2256	100%
Unidentified	1		1		2			1						7		1											
Total	169		361		563		2	231		200		1	9	854		165		2035		807		279		461		2256	
Source	Rackham 1996a, Tables 13, 14																	Noddle 1976-77, Noddle archive									

Appendix Table 5.3: Mammal NISP

Site	Beachview Studio (continued)										Buckquoy				
Dates	1134-1280	990-1220	990-1220	1163-1300					990-1210		late Iron Age	late Iron Age	Viking Age	Viking Age	Viking Age
Context types	Pit fill and midden in structure	Midden, sand and clay layers	Midden, sand and clay layers	Wall dug into midden	Peat ash, clay layers built up to exterior of structure	Rubble collapse layers	Drain fill	Wall fill	Sand and ash layers associated with disuse of structure	Sand and ash layers associated with disuse of structure	Mixed, including ?ritual	Mixed, including ?ritual	?Entirely midden	?Entirely midden	?Entirely midden
Recovery	>2mm	Hc	>2mm	Hc	Hc	Hc	Hc	Hc	Hc	>2mm	Hc	Hc	Hc	Hc	Hc
Phase or area	Area 1, phase R	Area 1, phase S	Area 1, phase S	Area 1, phase T	Area 1, phase U	Area 1, phase V	Area 1, phase W	Area 1, phase X	Area 1, phase Y	Area 1, phase Y	Phase I total	Phase II total	Phase III	Phase IV	Phase V
Dog									0.4%			0.3%			0.2%
Cat	2.9%								2.6%	18.2%	0.1%	1.6%			1.5%
Horse						1.3%			0.9%		3%	1.5%	1.4%	4%	2%
Pig	11.8%	2.8%	2.7%		24.3%	2.5%		25%	21.8%	31.8%	16.2%	20.4%	13.4%	9.9%	17.3%
Cattle	14.7%	8.5%	2.7%		21.6%	7.5%		50%	29.3%	9.1%	64.4%	45.9%	52.7%	61%	47.2%
Caprine	70.6%	88.7%	94.7%	100%	54.1%	88.8%		25%	45%	40.9%	16.4%	30.4%	32.5%	25.1%	31.8%
(of which sheep)		0.7%							0.9%						
(of which goat)												0.1%	2.2%		1.4%
Total domestic identifications	100% 34	100% 142	100% 113	100% 1	100% 37	100% 80	0	100% 4	100% 229	100% 22	100% 2006	100% 796	100% 277	100% 454	100% 2211

Appendix Table 5.3: Mammal NISP

Site	Saevar Howe							Brough of Deerness								
Dates	Iron Age	Iron Age	Iron Age	Iron Age	9th c. +/-	9th c. +/-	9th c. +/-	Med and ?later	late Iron Age	Viking Age to med	Med	Med and ?later	late Iron Age	Viking Age to med	Viking Age to med	Med and ?later
Context types	Internal floor deposits, midden	Midden	?Midden	Internal floor deposits, midden	Constru-ction, midden	Constru-ction, midden	Constru-ction, midden, abandon-ment	Mixed	Constru-ction	Constru-ction	Constru-ction and use	Decay and collapse, possibly non-anthropogenic	Constru-ction	Constru-ction	Constru-ction and use	Decay and collapse, possibly non-anthropogenic
Recovery	>5mm	>5mm	>5mm	>5mm	>5mm	>5mm	>5mm	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
Phase or area	Phase I a	Phase Ib	Phase Ic	Phase I total	Phase IIa	Phase IIb	Phase IIc	Outside enclosure, all phases	Chapel interior phase A	Chapel interior phase B	Chapel interior phase C	Chapel interior phase D	Enclosure phase A	Enclosure phase B	Enclosure phase C	Enclosure phase D
Seal															1 0.4%	
Pigmy shrew																
Common shrew																
Mole																
Whale sp.															1 0.4%	
Dog/Fox																
Dog																
Stoat																
Otter																
Cat					5 13.2%	2 1.4%	3 4.3%									
Horse		1 1.3%		1 0.6%		9 6.1%	2 2.9%			2 3.8%					4 1.5%	
Pig	7 16.7%	11 14.7%	7 13.5%	25 14.8%	5 13.2%	17 11.5%	16 22.9%	2		18 34%	1	22 10.9%	5 5.4%	2 3.4%	14 5.1%	
Deer family																
Red deer																
Roe deer																
Cattle	7 16.7%	12 16%	10 19.2%	29 17.2%	5 13.2%	54 36.5%	20 28.6%	7		4 7.5%	1	8 4%	11 12%	20 34.5%	59 21.6%	1 4%
Caprine	27 64.3%	47 62.7%	35 67.3%	109 64.5%	22 57.9%	66 44.6%	29 41.4%		1	8 15.1%	1	47 23.4%	3 3.3%	2 3.4%	27 9.9%	5 20%
(of which sheep)	4 9.5%	7 9.3%	2 3.8%	13 7.7%	4 10.5%	5 3.4%	6 8.6%					1 0.5%				
(of which goat)					1 2.6%											
Rodent												1 0.5%			1 0.4%	
Vole or mouse																
Vole species																
Bank vole																
Orkney vole											7	6 3%	2 2.2%			
Water vole																
Mouse sp.																
Wood Mouse																
House Mouse																
Ship/Common rat																1 4%
Common rat																
Rabbit	1 2.4%	4 5.3%		5 3%								33 16.4%	1 1.1%		8 2.9%	8 32%
Brown/Mountain hare																
Small mammal												2 1%				1 4%
Medium mammal 2												1 0.5%				1 4%
Medium mammal 1								6	11	9 17%	11	59 29.4%	42 45.7%	25 43.1%	77 28.2%	4 16%
Large mammal								6		10 18.9%	1	22 10.9%	28 30.4%	9 15.5%	78 28.6%	4 16%
Sea mammal																
Other					1 2.6%					2 3.8%					3 1.1%	
Total identified	42 100%	75 100%	52 100%	169 100%	38 100%	148 100%	70 100%	21	12	53 100%	22	201 100%	92 100%	58 100%	273 100%	25 100%
Unidentified								10		230	41	12	86	1167	355	1
Total	42	75	52	169	38	148	70	31	12	283	63	213	178	1225	628	26
Source	Rowley-Conwy 1983, Table 1							Rackham 1986, Tables 6, 7, 8								

Appendix Table 5.3: Mammal NISP

Site	Saevar Howe							Brough of Deerness								
Dates	Iron age	Iron age	Iron age	Iron age	9th c. +/-	9th c. +/-	9th c. +/-	Med and ?later	Late iron age	Viking age to med	Med	Med and ?later	Late iron age	Viking age to med	Viking age to med	Med and ?later
Context types	Internal floor deposits, midden	Midden	?Midden	Internal floor deposits, midden	Construction, midden	Construction, midden	Construction, midden, abandonment	Mixed	Construction	Construction	Construction and use	Decay and collapse, possibly non-anthropogenic	Construction	Construction	Construction and use	Decay and collapse, possibly non-anthropogenic
Recovery	>5mm	>5mm	>5mm	>5mm	>5mm	>5mm	>5mm	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
Phase or area	Phase I a	Phase Ib	Phase Ic	Phase I total	Phase IIa	Phase IIb	Phase IIc	Outside enclosure, all phases	Chapel interior phase A	Chapel interior phase B	Chapel interior phase C	Chapel interior phase D	Enclosure phase A	Enclosure phase B	Enclosure phase C	Enclosure phase D
Dog																
Cat					13.5%	1.4%	4.3%									
Horse		1.4%		0.6%		6.1%	2.9%			6.3%					3.8%	
Pig	17.1%	15.5%	13.5%	15.2%	13.5%	11.5%	22.9%	22.2%		56.3%	33.3%	28.6%	26.3%	8.3%	13.5%	
Cattle	17.1%	16.9%	19.2%	17.7%	13.5%	36.5%	28.6%	77.8%		12.5%	33.3%	10.4%	57.9%	83.3%	56.7%	16.7%
Caprine	65.9%	66.2%	67.3%	66.5%	59.5%	44.6%	41.4%		100%	25%	33.3%	61%	15.8%	8.3%	26%	83.3%
(of which sheep)	9.8%	9.9%	3.8%	7.9%	10.8%	3.4%	8.6%					1.3%				
(of which goat)					2.7%											
Total domestic identifications	100% 41	100% 71	100% 52	100% 164	100% 37	100% 148	100% 70	100% 9	100% 1	100% 32	100% 3	100% 77	100% 19	100% 24	100% 104	100% 6

Appendix Table 5.3: Mammal NISP

Site	Skaill, Deerness										Newark Bay											
Dates	Viking Age - med		Med and ?later		9-11th c.		8-9th c.		Med		?Late Iron Age	?Med	Med (Noddle)		Med	Med		Med and ?later (Noddle)		?Med		Med
Context types	Midden		Midden		Midden		Midden		Midden		Souterrains	"The Norse horses"	Unknown		Associated with wall	Associated with burials		Unknown		Floor fill		Below drain
Recovery	Hc		Hc		Hc		Hc		Hc		Hc	Hc	Hc		Hc	Hc		Hc		Hc		Hc
Phase or area	Viking' Site 2, 'Norse' Sites 3 and 4		Post-Viking' Site 1, 'Post-medieval' Site 4		Site 2, midden 1 (Potts)		Site 2, midden 3 (Potts)		Site 1, midden (Potts)		Souterrains	"The Norse horses"	Norse		Associated with wall	Associated with burials		Post Norse		Floor fill		Below drain
Seal	111	1.8%	1	0.4%	30	6.3%	2	1.3%	3	4.9%			86	51.2%		3	2.1%			20	8.8%	
Pigmy shrew																						
Common shrew																						
Mole																						
Whale sp													1	0.6%								
Dog/Fox																						
Dog																1	0.7%	3	6.3%			
Stoat																						
Otter					1	0.2%			1	1.6%			1	0.6%								
Cat							1	0.6%					6	3.6%						1	0.4%	
Horse	114	1.9%			19	4%						13	3	1.8%		1	0.7%	2	4.2%			
Pig	696	11.6%	43	16.3%									10	6%		6	4.2%	3	6.3%	39	17.2%	
Deer family	51	0.8%			24	5.1%	5	3.2%	6	9.8%												
Red deer					1	0.2%							1	0.6%								
Roe deer																						
Cattle	2751	45.7%	136	51.5%	236	49.8%	110	71%	29	47.5%			11	6.5%	2	17	12%	5	10.4%	35	15.4%	1
Caprine	2265	37.6%	83	31.4%	163	34.4%	37	23.9%	22	36.1%	4		20	11.9%	1	29	20.4%	11	22.9%	61	26.9%	
(of which sheep)																						
(of which goat)	p		2	0.8%																		
Rodent																						
Vole or mouse																						
Vole species																						
Bank vole																						
Orkney vole													2	1.2%		34	23.9%					
Water vole																						
Mouse sp.																						
Wood Mouse																						
House Mouse																						
Ship/Common rat																						
Common rat																						
Rabbit													10	6%				16	33.3%	3	1.3%	1
Brown/Mountain hare																						
Small mammal																1	0.7%			4	1.8%	
Medium mammal 2																						
Medium mammal 1																46	32.4%			57	25.1%	1
Large mammal																4	2.8%			7	3.1%	
Sea mammal																						
Other	36	0.6%	1	0.4%									17	10.1%				8	16.7%			
Total identified	6024	100%	264	100%	474	100%	155	100%	61	100%	4	13	168	100%	3	142	100%	48	100%	227	100%	3
Unidentified											2					149				96		
Total	6024		264		474		155		61		6	13	168		3	291		48		323		3
Source	Noddle 1997, Table 17 1a				Potts nd Unpublished report						Harland 2001b											

Appendix Table 5.3: Mammal NISP

Site	Skaill, Deerness					Newark Bay							
Dates	Viking Age - med	Med and ?later	9-11th c.	8-9th c.	Med	?Late Iron Age	?Med	Med (Noddle)	Med	Med	Med and ?later (Noddle)	?Med	Med
Context types	Midden	Midden	Midden	Midden	Midden	Souterrains	"The Norse horses"	Unknown	Associated with wall	Associated with burials	Unknown	Floor fill	Below drain
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc
Phase or area	Viking' Site 2, 'Norse' Sites 3 and 4	Post-Viking' Site 1, 'Post-medieval' Site 4	Site 2, midden 1 (Potts)	Site 2, midden 3 (Potts)	Site 1, midden (Potts)	Souterrains	"The Norse horses"	Norse	Associated with wall	Associated with burials	Post Norse	Floor fill	Below drain
Dog										1.9%	12.5%		
Cat				0.7%				12%				0.7%	
Horse	2%		4.5%				100%	6%		1.9%	8.3%		
Pig	11.9%	16.4%						20%		11.1%	12.5%	28.7%	
Cattle	47.2%	51.9%	56.5%	74.3%	56.9%			22%	66.7%	31.5%	20.8%	25.7%	100%
Caprine	38.9%	31.7%	39%	25%	43.1%	100%		40%	33.3%	53.7%	45.8%	44.9%	
(of which sheep)													
(of which goat)	p	0.8%											
Total domestic identifications	100% 5826	100% 262	100% 418	100% 148	100% 51	100% 4	100% 13	100% 50	100% 3	100% 54	100% 24	100% 136	100% 1

Appendix Table 5.3: Mammal NISP

Site	Earl's Bu																													
Dates	Viking Age - med		Med		970-1220		880-1160		Med		Med		990-1190		890-1160		Viking Age - med		Med		Viking Age - med		Med		970-1220		880-1160		Med	
Context types	Construction and use of mill		Collapse features of mill		Mill features		Midden		Midden		Midden		Midden		Midden		Redeposited midden		Redeposited midden		Construction and use of mill		Collapse features of mill		Mill features		Midden		Midden	
Recovery	Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc		Hc		>4mm		>4mm		>4mm		>4mm		>4mm	
Phase or area	C2		C3		F2		M1		M3		M3a		M3b		M3c		R1		R3		C2		C3		F2		M1		M3	
Seal	1	0.6%					1	0.1%									1	0.1%	1	0.1%										
Pigmy shrew																														
Common shrew																														
Mole																														
Whale sp							14	1.8%					1	0.1%																
Dog/Fox																														
Dog	1	0.6%					7	0.9%			1	0.4%	12	1.5%	17	1.2%	13	1.5%	9	0.9%	2	0.4%			1	0.1%	6	0.5%		
Stoat																														
Otter																														
Cat							3	0.4%			3	1.3%	10	1.2%	8	0.6%	4	0.5%	13	1.3%					2	0.3%	2	0.2%	1	2.4%
Horse	2	1.3%					1	0.1%			1	0.4%			6	0.4%			8	0.8%					1	0.1%				
Pig	14	8.9%	57	13%	7	5.7%	55	7.2%			19	8.3%	77	9.6%	86	6%	53	6.2%	56	5.6%	24	4.9%	5	5.9%	36	5.3%	82	7.1%	4	9.5%
Deer family																														
Red deer							1	0.1%																						
Roe deer																														
Cattle	35	22.3%	118	27%	21	17.2%	100	13.1%	10		29	12.7%	87	10.8%	267	18.6%	151	17.6%	174	17.3%	55	11.2%	7	8.2%	43	6.3%	130	11.2%	4	9.5%
Caprine	47	29.9%	160	36.6%	52	42.6%	302	39.7%	1		91	39.9%	314	39%	457	31.8%	236	27.6%	320	31.8%	230	46.9%	46	54.1%	404	59.2%	603	51.9%	21	50%
(of which sheep)																			1	0.1%										
(of which goat)																														
Rodent																														
Vole or mouse																														
Vole species																														
Bank vole																														
Orkney vole																														
Water vole																														
Mouse sp.																														
Wood Mouse																														
House Mouse																														
Ship/Common rat																														
Common rat																														
Rabbit			1	0.2%											1	0.1%					1	0.2%								
Brown/Mountain hare																														
Small mammal	2	1.3%	6	1.4%	4	3.3%	8	1.1%			4	1.8%	37	4.6%	34	2.4%	11	1.3%	23	2.3%	5	1%	2	2.4%	49	7.2%	25	2.2%	1	2.4%
Medium mammal 2																														
Medium mammal 1	2	1.3%					14	1.8%			2	0.9%	1	0.1%	5	0.3%	6	0.7%	5	0.5%	4	0.8%			3	0.4%	15	1.3%		
Large mammal	53	33.8%	95	21.7%	38	31.1%	255	33.5%	4		78	34.2%	267	33.1%	554	38.6%	381	44.5%	398	39.5%	169	34.5%	25	29.4%	144	21.1%	299	25.7%	11	26.2%
Sea mammal																														
Other																														
Total identified	157	100%	437	100%	122	100%	761	100%	15		228	100%	806	100%	1435	100%	856	100%	1007	100%	490	100%	85	100%	683	100%	1162	100%	42	100%
Unidentified	135		220		72		371		2		175		533		1154		508		769		1761		426		2115		4300		147	
Total	292		657		194		1132		17		403		1339		2589		1364		1776		2251		511		2798		5462		189	
Source	I Mainland, pers comm																													

Appendix Table 5.3: Mammal NISP

Site	Earl's Bu														
Dates	Viking Age - med	Med	970-1220	880-1160	Med	Med	990-1190	890-1160	Viking Age - med	Med	Viking Age - med	Med	970-1220	880-1160	Med
Context types	Construction and use of mill	Collapse features of mill	Mill features	Midden	Midden	Midden	Midden	Midden	Redeposited midden	Redeposited midden	Construction and use of mill	Collapse features of mill	Mill features	Midden	Midden
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc	>4mm	>4mm	>4mm	>4mm	>4mm
Phase or area	C2	C3	F2	M1	M3	M3a	M3b	M3c	R1	R3	C2	C3	F2	M1	M3
Dog	1%			1.5%		0.7%	2.4%	2%	2.8%	1.6%	0.6%		0.2%	0.7%	
Cat				0.6%		2.1%	2%	1%	0.9%	2.2%			0.4%	0.2%	3.3%
Horse	2%			0.2%		0.7%		0.7%		1.4%			0.2%		
Pig	14.1%	17%	8.8%	11.8%		13.2%	15.4%	10.2%	11.6%	9.7%	7.7%	8.6%	7.4%	10%	13.3%
Cattle	35.4%	35.2%	26.3%	21.4%	90.9%	20.1%	17.4%	31.7%	33%	30%	17.7%	12.1%	8.8%	15.8%	13.3%
Caprine	47.5%	47.8%	65%	64.5%	9.1%	63.2%	62.8%	54.3%	51.6%	55.2%	74%	79.3%	83%	73.3%	70%
(of which sheep)										0.2%					
(of which goat)															
Total domestic identifications	100% 99	100% 335	100% 80	100% 468	100% 11	100% 144	100% 500	100% 841	100% 457	100% 580	100% 311	100% 58	100% 487	100% 823	100% 30

Appendix Table 5.3: Mammal NISP

Site	Earl's Bu (continued)										Robert's Haven								Freswick											
Dates	Med		990-1190		890-1160		Viking Age - med		Med		11-13th c.		Viking Age - med		Viking Age - med		14-16th c.				?late Iron Age to med		?late Iron Age to med		Med		Med		late Iron-Age to Viking Age	
Context types	Midden		Midden		Midden		Redeposited midden		Redeposited midden		Midden		Midden		Midden		Midden		Midden associated with structures		Mostly midden		Mostly midden		Mostly midden		Mostly midden		Mixed, cultivation layers and deflated middens	
Recovery	>4mm		>4mm		>4mm		>4mm		>4mm		>1mm		>1mm		>1mm		>1mm		mixed		Hc		>2mm		Hc		>2mm		Hc	
Phase or area	M3a		M3b		M3c		R1		R3		Phase 1, area A		Phase 1, area B		Phase 2, area B		Area E		Inland, area 1		Inland, area 3		Inland, area 3		Inland, area 9		Inland, area 9		SCA, area 11	
Seal					1	0%											1	0.4%												
Pigmy shrew																														
Common shrew																														
Mole																														
Whale sp																														
Dog/Fox																														
Dog	53	2.5%	33	0.7%	63	0.8%	5	0.3%	3	1.2%							1	0.4%	3	1.9%					16	26.7%			1	0.9%
Stoat																					1	0.3%								
Otter																														
Cat	14	0.6%	100	2.2%	31	0.4%	7	0.4%	4	1.6%	1	0.6%					1	0.4%			2	0.7%							4	3.4%
Horse			1	0%	1	0%			4	1.6%			1																1	0.9%
Pig	159	7.4%	323	7.2%	317	4%	80	4.5%	18	7.1%	3	1.9%	1		5	10.2%	4	1.6%	7	4.5%	11	3.7%							2	1.7%
Deer family																														
Red deer																			5	3.2%										
Roe deer																											1			
Cattle	140	6.5%	514	11.4%	622	7.8%	172	9.6%	18	7.1%	16	10.3%			1	2%	11	4.5%	26	16.6%	74	25%	4		18	30%	4		18	15.4%
Caprine	1005	46.6%	1690	37.4%	3423	43%	583	32.6%	88	34.8%	5	3.2%	6		9	18.4%	34	14%	34	21.7%	20	6.8%			3	5%	4		4	3.4%
(of which sheep)	1	0%	1	0%			1	0.1%																						
(of which goat)																														
Rodent																														
Vole or mouse																														
Vole species																														
Bank vole																														
Orkney vole																														
Water vole																														
Mouse sp.																														
Wood Mouse																														
House Mouse																														
Ship/Common rat																														
Common rat																														
Rabbit															1	2%					74	25%			1	1.7%	1		8	6.8%
Brown/Mountain hare																														
Small mammal	85	3.9%	233	5.2%	241	3%	40	2.2%	16	6.3%																				
Medium mammal 2											3	1.9%					18	7.4%												
Medium mammal 1	9	0.4%	28	0.6%	10	0.1%	16	0.9%			74	47.4%	9		28	57.1%	132	54.3%	54	34.4%	23	7.8%	6		9	15%	8		25	21.4%
Large mammal	692	32.1%	1593	35.3%	3260	40.9%	884	49.5%	102	40.3%	54	34.6%	1		5	10.2%	39	16%	28	17.8%	90	30.4%	6		13	21.7%	7		54	46.2%
Sea mammal																	2	0.8%												
Other	1	0%																			1	0.3%								
Total identified	2158	100%	4515	100%	7969	100%	1787	100%	253	100%	156	100%	18		49	100%	243	100%	157	100%	296	100%	16		60	100%	25		117	100%
Unidentified	6529		13628		23603		5835		675		517		67		339		826		104		604		100		100		27		138	
Total	8687		18143		31572		7622		928		673		85		388		1069		261		900		116		160		52		255	
Source	I Mainland, pers. comm										Mainland nd a								Rackham 1995 Tables 45, 49, 55											

Appendix Table 5.3: Mammal NISP

Site	Earl's Bu					Robert's Haven				Freswick					
Dates	Med	990-1190	890-1160	Viking Age - med	Med	11-13th c.	Viking Age - med	Viking Age - med	14-16th c.		?late Iron Age to med	: ?late Iron Age to med	Med	Med	late Iron-Age to Viking Age
Context types	Midden	Midden	Midden	Redeposited midden	Redeposited midden	Midden	Midden	Midden	Midden	Midden associated with structures	Mostly midden	Mostly midden	Mostly midden	Mostly midden	Mixed, cultivation layers and deflated middens
Recovery	>4mm	>4mm	>4mm	>4mm	>4mm	>1mm	>1mm	>1mm	>1mm	Mixed	Hc	>2mm	Hc	>2mm	Hc
Phase or area	M3a	M3b	M3c	R1	R3	Phase 1, area A	Phase 1, area B	Phase 2, area B	Area E	Inland, area 1	Inland, area 3	Inland, area 3	Inland, area 9	Inland, area 9	SCA, area 11
Dog	3.9%	1.2%	1.4%	0.6%	2.2%				2%	4.3%			43.2%		3.3%
Cat	1%	3.8%	0.7%	0.8%	3%	4%			2%		1.9%				13.3%
Horse		0%	0%		3%		12.5%								3.3%
Pig	11.6%	12.1%	7.1%	9.4%	13.3%	12%	12.5%	33.3%	7.8%	10%	10.3%				6.7%
Cattle	10.2%	19.3%	14%	20.3%	13.3%	64%		6.7%	21.6%	37.1%	69.2%	100%	48.6%	50%	60%
Caprine	73.3%	63.5%	76.8%	68.8%	65.2%	20%	75%	60%	66.7%	48.6%	18.7%		8.1%	50%	13.3%
(of which sheep)	0.1%	0%		0.1%											
(of which goat)															
Total domestic identifications	100% 1371	100% 2661	100% 4457	100% 847	100% 135	100% 25	100% 8	100% 15	100% 51	100% 70	100% 107	100% 4	100% 37	100% 8	100% 30

Appendix Table 5.3: Mammal NISP

Site	Freswick (continued)																	
Dates	late Iron-Age to Viking Age		late Iron-Age to Viking Age		late Iron-Age to Viking Age		late Iron-Age to Viking Age		late Iron-Age to Viking Age		late Iron-Age to Viking Age		late Iron-Age to Viking Age		early 11th c. to early 14th		early 11th c. to early 14th	
Context types	Mixed, cultivation layers and deflated middens		Mixed, cultivation layers and deflated middens		Mixed, cultivation layers and deflated middens		Mixed, cultivation layers and deflated middens		Mixed, cultivation layers and deflated middens		Mixed, cultivation layers and deflated middens		Mixed, cultivation layers and deflated middens		Midden		Midden, deflated midden and sand blows	
Recovery	>2mm		Hc		Hc		Hc		>2mm		Hc		>2mm		>2mm		Hc	
Phase or area	SCA, area 11		SCA, area 12		SCA, area 12		SCA, area 13		SCA, area 13		SCA, area 14		SCA, area 14		NCA, area 4		NCA, area 5	
Seal																		
Pigmy shrew																		
Common shrew																		
Mole																		
Whale sp.																		
Dog/Fox																		
Dog																		
Stoat																		
Otter																		
Cat	40	26%													1	0.2%		
Horse			1	1.4%	1	0.7%	2	2.1%										
Pig	4	2.6%	4	5.5%	8	6%	1	1%	1	1.7%	5	2.9%	5	2.3%	1	0.2%		
Deer family																		
Red deer			2	2.7%			1	1%	1	1.7%					1	0.2%		
Roe deer																		
Cattle	16	10.4%	13	17.8%	24	17.9%	17	17.7%	12	20.3%	35	20.2%	39	18.3%	155	35%	26	35.6%
Caprine	8	5.2%	7	9.6%	6	4.5%	4	4.2%	7	11.9%	12	6.9%	27	12.7%	10	2.3%	1	1.4%
(of which sheep)																		
(of which goat)																		
Rodent																		
Vole or mouse																		
Vole species																		
Bank vole																		
Orkney vole																		
Water vole																		
Mouse sp.																		
Wood Mouse																		
House Mouse																		
Ship/Common rat																		
Common rat																		
Rabbit	4	2.6%	4	5.5%	10	7.5%					3	1.7%	4	1.9%			1	1.4%
Brown/Mountain hare															18	4.1%		
Small mammal																		
Medium mammal 2																	28	38.4%
Medium mammal 1	25	16.2%	18	24.7%	37	27.6%	37	38.5%	23	39%	35	20.2%	80	37.6%	112	25.3%		
Large mammal	57	37%	24	32.9%	48	35.8%	34	35.4%	15	25.4%	83	48%	58	27.2%	143	32.3%	17	23.3%
Sea mammal																		
Other															2	0.5%		
Total identified	154	100%	73	100%	134	100%	96	100%	59	100%	173	100%	213	100%	443	100%	73	100%
Unidentified	125		125		125		173		1194		86		923		674		83	
Total	198		198		198		269		1253		259		1136		1117		156	
Source	Rackham 1995, Tables 33, 35, 45																	

Appendix Table 5.3: Mammal NISP

Site	Freswick (continued)								
Dates	late Iron-Age to Viking Age	late Iron-Age to Viking Age	late Iron-Age to Viking Age	late Iron-Age to Viking Age	late Iron-Age to Viking Age	late Iron-Age to Viking Age	late Iron-Age to Viking Age	early 11th c. to early 14th	early 11th c. to early 14th
Context types	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Midden	Midden, deflated midden and sand blows
Recovery	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm	>2mm	Hc
Phase or area	SCA, area 11	SCA, area 12	SCA, area 12	SCA, area 13	SCA, area 13	SCA, area 14	SCA, area 14	NCA, area 4	NCA, area 5
Dog									
Cat	58.8%							0.6%	
Horse		4%	2.6%	8.3%					
Pig	5.9%	16%	20.5%	4.2%	5%	9.6%	7%	0.6%	
Cattle	23.5%	52%	61.5%	70.8%	60%	67.3%	54.9%	92.8%	96.3%
Caprine	11.8%	28%	15.4%	16.7%	35%	23.1%	38%	6%	3.7%
(of which sheep)									
(of which goat)									
Total domestic identifications	100% 68	100% 25	100% 39	100% 24	100% 20	100% 52	100% 71	100% 167	100% 27

Appendix Table 5.3: Mammal NISP

Site	Freswick (continued)														
Dates	early 11th c. to early 14th		early 11th c. to early 14th		early 11th c. to early 14th	early 11th c. to early 14th	early 11th c. to early 14th	?late Iron Age to med		?late Iron Age to med		6th to 14th c.		6th to 14th c.	
Context types	Midden, deflated midden and cultivation layers		Midden, deflated midden and cultivation layers		Midden, deflated midden and cultivation layers	Deflated midden and sandy layers	Deflated midden and sandy layers	Midden and structural features		Midden and structural features		Mostly midden, also structural features		Mostly midden, also structural features	
Recovery	>2mm		Hc		>2mm	Hc	>2mm	Hc		>2mm		Hc		>2mm	
Phase or area	NCA, area 5		NCA, area 6		NCA, area 6	NCA, area 10	NCA, area 10	CCA, area 7		CCA, area 7		CCA, area 8		CCA, area 8	
Seal															
Pigmy shrew															
Common shrew															
Mole															
Whale sp								9	3.4%	1	0.4%				
Dog/Fox															
Dog															
Stoat															
Otter															
Cat			1	1.8%				2	0.8%	1	0.4%	18	4.3%	25	13.1%
Horse	1	3.3%				1		3	1.1%	1	0.4%				
Pig	1	3.3%								2	0.8%	5	1.2%	2	1%
Deer family															
Red deer												1	0.2%		
Roe deer															
Cattle	12	40%	21	37.5%	4	3	3	117	44%	68	28.6%	138	33.1%	59	30.9%
Caprine			2	3.6%		2	2	9	3.4%	7	2.9%	17	4.1%	1	0.5%
(of which sheep)												1	0.2%		
(of which goat)															
Rodent															
Vole or mouse															
Vole species															
Bank vole															
Orkney vole															
Water vole															
Mouse sp.															
Wood Mouse															
House Mouse															
Ship/Common rat															
Common rat															
Rabbit	1	3.3%	5	8.9%	6	2	5	7	2.6%			3	0.7%	1	0.5%
Brown/Mountain hare															
Small mammal															
Medium mammal 2	5	16.7%	9	16.1%	5	1	6								
Medium mammal 1								55	20.7%	56	23.5%	83	19.9%	54	28.3%
Large mammal	10	33.3%	18	32.1%	8	8	13	64	24.1%	100	42%	152	36.5%	49	25.7%
Sea mammal															
Other										2	0.8%				
Total identified	30	100%	56	100%	23	17	29	266	100%	238	100%	417	100%	191	100%
Unidentified	137		197		150	11	168	79		1628		223		1055	
Total	167		253		173	28	197	345		1866		640		1246	
Source	Rackham 1995 , Tables 33, 35, 45														

Table 5.3: Mammal NISP

Site	Freswick (continued)								
Dates	early 11th c. to early 14th	early 11th c. to early 14th	early 11th c. to early 14th	early 11th c. to early 14th	early 11th c. to early 14th	?late Iron Age to med	?late Iron Age to med	6th to 14th c.	6th to 14th c.
Context types	Midden, deflated midden and cultivation layers	Midden, deflated midden and cultivation layers	Midden, deflated midden and cultivation layers	Deflated midden and sandy layers	Deflated midden and sandy layers	Midden and structural features	Midden and structural features	Mostly midden, also structural features	Mostly midden, also structural features
Recovery	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm	Hc	>2mm
Phase or area	NCA, area 5	NCA, area 6	NCA, area 6	NCA, area 10	NCA, area 10	CCA, area 7	CCA, area 7	CCA, area 8	CCA, area 8
Dog									
Cat		4.2%				1.5%	1.3%	10.1%	28.7%
Horse	7.1%			16.7%		2.3%	1.3%		
Pig	7.1%						2.5%	2.8%	2.3%
Cattle	85.7%	87.5%	100%	50%	60%	89.3%	86.1%	77.5%	67.8%
Caprine		8.3%		33.3%	40%	6.9%	8.9%	9.6%	1.1%
(of which sheep)								0.6%	
(of which goat)									
Total domestic identifications	100% 14	100% 24	100% 4	100% 6	100% 5	100% 131	100% 79	100% 178	100% 87

Appendix Table 5.4: Bird NISP

Site	Sandwick North				Scalloway	Jarlshof	Quoygrew									Tuquoy
Dates	11-12th c	11-12th c	12-13th c	13-14th c	9-10th c.	early 9th c. to med	676-896	1066-1294	Med	Viking Age	Viking Age	779-981	779-981	1035-1261	1035-1261	Viking Age to med
Context types	Midden	Midden	Midden associated with structure	Midden associated with structure	Midden in disused and collapsing broch	Mostly midden	Fish midden	Fish midden	Fish midden	Farm mound midden	Farm mound midden	Farm mound midden	Farm mound midden	Farm mound midden	Farm mound midden	Mixed
Recovery	Hc	>4mm	Hc	Hc	Mixed	Select-ive Hc	>4mm	>4mm	>4mm	>4mm	Hc	>4mm	Hc	>4mm	Hc	Mixed
Phases	Phase 2	Phase 2	Phase 3	Phase 4	Block 7.1	All	Phase 1.2	Phase 2	Phase 7	Phase i	Phase i	Phase ii	Phase ii	Phase iii	Phase iii	All
Divers	1 1%															
Great Northern Diver																
Red/Black-throated Diver																
Red-throated Diver						p										
Shearwater sp																
Fulmar	2 1.9%		1 2.5%					1 1.5%								
Manx Shearwater	2 1.9%			1				1 1.5%					1 2.4%		4 1.5%	
Gannet	34 33%		1 2.5%		14 7.9%	p		14 21.2%					1 2.4%	1 1.9%	14 5.1%	33 6.8%
Cormorant/Shag	2 1.9%	2		1											4 1.5%	
Cormorant	6 5.8%	2	2 5%		14 7.9%	p	1	1 1.5%			3		1 2.4%	1 1.9%	17 6.3%	16 3.3%
Shag					3 1.7%	p		2 3%					8 19.5%	3 5.7%	43 15.8%	62 12.8%
Grey Heron			1 2.5%			p										
Swan, Goose and Duck family																30 6.2%
Swans																
Mute Swan																
Whooper Swan						p										
Goose					4 2.3%	p							1 2.4%		3 1.1%	83 17.1%
Greylag Goose/ Bean Goose	2 1.9%		3 7.5%													
Domestic/Wild Greylag Goose	1 1%															
Shelduck						p										
Duck sp.			1 2.5%			p							1 2.4%		3 1.1%	
Mallard					8 4.5%											
Teal					4 2.3%											
Wigeon																
Shoveler						p										
Eider			2 5%			p										
Goldeneye																
Pochard																
Red-breasted Merganser																
White-tailed Eagle																
White-tailed Eagle/ Golden Eagle															2 0.7%	
Goshawk																
Buzzard																6 1.2%
Kestrel																
Merlin																
Grouse Family															1 0.4%	
Red Grouse																
Galliformes																
Fowl	5 4.9%	2	3 7.5%		23 13%	p		1 1.5%					1 2.4%	1 1.9%	13 4.8%	12 25.3%
Crane																
Wader								2 3%								13 2.7%

Appendix Table 5.4: Bird NISP

Oystercatcher									p															
Rail and Crake Family	2	1.9%																						
Water Rail																								
Lapwing																								
Plovers																			3	5.7%	13	4.8%		
Golden Plover																								
Sandpiper and Snipe family											3	4.5%												
Dunlin																								
Knot																								
Curlews				1	2.5%																			
Bar-tailed Godwit							2	1.1%																
Curlew							3	1.7%	p															
Whimbrel																								
Greenshank																								
Snipe							14	7.9%																
Grey Phalarope																								
Pomarine Skua																								
Gull Family											1	1.5%				1	1	2.4%			17	6.3%	46	9.5%
Common Gull/Kittiwake	1	1%		2	5%												1	2.4%			1	0.4%		
Common Gull																	3	7.3%			1	0.4%		
Herring/ Lesser Black-backed Gull	2	1.9%								1	3	4.5%	1			1	2	4.9%	4	7.5%	36	13.2%		
Herring Gull							6	3.4%	p								2	4.9%			2	0.7%		
Lesser Black-backed Gull																								
Great Black-backed/ Glaucous	3	2.9%																						
Great Black-backed Gull									p		2	3%	1				3	7.3%	6	11.3	22	8.1%		
Black-headed Gull									p								1	2.4%	1	1.9%				
Kittiwake							4	2.3%	p		3	4.5%				2			6	11.3	6	2.2%		
Auk Family	1	1%																						
Great Auk																								
Razorbill/ Guillemot	2	1.9%		4	10%						9	13.6%	1				4	9.8%	5	9.4%	33	12.1%		
Razorbill	1	1%																					18	3.7%
Guillemot	24	23.3%		10	25%	1	4	2.3%	p														15	3.1%
Puffin/ Black Guillemot																								
Puffin	1	1%					49	27.7%		2	7	10.6%				1	4	9.8%	2	3.8%	25	9.2%	3	0.6%
Black Guillemot																								
Little Auk											1	1.5%												
Dove/ Pigeon Subfamily																							13	2.7%
Rock/Stock Dove																								
Rock Dove																								
Stock Dove																								
Wood Pigeon																								
Short-eared Owl																								
Passerines										1	14	21.2%	2	1		2	6	14.6%	17	32.1%	8	2.9%		
Small Passerines																							14	2.9%
Thrush and Chat Family																								
Blackbird/Ring Ouzel											1	1.5%												
Redwing/ Song Thrush																								
Finch																								
Starling																								
Crows									p															
Rook/ Crow																								
Carrion Crow							20	11.3%																
Raven	11	10.7%		9	22.5%		5	2.8%	p										3	5.7%	4	1.5%	11	2.3%
Total identified	103	100%	6	40	100%	3	177	100%	0	5	66	100%	5	1	3	7	4	100%	53	100%	27	100%	48	100%
Unidentified Bird	82		9	24		4				24	176		5	3		25	41		230		256		171	
Total	185		15	64		7	177		0	29	242		10	4	3	32	82		283		528		657	
	Barrett and Oltmann 2000, Tables 10, 12						O'Sullivan 1998a, Table 23		Platt 1956*	Chapter Seven													Hamilton-Dyer 1991	

*Identifications were also made of the following species, not found elsewhere and thus not in the list: velvet scoter, bittern, fork-tailed petrel, blackcock, peregrine falcon, magpie, and slavonian grebe

Appendix Table 5.4: Bird NISP

Site	Pool				Brough of Birsay Rescue Excavations			Brough Road											
Dates	late Iron Age - Viking Age interface		Viking Age to mid 11th c.		Late Viking Age	Late Viking-Age to early med	Late Viking-Age to early med	7-11th c.	7-11th c.	7-11th c.	7-9th c.			9-13th c.		9-11th c.	7-11th c.		
Context types	Mostly midden		Mostly midden		Floor, drainage, wall fill, agricultural function	Floor, wall fill, hearth, pits, industrial fuction	Floor deposits, domestic	Midden	Midden	Disturbed midden	Sand	Stone spread	Flagstones	Midden		Midden	Cist graves and associated midden	Stone spread with sand	Sand
Recovery	Mixed		Mixed		Hc	Hc	Hc	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed		Mixed	Mixed	Mixed	Mixed
Phases	Phase 7		Phase 8		Phase 2.2, site VIII	Phase 3, site VII	Phase 3, site VIII	Area 1, phase D	Area 1, phase F1	Area 1, phase F2	Area 2, phase A	Area 2, phase B1	Area 2, phase B2	Area 2, phase C1		Area 2, phase C2	Area 2, phase D	Area 2, phase E1	Area 2, phase E2
Divers																			
Great Northern Diver																			
Red/Black-throated Diver																1			
Red-throated Diver																			
Shearwater sp.																			
Fulmar	2	0.5%																	
Manx Shearwater	1	0.3%							2					14	28%	5		1	
Gannet	40	10.8%	61	39.4%				2	2		3	1	2	3	6%	4		1	
Cormorant/Shag	4	1.1%												2	4%	1			
Cormorant	61	16.4%	19	12.3%									1			2			
Shag	71	19.1%	23	14.8%					1			1		3	6%	3			
Grey Heron														1	2%				
Swan, Goose and Duck family	5	1.3%																	
Swans	1	0.3%																	
Mute Swan																			
Whooper Swan																			
Goose	3	0.8%	1	0.6%	3		23												
Greylag Goose/ Bean Goose	38	10.2%	8	5.2%															
Domestic/Wild Greylag Goose								2			1					7			
Shelduck																			
Duck sp.														1	2%				
Mallard	3	0.8%	1	0.6%										11	22%				
Teal	1	0.3%																	
Wigeon																			
Shoveler																			
Eider														1	2%			1	
Goldeneye																			
Pochard	1	0.3%																	
Red-breasted Merganser	2	0.5%																	
White-tailed Eagle	1	0.3%																	
White-tailed Eagle/ Golden Eagle																			
Goshawk																			
Buzzard																			
Kestrel	3	0.8%																	
Merlin	5	1.3%																	
Grouse Family																			
Red Grouse																			
Galliformes																			
Fowl	8	2.2%	5	3.2%												3			

Appendix Table 5.4: Bird NISP

Crane																			
Wader																			
Oystercatcher	3	0.8%												2	4%				
Rail and Crake Family																			
Water Rail																			
Lapwing																			
Plovers	2	0.5%												3	6%				
Golden Plover																			
Sandpiper and Snipe family																			
Dunlin																			
Knot			1	0.6%															
Curlews																			
Bar-tailed Godwit																			
Curlew	2	0.5%														1			
Whimbrel																			
Greenshank																			
Snipe																			
Grey Phalarope																			
Pomarine Skua																			
Gull Family	3	0.8%	1	0.6%		p		1			1					2			
Common Gull/Kittiwake																			
Common Gull	1	0.3%	1	0.6%															
Herring/ Lesser Black-backed Gull	20	5.4%	9	5.8%					2					1	2%				
Herring Gull																			
Lesser Black-backed Gull								1											
Great Black-backed/ Glaucous Gull																1			
Great Black-backed Gull	19	5.1%	4	2.6%				2											
Black-headed Gull																			
Kittiwake	17	4.6%																	
Auk Family														1	2%				
Great Auk	1	0.3%	1	0.6%															1
Razorbill/ Guillemot																			
Razorbill	14	3.8%	4	2.6%				1						2	4%				
Guillemot	5	1.3%	9	5.8%							1						1	1	
Puffin/ Black Guillemot																			
Puffin	6	1.6%	1	0.6%					1		2			1	2%	2		1	
Black Guillemot	1	0.3%																	
Little Auk	1	0.3%				p			1									1	
Dove/ Pigeon Subfamily						p												1	
Rock/Stock Dove	1	0.3%																	
Rock Dove														1	2%				
Stock Dove																			
Wood Pigeon																			
Short-eared Owl																			
Passerines	1	0.3%	1	0.6%		p			2										
Small Passerines																1			
Thrush and Chat Family	1	0.3%	3	1.9%															
Blackbird/Ring Ouzel																			
Redwing/ Song Thrush																			
Finch																			
Starling														1	2%				
Crows														1	2%				
Rook/ Crow	1	0.3%	1	0.6%										1	2%				
Carrion Crow																			
Raven	23	6.2%	1	0.6%															
Total identified	372	100%	15	100%	3	0	23	10	11	0	9	2	3	50	100%	33	5	7	1
Unidentified Bird	106		38		1			4	16	1	9		1	25		24	2	7	4
Total	478		193		4	0	23	14	27	1	18	2	4	75		57	7	14	5
	Barrett 1995, Table 5.7a				Sellar 1982, Tables 11, 18, see note regarding recovery in Appendix One			Rackham 1989, Tables 18, 19											

Appendix Table 5.4: Bird NISP

Site	Beachview (Burnside)															
Dates	1020-1320	1020-1320	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	1020-1280	Med
Context types	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Midden	Interface of midden and sand
Recovery	Hc	>2mm	Hc	>2mm	>2mm	>2mm	Hc	Hc	Hc	Hc	Hc	>2mm	>2mm	>2mm	>2mm	Hc
Phases	Area 3, phase X	Area 3, phase X	Area 2, phase W, episode 5	Area 2, phase W, episode 3	Area 2, phase W, episode 5	Area 2, phase W total	Area 2, phase X, episode 6 PK	Area 2, phase X, episode 6 PN	Area 2, phase X, episode 7	Area 2, phase X, episode 8	Area 2, phase X total	Area 2, phase X, episode 6	Area 2, phase X, episode 7	Area 2, phase X, episode 8	Area 2, phase X total	Area 2, phase Y, episode 10
Divers																
Great Northern Diver																
Red/Black-throated Diver																
Red-throated Diver																
Shearwater sp.																
Fulmar																
Manx Shearwater																
Gannet	1		2		2	2	12			11	23 35.9%	2	3		5	
Cormorant/Shag							1				1 1.6%		1		1	1
Cormorant							2	1			3 4.7%					
Shag	2						2			1	3 4.7%					
Grey Heron																
Swan, Goose and Duck family																
Swans																
Mute Swan																
Whooper Swan																
Goose					1		3			16	19 29.7%			2	2	
Greylag Goose/ Bean Goose																
Domestic/Wild Greylag Goose																
Shelduck																
Duck sp.																
Mallard																
Teal																
Wigeon																
Shoveler																
Eider																
Goldeneye																
Pochard																
Red-breasted Merganser																
White-tailed Eagle																
White-tailed Eagle/ Golden Eagle																
Goshawk																
Buzzard																
Kestrel														1	1	
Merlin																
Grouse Family																
Red Grouse																
Galliformes												1			1	
Fowl			2		3	3	1			3	4 6.3%					

Appendix Table 5.4: Bird NISP

Crane																	
Wader															4	4	
Oystercatcher																	
Rail and Crake Family																	
Water Rail																	
Lapwing																	
Plovers																	
Golden Plover																	
Sandpiper and Snipe family																	
Dunlin																	
Knot																	
Curlews							1				1	1.6%					
Bar-tailed Godwit																	
Curlew														1		1	
Whimbrel																	
Greenshank																	
Snipe																	
Grey Phalarope																	
Pomarine Skua																	
Gull Family																	
Common Gull/Kittiwake																	
Common Gull										2	2	3.1%					
Herring/ Lesser Black-backed Gull									1	1	2	3.1%					
Herring Gull																	
Lesser Black-backed Gull																	
Great Black-backed/ Glaucous Gull																	
Great Black-backed Gull																	
Black-headed Gull																	
Kittiwake																	
Auk Family										1	1	1.6%					
Great Auk																	
Razorbill/ Guillemot													4			4	
Razorbill																	
Guillemot			1				3				3	4.7%	1	2		3	
Puffin/ Black Guillemot																	
Puffin			1											1		1	1
Black Guillemot					1	1								1		1	
Little Auk																	
Dove/ Pigeon Subfamily							1				1	1.6%					
Rock/Stock Dove	1				11	11	1				1	1.6%					
Rock Dove																	
Stock Dove																	
Wood Pigeon																	
Short-eared Owl																	
Passerines																	
Small Passerines													2		6	8	
Thrush and Chat Family																	
Blackbird/Ring Ouzel																	
Redwing/ Song Thrush																	
Finch																	
Starling		1											1		2	3	
Crows																	
Rook/ Crow																	
Carrion Crow																	
Raven																	
Total identified	4	1	6	0	18	17	27	1	1	35	64	100%	11	9	15	35	2
Unidentified Bird	2	7	4	3	7	10	5		1		6		9	22	4	35	
Total	6	8	10	3	25	27	32	1	2	35	70		20	31	19	70	2
							Allison and Rackham 1996, Tables M24, M25, Rackham 1996a, Table 5										

Appendix Table 5.4: Bird NISP

Site	Beachview (Studio)																	
Dates	980-1206	1030-1280	1001-1410		1020-1280						1134-1280	1134-1280	990-1220	990-1220		1163-1300	990-1210	990-1210
Context types	Sand overlying rubble	Ash dump, sandy deposits	Midden	Sand blow, wall	Sands, burnt peat	Wall fill and rubble	Mixed, including midden	Peat ash, sandy layers	Hearth deposits	Sandy deposits in structure	Pit fill and midden in structure	Pit fill and midden in structure	Midden, sand and clay layers	Midden, sand and clay layers	Peat ash, clay layers built up to exterior	Rubble collapse layers	Sand and ash layers associated with disuse	Sand and ash layers associated with disuse of structure
Recovery	Hc	Hc	Hc	Hc	Hc	Hc	Hc	>2 mm	>2 mm	>2mm	Hc	>2mm	Hc	>2mm	Hc	Hc	Hc	>2mm
Phases	Area 1D/E, phase Q	Area 1D/E, phase S	Area 1D/E, phase U	Area 1D/E, phase V	Area 1D/E, phase W	Area 1D/E, phase X	Area 1D/E, phase Y	Area 1, phase L	Area 1, phase P	Area 1, phase Q	Area 1, phase R	Area 1, phase R	Area 1, phase S	Area 1, phase S	Area 1, phase U	Area 1, phase V	Area 1, phase Y	Area 1, phase Y
Divers																		
Great Northern Diver																	4 9.8%	
Red/Black-throated Diver																		
Red-throated Diver																		
Shearwater sp.																		
Fulmar																		
Manx Shearwater			4												1		1 2.4%	
Gannet			12				1	1			2	1	3	1	1	3	15 36.6%	2
Cormorant/Shag			1				2											
Cormorant												1						
Shag		1	1											1			1 2.4%	
Grey Heron																		
Swan, Goose and Duck family																		
Swans																		
Mute Swan																		
Whooper Swan																		
Goose			5		1	1	2							2			2 4.9%	
Greylag Goose/ Bean Goose																		
Domestic/Wild Greylag Goose																		
Shelduck																		
Duck sp							1										1 2.4%	
Mallard		1				1												
Teal																		
Wigeon																		
Shoveler																		
Eider												1						
Goldeneye																		
Pochard																		
Red-breasted Merganser																		
White-tailed Eagle																		
White-tailed Eagle/ Golden Eagle																		
Goshawk																		
Buzzard																		
Kestrel																		
Merlin																		
Grouse Family																		
Red Grouse							3											
Galliformes																		
Fowl							2					1		3			6 14.6%	2

Appendix Table 5.4: Bird NISP

Crane																			
Wader			1																1
Oystercatcher																			
Rail and Crake Family							2												
Water Rail																			
Lapwing																			
Plovers							2												
Golden Plover																			
Sandpiper and Snipe family																			
Dunlin																			
Knot																			
Curlews																			
Bar-tailed Godwit																			
Curlew																			
Whimbrel																			
Greenshank																			
Snipe																			
Grey Phalarope																			
Pomarine Skua																			
Gull Family							1												
Common Gull/Kittiwake																			
Common Gull																			
Herring/ Lesser Black-backed Gull					1		2												
Herring Gull																			
Lesser Black-backed Gull																			
Great Black-backed/ Glaucous Gull			1				3												
Great Black-backed Gull																			
Black-headed Gull																			
Kittiwake																			
Auk Family			1														1	2.4%	
Great Auk																			
Razorbill/ Guillemot																			
Razorbill																			
Guillemot						1								1			1	2.4%	
Puffin/ Black Guillemot																			
Puffin							2										3	7.3%	
Black Guillemot																			
Little Auk																			
Dove/ Pigeon Subfamily							1									1	1	2.4%	
Rock/Stock Dove							3							1			2	4.9%	
Rock Dove																			
Stock Dove																			
Wood Pigeon							6												
Short-eared Owl																			
Passerines																			
Small Passerines						1			1					1			1	2.4%	
Thrush and Chat Family																			
Blackbird/Ring Ouzel																			
Redwing/ Song Thrush																			
Finch																			
Starling												2					2	4.9%	
Crows																			
Rook/ Crow	1																		
Carrion Crow																			
Raven					2	1	1												
Total identified	1	2	26	0	4	5	34	1	1	0	2	6	3	10	2	4	41	100%	5
Unidentified Bird		1	2	1	3		8	1	1	3	4	6	1	6			8		3
Total	1	3	28	1	7	5	42	2	2	3	6	12	4	16	2	4	49		8

Rackham 1996a Tables 11, 13, 14

Appendix Table 5.4: Bird NISP

Site	Buckquoy							Saevar Howe						
Dates	late Iron Age		late Iron Age	Viking Age	Viking Age	Viking Age		Iron Age	Iron Age	Iron Age	Iron Age	9th c. +/-	9th c. +/-	9th c. +/-
Context types	Mixed, including ?ritual		Mixed, including ?ritual	?entirely midden	?entirely midden	?entirely midden		Internal floor deposits, midden	Midden	?midden	Mostly midden	Construction, midden	Construction, midden	Construction, midden, abandonment
Recovery	Hc		Hc	Hc	Hc	Hc		>5mm	>5mm	>5mm	>5mm	>5mm	>5mm	>5mm
Phases	Phase I		Phase II total	Phase III	Phase IV	Phase V		Phase I a	Phase Ib	Phase Ic	Phase I total	Phase IIa	Phase IIb	Phase IIc
Divers														
Great Northern Diver	3	6.4%	6	1	1	3	2.5%							2
Red/Black-throated Diver														
Red-throated Diver														
Shearwater sp.														
Fulmar	5	10.6%	1		3									
Manx Shearwater	3	6.4%		1	4	6	5.1%						1	1
Gannet	16	34%	11	1	8	39	33.1%		1	1	2	1	5	3
Cormorant/Shag														
Cormorant			1	1		1	0.8%		1		1		1	
Shag						7	5.9%	1			1			
Grey Heron														
Swan, Goose and Duck family														
Swans														
Mute Swan														
Whooper Swan						3	2.5%							
Goose														
Greylag Goose/ Bean Goose														
Domestic/Wild Greylag Goose					1	12	10.2%							
Shelduck					2	2	1.7%							
Duck sp.						2	1.7%							
Mallard														
Teal														
Wigeon	1	2.1%				1	0.8%							
Shoveler														
Eider														
Goldeneye														
Pochard														
Red-breasted Merganser														
White-tailed Eagle														
White-tailed Eagle/ Golden Eagle														
Goshawk														
Buzzard														
Kestrel														
Merlin														
Grouse Family														
Red Grouse														
Galliformes														
Fowl	1	2.1%		1	1	9	7.6%			1	1		1	1

Appendix Table 5.4: Bird NISP

Crane														
Wader														
Oystercatcher														
Rail and Crake Family														
Water Rail														
Lapwing														
Plovers														
Golden Plover														
Sandpiper and Snipe family	1	2.1%	1											
Dunlin						1	0 8%							
Knot						1	0 8%							
Curlews														
Bar-tailed Godwit														
Curlew	4	8 5%	4											
Whimbrel														
Greenshank						1	0 8%							
Snipe														
Grey Phalarope						1	0 8%							
Pomarine Skua						1	0 8%							
Gull Family	1	2 1%		1										
Common Gull/Kittiwake														
Common Gull														
Herring/ Lesser Black-backed Gull						3	2 5%							
Herring Gull									1		1	2	3	1
Lesser Black-backed Gull														1
Great Black-backed/ Glaucous Gull	1	2.1%		1		2	1.7%							
Great Black-backed Gull														
Black-headed Gull			1											
Kittiwake														1
Auk Family														
Great Auk			1											
Razorbill/ Guillemot									1		1	1		
Razorbill						2	1.7%							
Guillemot	7	14 9%			1	5	4 2%							
Puffin/ Black Guillemot														
Puffin	3	6 4%	2	1	1	1	0 8%							
Black Guillemot			1											
Little Auk			1			3	2.5%							
Dove/ Pigeon Subfamily														2
Rock/Stock Dove														
Rock Dove					1	2	1.7%							
Stock Dove														
Wood Pigeon														
Short-eared Owl														
Passerines														
Small Passerines														
Thrush and Chat Family														
Blackbird/Ring Ouzel														
Redwing/ Song Thrush	1	2.1%				1	0 8%							
Finch														
Starling			1			2	1.7%							
Crows														
Rook/ Crow					1	7	5 9%							
Carrion Crow														
Raven				1										
Total identified	47	100%	31	9	24	118	100%	1	4	2	7	4	11	12
Unidentified Bird	2				3	7								
Total	49		31	9	27	125		1	4	2	7	4	11	12
	Bramwell 1976-77 Table 10 (also one osprey identification from Phase I)							Rowley-Conwy 1983, Table 1						

Appendix Table 5.4: Bird NISP

Site	Brough of Deerness				Skaill		Newark Bay		Earl's Bu		Robert's Haven	
Dates	Viking Age to med	Med	Med and ?later	Med and ?later	Viking Age to med	Med	?Viking Age to ?Med	Med	Med	Med	11-13th c.	Viking Age - med
Context types	Construction	Construction and use	Decay and collapse, possibly non-anthropogenic	Decay and collapse, possibly non-anthropogenic	Midden	Midden	?	?	Midden	Midden	Midden	Midden
Recovery	Mixed	Mixed	Mixed	Mixed	Hc	Hc	Hc	Hc	>4mm	Hc	>1mm	>1mm
Phases	Chapel interior phase B	Chapel interior phase C	Chapel interior phase D	Enclosure phase D	Viking' Site 2 and 'Norse' Site 4	Medieval	Norse	Medieval	M3 all	M3 all	Phase 1, area A	Phase 1, area B
Divers												
Great Northern Diver					1 0.4%							
Red/Black-throated Diver												
Red-throated Diver			1 1.9%		1 0.4%							
Shearwater sp.											6 16.7%	
Fulmar												
Manx Shearwater					2 0.8%			2 2.1%			18 50%	
Gannet		2			20 8.3%							
Cormorant/Shag					14 5.8%						2 5.6%	1
Cormorant					10 4.2%		1	1 1.1%	1 1.8%		1 2.8%	
Shag					38 15.8%	4	1	2 2.1%				
Grey Heron					2 0.8%			1 1.1%				
Swan, Goose and Duck family												
Swans												
Mute Swan												
Whooper Swan												
Goose								1 1.1%				
Greylag Goose/ Bean Goose												
Domestic/Wild Greylag Goose			1 1.9%		20 8.3%	4	2	7 7.4%	5 8.9%	2		
Shelduck								1 1.1%				
Duck sp							2	1 1.1%	1 1.8%			
Mallard					1 0.4%			5 5.3%				
Teal												
Wigeon												
Shoveler								1 1.1%				
Eider					4 1.7%			2 2.1%		1		
Goldeneye												
Pochard								1 1.1%				
Red-breasted Merganser			1 1.9%									
White-tailed Eagle					1 0.4%							
White-tailed Eagle/ Golden Eagle									1 1.8%			
Goshawk												
Buzzard					4 1.7%							
Kestrel								1 1.1%				
Merlin												
Grouse Family												
Red Grouse					14 5.8%		1	6 6.3%				
Galliformes									1 1.8%		2 5.6%	
Fowl					14 5.8%	2	2	26 27.4%	17 30.4%	5		
Crane												
Wader		1					1	2 2.1%				

Appendix Table 5.4: Bird NISP

Oystercatcher						1	0 4%		1								
Rail and Crake Family			1	1.9%						1	1 1%						
Water Rail						1	0 4%										
Lapwing						2	0 8%										
Plovers						1	0 4%		1	2	2 1%						
Golden Plover						3	1 3%		4	4	4 2%						
Sandpiper and Snipe family		1	1	1 9%		1	0 4%										
Dunlin																	
Knot																	
Curlews									1	2	2 1%						
Bar-tailed Godwit									1								
Curlew			1	1 9%		2	0 8%										
Whimbrel									1	1	1 1%						
Greenshank																	
Snipe									1	1	1 1%				1	2 8%	
Grey Phalarope									1								
Pomarine Skua																	
Gull Family						1	0 4%		2	1	1 1%				4	11 1%	
Common Gull/Kittiwake									1								
Common Gull																	
Herring/ Lesser Black-backed Gull						32	13 3%										
Herring Gull																	
Lesser Black-backed Gull					2												
Great Black-backed/ Glaucous Gull						10	4 2%										
Great Black-backed Gull									1	1	1 1%						
Black-headed Gull																	
Kittiwake																	
Auk Family																	
Great Auk						1	0 4%		1								
Razorbill/ Guillemot						4	1 7%										
Razorbill						7	2 9%			1	1 1%						
Guillemot						8	3.3%			7	7 4%						
Puffin/ Black Guillemot										2	2 1%						
Puffin			3	5 6%				1	1			1	1 8%				
Black Guillemot									2								
Little Auk			20	37%		2	0 8%										
Dove/ Pigeon Subfamily						3	1 3%	4									
Rock/Stock Dove			19	35 2%													
Rock Dove									2	9	9 5%	25	44 6%	6			
Stock Dove																	
Wood Pigeon																	
Short-eared Owl						1	0 4%										
Passerines															1	2 8%	
Small Passerines																	
Thrush and Chat Family			1	1 9%													
Blackbird/Ring Ouzel			2	3.7%					1	1	1 1%						
Redwing/ Song Thrush			1	1.9%													
Finch															1	2 8%	
Starling		1	2	3.7%					2	1	1 1%						
Crows												3	5 4%				
Rook/ Crow						8	3.3%		2								
Carrion Crow												1	1 8%				
Raven						6	2 5%			1	1 1%			1			
Total identified	0	5	54	100%	2	240	100%	15	36	95	100%	56	100%	15	36	100%	1
Unidentified Bird	2	4	16		1	50		4	1			408		29	243		29
Total	2	9	70		3	290		19	37	95		464		44	279		30
	Rackham 1986, Tables 6, 7					Allison 1997, Tables 19 1, 19 2			Harland 2001b (also one tawny owl from first phase and one peregrine falcon from second phase)			Mainland nd a, Table 4b			RL Parks pers comm.		

Appendix Table 5.4: Bird NISP

Site	Robert's Haven (cont'd)		Freswick												
Dates	Viking Age - med	14-16th c.	?Late Iron Age	Med	?Late Iron Age to med	Late Iron-Age to Viking Age	Late Iron-Age to Viking Age	Late Iron-Age to Viking Age	Late Iron-Age to Viking Age	Early 11th c to early 14th c	Early 11th c. To late 14th c.	Late Viking Age to c. 1400	10th to 13th c	?Late Iron Age to med	6th to 14th c.
Context types	Midden	Midden	Midden associated with structures	Mostly midden	Mostly midden	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Mixed, cultivation layers and deflated middens	Midden	Midden, deflated midden and sand blows	Midden, deflated midden and cultivation layers	Deflated midden and sandy layers	Midden and structural features	Mostly midden, also structural features
Recovery	>1mm	>1mm	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	>2mm	Mixed	Mixed	Mixed	Mixed	Mixed
Phases	Phase 2, area B	Area E	Inland, area 1	Inland, area 9	Inland, area 3	SCA, area 11	SCA, area 12	SCA, area 13	SCA, area 14	NCA, area 4	NCA, area 5	NCA, area 6	NCA, area 10	CCA, area 7	CCA, area 8
Divers															
Great Northern Diver															
Red/Black-throated Diver															
Red-throated Diver															
Shearwater sp															
Fulmar															
Manx Shearwater					1	5				3 1.4%		2 4.1%		4 5.6%	1 1.1%
Gannet			2				1			1 0.5%	3			2 2.8%	
Cormorant/Shag									1						
Cormorant										2 1%					7 7.5%
Shag		1			1	1			1	14 6.8%	1	1 2%		2 2.8%	5 5.4%
Grey Heron															
Swan, Goose and Duck family															
Swans															
Mute Swan															
Whooper Swan															
Goose		1			1										
Greylag Goose/ Bean Goose								1				1 2%		10 14.1%	
Domestic/Wild Greylag Goose															
Shelduck															
Duck sp										1 0.5%					1 1.1%
Mallard															
Teal															
Wigeon															
Shoveler															
Eider															
Goldeneye															
Pochard															
Red-breasted Merganser															
White-tailed Eagle															
White-tailed Eagle/ Golden Eagle															
Goshawk															
Buzzard															
Kestrel			1												
Merlin															
Grouse Family					1										
Red Grouse															1 1.1%
Galliformes		3													
Fowl		1			3	1				68 32.9%				9 12.7%	39 41.9%

Appendix Table 5.4: Bird NISP

Crane										1	0.5%	2				1	1.4%		
Wader																		1	1.1%
Oystercatcher																			
Rail and Crake Family																			
Water Rail																			
Lapwing																		3	3.2%
Plovers			1		2														
Golden Plover																			
Sandpiper and Snipe family																			
Dunlin																			
Knot																			
Curlews																			
Bar-tailed Godwit																			
Curlew																			
Whimbrel																			
Greenshank																			
Snipe																			
Grey Phalarope																			
Pomarine Skua										14	6.8%	5	22	44.9%		1	1.4%		
Gull Family		1								1	0.5%	8				1	1.4%		
Common Gull/Kittiwake																			
Common Gull									1	7	3.4%		1	2%		3	4.2%	1	1.1%
Herring/ Lesser Black-backed Gull					2	1													
Herring Gull																			
Lesser Black-backed Gull									1	57	27.5%					2	2.8%		
Great Black-backed/ Glaucous Gull					1	3													
Great Black-backed Gull																			
Black-headed Gull												12	8	16.3%		1	1.4%		
Kittiwake																			
Auk Family	1																		
Great Auk			1						1	8	3.9%					6	8.5%	2	2.2%
Razorbill/ Guillemot	1				1			1	2	5	2.4%	1	8	16.3%		3	4.2%	3	3.2%
Razorbill								2		18	8.7%	1	6	12.2%	1	5	7%	6	6.5%
Guillemot								1								6	8.5%	7	7.5%
Puffin/ Black Guillemot						1				1	0.5%					12	16.9%	11	11.8%
Puffin																		1	1.1%
Black Guillemot									1	1	0.5%							1	1.1%
Little Auk																		2	2.2%
Dove/ Pigeon Subfamily				1	1	1													
Rock/Stock Dove																			
Rock Dove																			
Stock Dove					1														
Wood Pigeon																			
Short-eared Owl																			
Passerines								1	2	5	2.4%	2				2	2.8%		
Small Passerines			1		1														
Thrush and Chat Family																			
Blackbird/Ring Ouzel																			
Redwing/ Song Thrush																			
Finch																			
Starling			2																
Crows																		1	1.1%
Rook/ Crow																			
Carrion Crow																1	1.4%		
Raven																			
Total identified	2	7	8	1	16	13	1	6	10	20	100%	35	49	100%	1	71	100%	93	100%
Unidentified Bird	85	234	85	1	7	46	4	4	12	220		18	57		3	128		39	
Total	87	241	87	2	23	59	5	10	22	427		53	106		4	199		132	
	RL Parks pers comm		Allison 1995, Table 64																

Appendix Six: Supplementary tables and figures

This appendix contains data supplementary to Chapter Eight.

St. Boniface			Sieved (>1mm)	
		Mammal	Fish	Bird
7	NISP	19	1324	TNB of 60 from all phases
		1.4%	98.6%	
	TNB	-	2651	
8	NISP	33	9248	
		0.4%	99.6%	
	TNB	-	24890	
9	NISP	-	1366	
	TNB	-	3436	

Robert's Haven			Sieved	
		Mammal	Fish	Bird
Fish sieved to >4mm, but fish dentaries, premaxillae, otoliths and vertebrae sieved to >2mm and identified; mammal and bird sieved to >1mm				
Phase 1, Area A	NISP		19341	36
	TNB	844	51914	295
		1.6%	97.9%	0.6%
Phase 1, Area B	NISP		553	1
	TNB	96	955	30
		8.9%	88.3%	2.8%
Area E	NISP		4070	7
	TNB	1356	6969	241
		15.8%	81.4%	2.8%
Phase 2, Area B	NISP	60	844	2
		6.6%	93.2%	0.2%
	TNB	415	1999	87
		16.6%	79.9%	3.5%

Saevar Howe			Sieved (>5mm)	
		Mammal	Fish	Bird
Phase I a	NISP	41		1
	TNB			
Phase Ib	NISP	71		4
	TNB			
Phase Ic	NISP	52		2
	TNB			
Phase I total	NISP	164	115	7
		57.3%	40.2%	2.4%
	TNB		161	
Phase IIa	NISP	37	80	4
		30.6%	66.1%	3.3%
	TNB		126	
Phase IIb	NISP	148	532	11
		21.4%	77%	1.6%
	TNB		874	
Phase IIb/c	NISP		107	
	TNB		207	
Phase IIc	NISP	70	150	12
		30.2%	64.7%	5.2%
	TNB		305	

Appendix Table 6.1: Summary NISP and TNB by phasing and context type for fully sieved sites (St. Boniface, Saevar Howe and Robert's Haven)

Sandwick North		Sieved			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
Mammal and bird >4mm, fish >2mm but unidentified bones only counted from >4mm										
Phase 1	NISP				16 36.4%	28 63.6%	0%			
	TNB				81 39.5%	124 60.5%	0%			
Phase 2	NISP	9 2.5%	342 95.8%	6 1.7%	392 15.5%	2034 80.4%	103 4.1%	401 13.9%	2376 82.3%	109 3.8%
	TNB	599 26.6%	1635 72.7%	15 0.7%	2879 30.9%	6243 67.1%	185 2%	3478 30.1%	7878 68.2%	200 1.7%
Phase 3	NISP	0%	162 100%	0%	399 36.8%	645 59.5%	40 3.7%	399 32%	807 64.8%	40 3.2%
	TNB	20 4.2%	460 95.8%	0%	1778 46.1%	2015 52.2%	64 1.7%	1798 41.5%	2475 57.1%	64 1.5%
Phase 4	NISP				42 4.9%	812 94.7%	3 0.4%			
	TNB				214 8.9%	2182 90.8%	7 0.3%			

Quoygrew		Sieved			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
Column A: Subset of samples entirely identified with >2mm recovery										
Phases 1.2, 2 and 7	NISP	76 2.8%	2614 96.9%	8 0.3%						
	TNB	954 6.4%	13988 93.3%	54 0.4%						
Quoygrew all, >4mm										
Phase i	NISP	44 27.5%	115 71.9%	1 0.6%	21		3	65 35.3%	115 62.5%	4 2.2%
	TNB	396 46.8%	446 52.7%	4 0.5%	35		3	431 48.8%	446 50.5%	7 0.8%
Phase ii	NISP	639 14.2%	3861 85.7%	7 0.2%	1503		41	2142 35.4%	3861 63.8%	48 0.8%
	TNB	8320 38.4%	13304 61.4%	32 0.1%	3954		82	12274 47.8%	13304 51.8%	114 0.4%
Phase iii	NISP	756 18.9%	3185 79.7%	53 1.3%	3367		272	4123 54%	3185 41.7%	325 4.3%
	TNB	6690 25.4%	19352 73.5%	283 1.1%	6519		528	13209 39.6%	19352 58%	811 2.4%
Phase 1.2	NISP	8 4.2%	178 93.2%	5 2.6%						
	TNB	129 9.3%	1227 88.6%	29 2.1%						
Phase 2	NISP	91 3.4%	2531 94.2%	66 2.5%						
	TNB	1190 8.1%	13333 90.3%	242 1.6%						
Phase 7	NISP	7 14.6%	36 75%	5 10.4%						
	TNB	66 48.5%	60 44.1%	10 7.4%						

Beachview		Sieved (>4mm)			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
Main midden contexts										
Area 3, Phase X	NISP	253 35.9%	451 64%	1 0.1%	309 91.4%	25 7.4%	4 1.2%	562 53.9%	476 45.6%	5 0.5%
	TNB	2556 16%	13419 84%	8 0.1%	313 84.4%	52 14%	6 1.6%	2869 17.5%	13471 82.4%	14 0.1%
Area 3, Phase Y	NISP				20 100%	0%	0%			
	TNB				20 100%	0%	0%			
Area 2, Phase W total	NISP	204 56.5%	139 38.5%	18 5%	139 67.8%	60 29.3%	6 2.9%	343 60.6%	199 35.2%	24 4.2%
	TNB	698 25.6%	1996 73.3%	28 1%	140 46.7%	150 50%	10 3.3%	838 27.7%	2146 71%	38 1.3%
Area 2, Phase X total	NISP	3065 54.3%	2548 45.1%	35 0.6%	1327 49.4%	1296 48.2%	64 2.4%	4392 52.7%	3844 46.1%	99 1.2%
	TNB	11229 24.3%	34822 75.5%	70 0.2%	1334 36.6%	2242 61.5%	70 1.9%	12563 25.2%	37064 74.5%	140 0.3%
Areas 2, Phase Y total	NISP				71 94.7%	2 2.7%	2 2.7%			
	TNB				71 91%	5 6.4%	2 2.6%			

Beachview Studio		Sieved (>4mm)			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
Main midden contexts										
Area 1D/E, Phase T	NISP				36 97.3%	1 2.7%	0%			
	TNB				37 97.4%	1 2.6%	0%			
Area 1D/E, Phase U	NISP				1540 92.2%	105 6.3%	26 1.6%			
	TNB				1544 85%	244 13.4%	28 1.5%			
Area 1D/E, Phase Y	NISP	0%	43 100%	0%	1908 70.5%	765 28.3%	34 1.3%	1908 69.4%	808 29.4%	34 1.2%
	TNB	0%	127 100%	0%	1952 48.6%	2020 50.3%	42 1%	1952 47.1%	2147 51.8%	42 1%
Area 1, Phase R	NISP	163 12.9%	1099 86.7%	6 0.5%	3 42.9%	2 28.6%	2 28.6%	166 13%	1101 86.4%	8 0.6%
	TNB	164 1.4%	11429 98.5%	12 0.1%	3 42.9%	4 57.1%	0%	167 1.4%	11433 98.5%	12 0.1%
Area 1, Phase S	NISP	526 36.4%	909 62.9%	10 0.7%	360 84.5%	63 14.8%	3 0.7%	886 47.4%	972 52%	13 0.7%
	TNB	528 6%	8206 93.8%	16 0.2%	361 77.5%	101 21.7%	4 0.9%	889 9.6%	8307 90.1%	20 0.2%

Beachview Studio		Sieved (>4mm)			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
Non-midden and mixed contexts										
Area 1 D/E Phase Q	NISP				124 87.3%	17 12%	1 0.7%			
	TNB				124 86.7%	18 12.6%	1 0.7%			
Area 1 D/E Phase R	NISP				1	0%	0%			
	TNB									
Area 1 D/E Phase S	NISP				374 70.3%	156 29.3%	2 0.4%			
	TNB				377 55%	306 44.6%	3 0.4%			
Area 1 D/E Phase V	NISP				98 97%	3 3%	0%			
	TNB				100 95.2%	5 4.8%	0%			
Area 1 D/E Phase W	NISP	28 93.3%	2 6.7%	0%	328 90.1%	32 8.8%	4 1.1%	356 90.4%	34 8.6%	4 1%
	TNB	28 17.5%	132 82.5%	0%	330 82.1%	72 17.9%	0%	358 63.7%	204 36.3%	0%
Area 1 D/E Phase X	NISP				25 52.1%	18 37.5%	5 10.4%			
	TNB				25 48.1%	22 42.3%	5 9.6%			
Area 1 Phase K	NISP				2 40%	3 60%	0%			
	TNB				2 40%	3 60%	0%			
Area 1 Phase L	NISP	13 7.4%	161 92%	1 0.6%	15 100%	0%	0%	28 14.7%	161 84.7%	1 0.5%
	TNB	13 0.4%	3034 99.5%	2 0.1%	15 83.3%	0%	3 16.7%	28 0.9%	3034 98.9%	5 0.2%
Area 1 Phase N	NISP	3 33.3%	6 66.7%	0%	53 86.9%	8 13.1%	0%	56 80%	14 20%	0%
	TNB	0%	109 97.3%	3 2.7%	53 49.1%	55 50.9%	0%	53 24.1%	164 74.5%	3 1.4%
Area 1 Phase P	NISP	5 38.5%	7 53.8%	1 7.7%	16 61.5%	10 38.5%	0%	21 53.8%	17 43.6%	1 2.6%
	TNB	94 51.4%	87 47.5%	2 1.1%	16 57.1%	12 42.9%	0%	110 52.1%	99 46.9%	2 0.9%
Area 1 Phase Q	NISP	39 1.7%	2283 98.3%	0%	1 33.3%	2 66.7%	0%	40 1.7%	2285 98.3%	0%
	TNB	39 1.5%	2490 98.3%	3 0.1%	1 33.3%	2 66.7%	0%	40 1.6%	2492 98.3%	3 0.1%
Area 1 Phase T	NISP				2 6.9%	27 93.1%	0%			
	TNB				2 0.9%	223 99.1%	0%			
Area 1 Phase U	NISP				230 63.4%	131 36.1%	2 0.6%			
	TNB				250 61.4%	155 38.1%	2 0.5%			
Area 1 Phase V	NISP				200 60.1%	129 38.7%	4 1.2%			
	TNB									

Area 1 Phase W	NISP				1 4.2%	23 95.8%	0%			
	TNB									
Area 1 Phase X	NISP				9 81.8%	2 18.2%	0%			
	TNB				9 1.1%	788 98.9%	0 0%			
Area 1 Phase Y	NISP	164 12.9%	1106 86.7%	5 0.4%	847 44.5%	1017 53.4%	41 2.2%	1011 31.8%	2123 66.8%	46 1.4%
	TNB	165 1.6%	10296 98.3%	8 0.1%	854 44.5%	1017 53%	49 2.6%	1019 8.2%	11313 91.3%	57 0.5%

Earl's Bu		Sieved (>4mm)			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
(some 'sieved' contexts were first hand collected, as discussed in Chapters Three and Four)										
C2	NISP	490 71.8%	192 28.2%	0%	157 91.8%	14 8.2%	0%	647 75.8%	206 24.2%	0%
	TNB	2251 67.4%	1091 32.6%	0%	292 86.6%	45 13.4%	0%	2543 69.1%	1136 30.9%	0%
C3	NISP	85 76.6%	26 23.4%	0%	437 92.6%	35 7.4%	0%	522 89.5%	61 10.5%	0%
	TNB	511 76.8%	154 23.2%	0%	657 82.7%	137 17.3%	0%	1168 80.1%	291 19.9%	0%
F2	NISP	683 70.5%	286 29.5%	0%	122 93.1%	9 6.9%	0%	805 73.2%	295 26.8%	0%
	TNB	2798 68.6%	1278 31.4%	0%	194 90.2%	21 9.8%	0%	2992 69.7%	1299 30.3%	0%
M1	NISP	1162 67.9%	550 32.1%	0%	761 97.9%	16 2.1%	0%	1923 77.3%	566 22.7%	0%
	TNB	5462 69.5%	2401 30.5%	0%	1132 95%	60 5%	0%	6594 72.8%	2461 27.2%	0%
M3a	NISP	2157 52.4%	1958 47.6%	0%	228 86%	37 14%	0%	2385 54.5%	1995 45.5%	0%
	TNB	8686 50.9%	8369 49.1%	0%	403 73.9%	142 26.1%	0%	9089 51.6%	8511 48.4%	0%
M3b	NISP	4515 56%	3543 44%	0%	806 79.5%	208 20.5%	0%	5321 58.7%	3751 41.3%	0%
	TNB	18143 57.2%	13584 42.8%	0%	1339 68.4%	619 31.6%	0%	19482 57.8%	14203 42.2%	0%
M3c	NISP	7969 52.8%	7116 47.2%	0%	1435 83%	293 17%	0%	9404 55.9%	7409 44.1%	0%
	TNB	31572 57.4%	23475 42.6%	0%	2589 74.3%	895 25.7%	0%	34161 58.4%	24370 41.6%	0%
M3 (all)	NISP	14683 52.1%	13450 47.7%	56 0.2%	2484 78%	685 21.5%	15 0.5%	17167 54.7%	14135 45.1%	71 0.2%
	TNB	58590 54.8%	47798 44.7%	464 0.4%	4348 65.6%	2233 33.7%	44 0.7%	62938 55.5%	50031 44.1%	508 0.4%
R1	NISP	1787 57.2%	1338 42.8%	0%	856 93.8%	57 6.2%	0%	2643 65.5%	1395 34.5%	0%
	TNB	7622 59.3%	5226 40.7%	0%	1364 88.8%	172 11.2%	0%	8986 62.5%	5398 37.5%	0%
R3	NISP	253 51%	243 49%	0%	1007 90%	112 10%	0%	1260 78%	355 22%	0%
	TNB	928 49%	966 51%	0%	1776 79.9%	446 20.1%	0%	2704 65.7%	1412 34.3%	0%

Freswick		Sieved (>2mm)			Hand collected			All		
		Mam.	Fish	Bird	Mam.	Fish	Bird	Mam.	Fish	Bird
Fish assemblage incomplete, see NISP table for details										
Inland, Area 1	NISP							157		8
	TNB							261		12
Inland, Area 3	NISP	16	1455		296			312 17.6%	1455 82.3%	1 0.1%
	TNB	100			604			704		2
Inland, Area 9	NISP	25	175		60			85 30.8%	175 63.4%	16 8.3%
	TNB	52			160			212		23
SCA, Area 11	NISP	154	289 (NISP for these areas presented together)		117					13
	TNB	643			255					59
SCA, Area 12	NISP	134			73					1
	TNB	865			198					5
SCA, Area 13	NISP	59			96					6
	TNB	1253			269					10
SCA, Area 14	NISP	213			173					10
	TNB	1136			259					22
SCA total	NISP	560	289		459			1019 76.2%	289 21.6%	30 7.2%
	TNB	3897			981			4878		96
NCA, Area 4	NISP	443 18.8%	1706 72.4%	207 8.8%						
	TNB	1117		427						
NCA, Area 5	NISP	30			73					35
	TNB	167			156					53
NCA, Area 6	NISP	23			56					49
	TNB	173			253					106
NCA, Area 10	NISP	29			17					1
	TNB	197			28					4
SCA, Area 11	NISP	238			266					71
	TNB	1866			345					199
SCA, Area 12	NISP	191			417					93
	TNB	1246			640					132

Appendix Table 6.2: Summary NISP and TNB by phasing and context type for sites with both sieving and hand collection, separately quantified (Sandwick North, Quoygrew, Beachview, Beachview Studio, Earl's Bu and Freswick)

Sandwick		Mixed recovery		
		Mammal	Fish	Bird
Sieved from >1.5mm to >3mm with some hand collection; only 6 cranial elements plus vertebrae identified and counted for fish but all counted for mammal and birds				
Early Phase, Area 3	NISP	273	106	
	TNB	549	918	38
		36.5%	61%	2.5%
Early Phase, Area 4	NISP	87	37	
	TNB	173	362	12
		31.6%	66.2%	2.2%
Middle Phase, Area 2	NISP	22	908	0
	TNB	35	9229	0%
		0.4%	99.6%	
Middle Phase, Area 3	NISP	147	113	
	TNB	379	995	10
		27.4%	71.9%	0.7%
Middle Phase, Area 4	NISP	84	32	
	TNB	207	299	15
		39.7%	57.4%	2.9%
Late Phase, Area 3	NISP	865	808	
	TNB	2118	4939	78
		29.7%	69.2%	1.1%
Late Phase, Area 4	NISP	354	325	
	TNB	944	2881	51
		24.4%	74.3%	1.3%

Scalloway		Mixed >4mm and hand collection		
		Mammal	Fish	Bird
Late Phase 3	NISP	1673	1832	20
		47.4%	52.0%	0.6%
Block 7.1	NISP	1448	2202	177
		37.8%	57.6%	4.6%

Pool		Mixed >4mm and hand collection		
		Mam.	Fish	Bird
Phase 7.1	NISP	4436	134	
		97.1%	2.9%	
	TNB	7411	225	
		97.1%	2.9%	
Phase 7.2	NISP	6434	4370	
		59.6%	40.4%	
	TNB	9977	6252	
		61.5%	38.5%	
Phase 8.1	NISP	1320	755	
		63.6%	36.4%	
	TNB	1975	1126	
		63.7%	36.3%	
Phase 8.2	NISP	232	202	
		53.5%	46.5%	
	TNB	302	242	
		55.5%	44.5%	
Phase 8.2.1	NISP	204	216	
		48.6%	51.4%	
	TNB	265	323	
		45.1%	54.9%	

Phase 8.2.2	NISP	1669 61.9%	1027 38.1%	
	TNB	2291 60.1%	1519 39.9%	
Phase 8.2.3	NISP	1810 46%	2124 54%	
	TNB	2744 46.3%	3184 53.7%	

Brough Road		Mixed >4mm and hand collection		
		Mam.	Fish	Bird
Area 1, Phase C	NISP	41 91.1%	4 8.9%	0%
	TNB	41 83.7%	8 16.3%	0%
Area 1, Phase D	NISP	404 53.8%	337 44.9%	10 1.3%
	TNB	467 43%	604 55.7%	14 1.3%
Area 1, Phase E	NISP	39 81.3%	9 18.8%	0%
	TNB	39 73.6%	14 26.4%	0%
Area 1, Phase F1	NISP	1304 84.1%	235 15.2%	11 0.7%
	TNB	1306 69.5%	545 29%	27 1.4%
Area 1, Phase F2	NISP	327 91.6%	30 8.4%	0%
	TNB	328 88.2%	43 11.6%	1 0.3%
Area 2, Phase A	NISP	442 66.2%	217 32.5%	9 1.3%
	TNB	470 51.5%	425 46.5%	18 2%
Area 2, Phase B1	NISP	70 79.5%	16 18.2%	2 2.3%
	TNB	70 76.9%	19 20.9%	2 2.2%
Area 2, Phase B2	NISP	45 40.2%	64 57.1%	3 2.7%
	TNB	50 24.6%	149 73.4%	4 2%
Area 2, Phase C1	NISP	899 32.4%	1828 65.8%	50 1.8%
	TNB	989 21.7%	3485 76.6%	75 1.6%
Area 2, Phase C2	NISP	1021 34.2%	1932 64.7%	33 1.1%
	TNB	1118 15.6%	6000 83.6%	57 0.8%
Area 2, Phase D	NISP	30 65.2%	11 23.9%	5 10.9%
	TNB	30 62.5%	11 22.9%	7 14.6%
Area 2, Phase	NISP	340 64.4%	181 34.3%	7 1.3%

E1	TNB	397 52.7%	343 45.5%	14 1.9%
Area 2, Phase E2	NISP	257 93.1%	18 6.5%	1 0.4%
	TNB	257 82.9%	48 15.5%	5 1.6%
Area 3, Phase A	NISP	9 24.3%	28 75.7%	0%
	TNB	9 14.5%	53 85.5%	0%
Area 3, Phase B	NISP	3 25%	9 75%	0%
	TNB	3 4.2%	68 95.8%	0%
Area 3, Phase C	NISP	49 50.5%	48 49.5%	0%
	TNB	49 16.7%	244 83.3%	0%

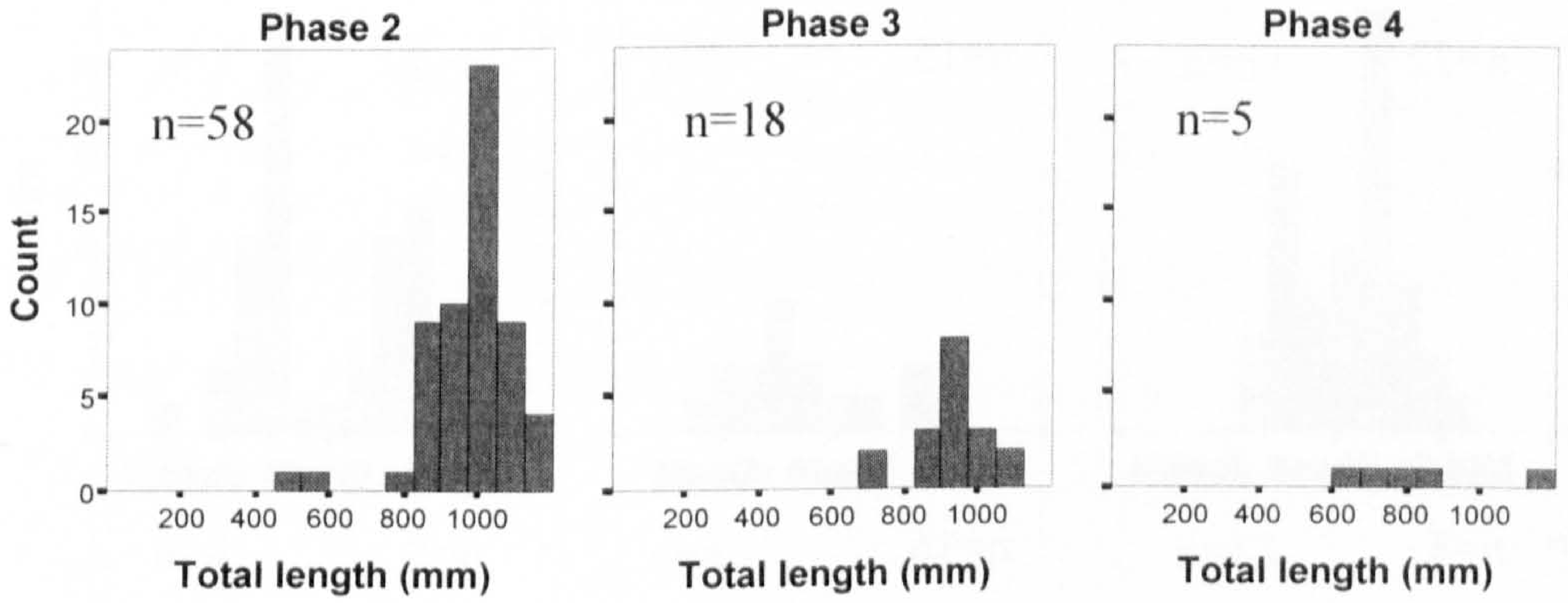
Brough of Deerness		Mixed >4mm and hand collected		
		Mam.	Fish	Bird
Outside enclosure, all phases	NISP	21	0	0
	TNB	31	0	0
Chapel interior Phase A	NISP	12	0	0
	TNB	12	0	0
Chapel interior Phase B	NISP	53 96.4%	2 3.6%	0%
	TNB	283 96.9%	9 3.1%	2 0.7%
Chapel interior Phase C	NISP	22 64.7%	7 20.6%	5 14.7%
	TNB	63 74.1%	13 15.3%	9 10.6%
Chapel interior Phase D	NISP	201 74.2%	16 5.9%	54 19.9%
	TNB	213 68.7%	27 8.7%	70 22.6%
Enclosure Phase A	NISP	92 98.9%	1 1.1%	0%
	TNB	178 99.4%	1 0.6%	0%
Enclosure Phase B	NISP	58	0	0
	TNB	1225	0	0
Enclosure Phase C	NISP	273	0	0
	TNB	628	0	0
Enclosure Phase D	NISP	25 89.3%	1 3.6%	2 7.1%
	TNB	26 86.7%	1 3.3%	3 10%

Appendix Table 6.3: Summary NISP and TNB by phasing and context type for sites with mixed sieved and hand collected bone, quantified together (Sandwick, Scalloway, Pool, Brough Road and Brough of Deerness)

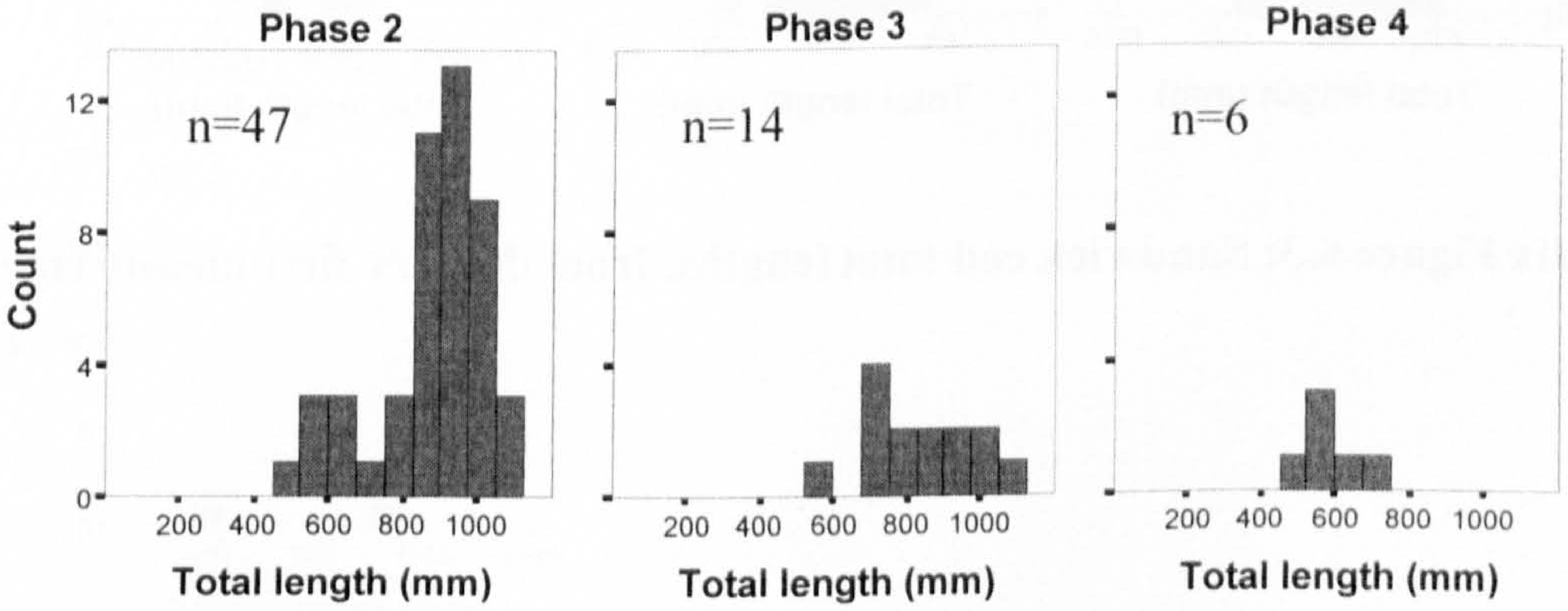
Brough of Birsay, Rescue Excavations		Hand collected		
		Mammal	Fish	Bird
Phase 1, Site VII	NISP	920	5	2
		99.2%	0.5%	0.2%
Phase 1, Site VIII	NISP	297	0%	0%
		100%		
Phase 1, Site IX	NISP	178	0%	0%
		100%		
Phase 2.1, Site IX	NISP	389	1	1
		99.5%	0.3%	0.3%
Phase 2.2, Site VII	NISP	456	45	3
		90.5%	8.9%	0.6%
Phase 2.2, Site VIII	NISP	731	1	4
		99.3%	0.1%	0.5%
Phase 2.2, Site IX	NISP	1054	4	4
		99.2%	0.4%	0.4%
Phase 3, Site VII	NISP	1426	35	10
		96.9%	2.4%	0.7%
Phase 3, Site VIII	NISP	634	5	23
		95.8%	0.8%	3.5%

Brough of Birsay Room 5		Hand collected		
		Mammal	Fish	Bird
Phase 1	NISP	1094	5	5
		99.1%	0.5%	0.5%
Phase 2	NISP	391	3	0%
		99.2%	0.8%	
Phase 3a	NISP	244	32	4
		87.1%	11.4%	1.4%
Phase 3b	NISP	338	41	0%
		89.2%	10.8%	
Phase 4	NISP	1269	443	15
		73.5%	25.7%	0.9%
Drain fill	NISP	485	22	1
		95.5%	4.3%	0.2%

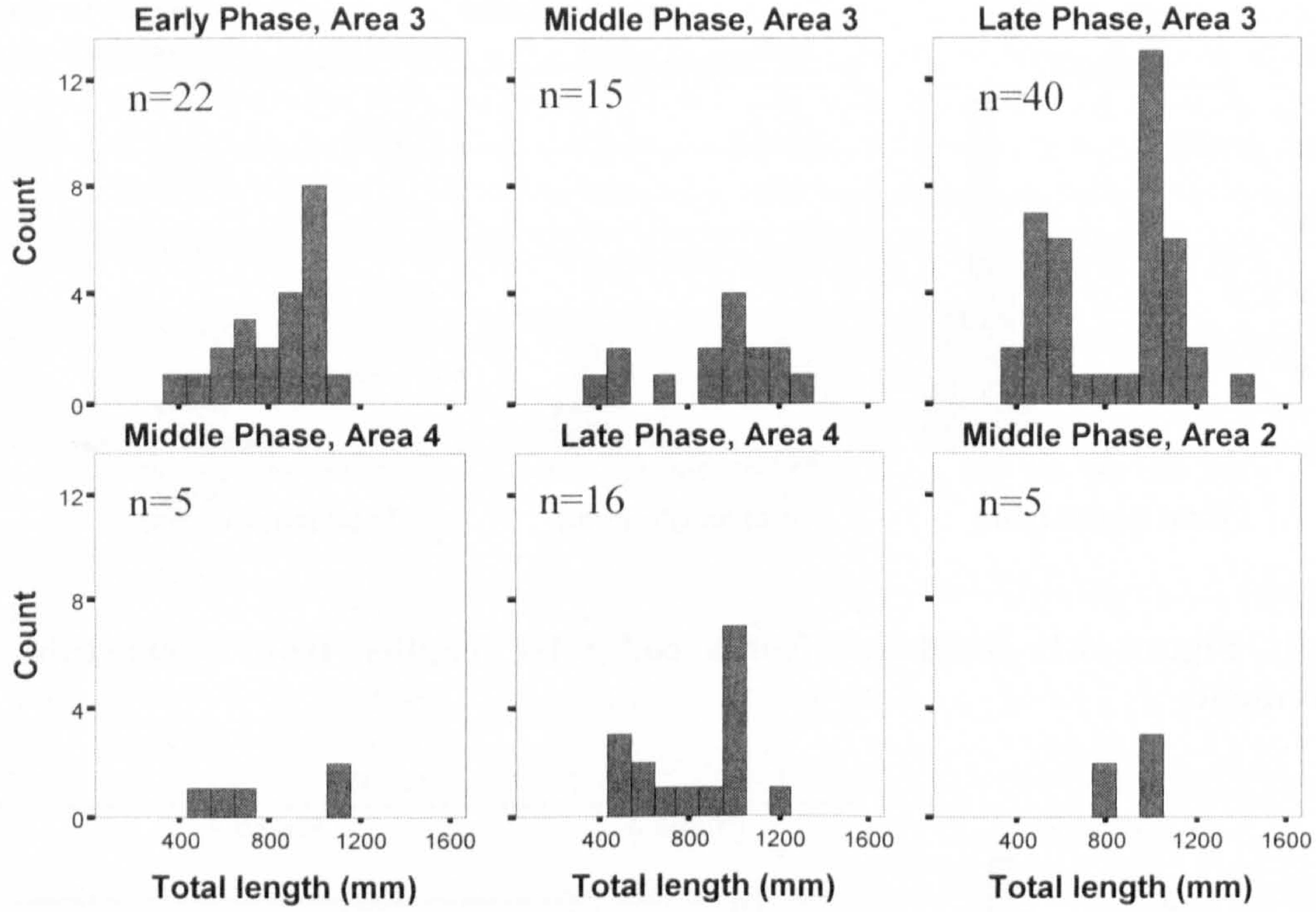
Appendix Table 6.4: Summary NISP by phasing and context type for sites with hand collected bone only (Brough of Birsay Rescue Excavations and Room 5)



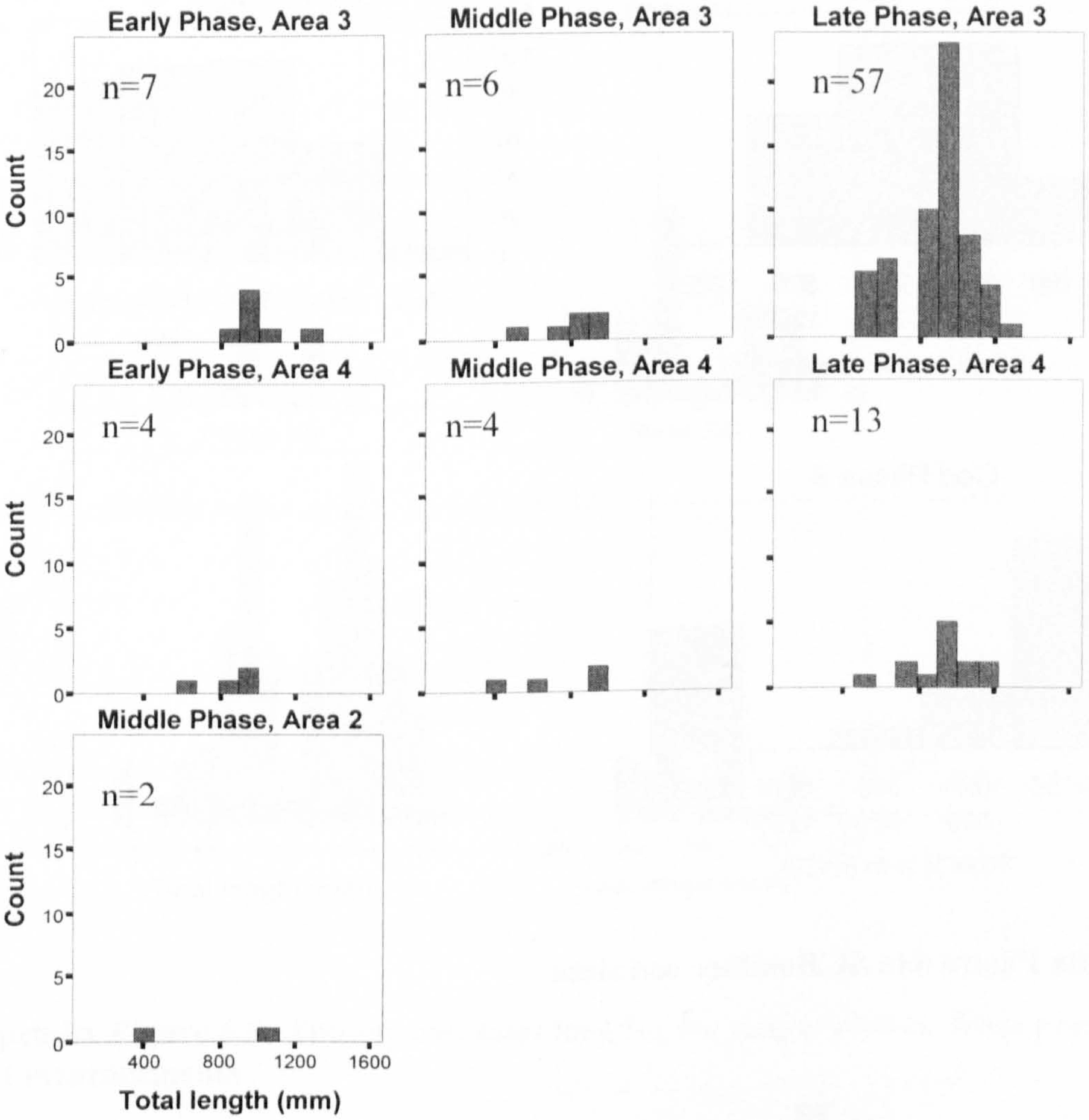
Appendix Figure 6.1: Sandwick North cod total lengths, from premaxilla first measurements



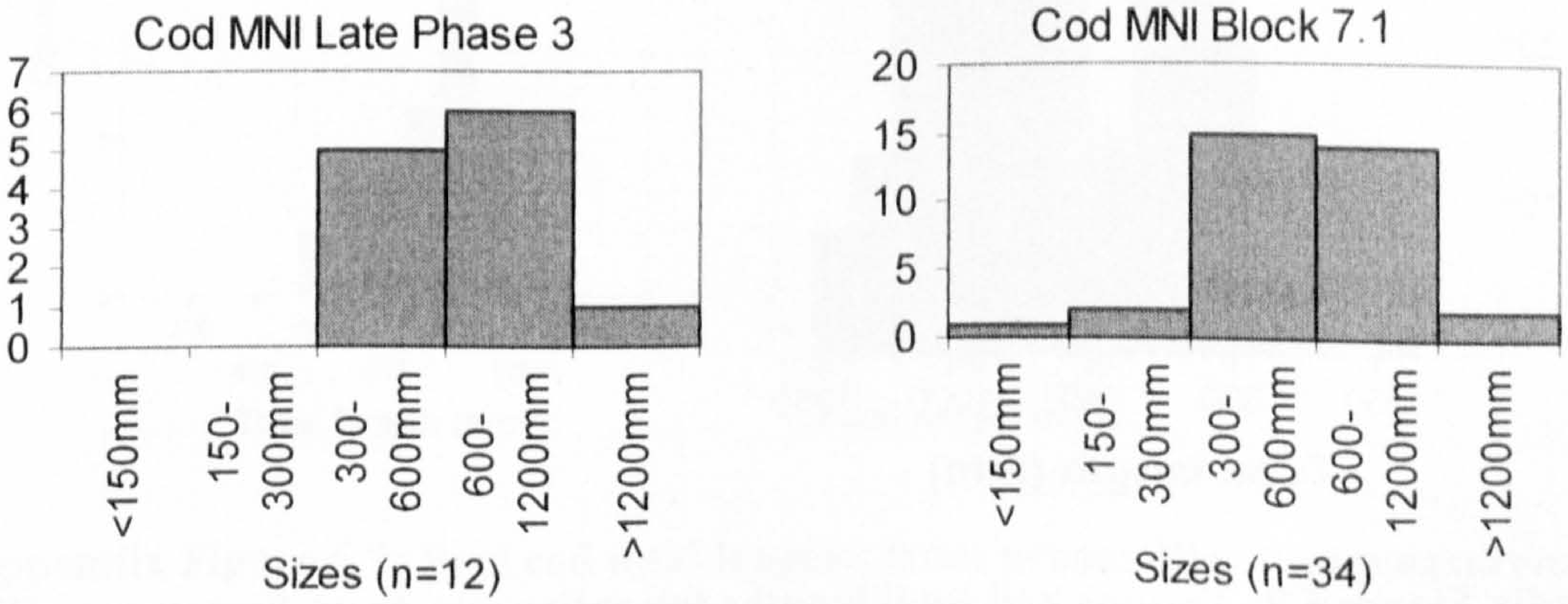
Appendix Figure 6.2: Sandwick North cod total lengths, from dentary first measurements



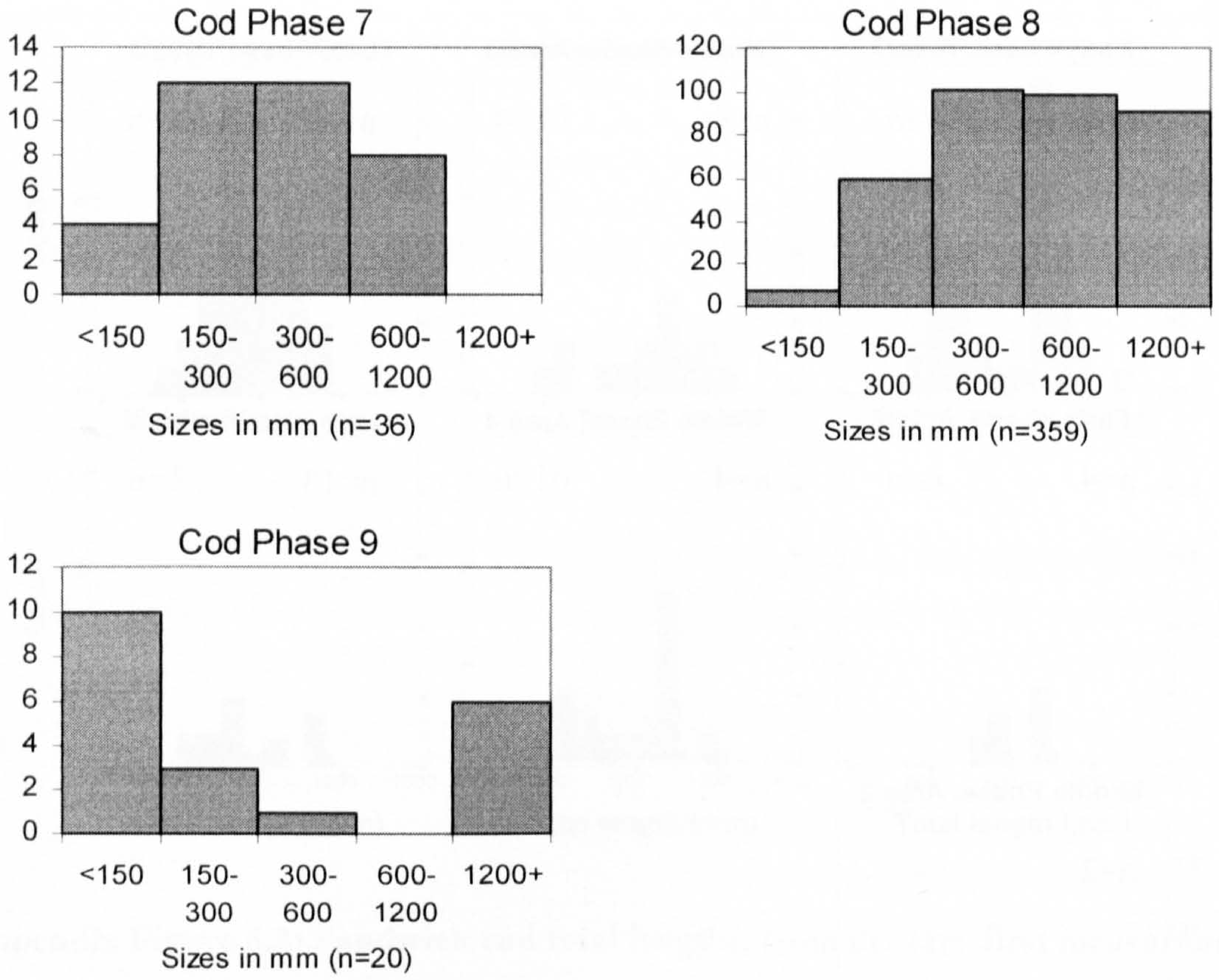
Appendix Figure 6.3: Sandwick cod total lengths, from dentary first measurements



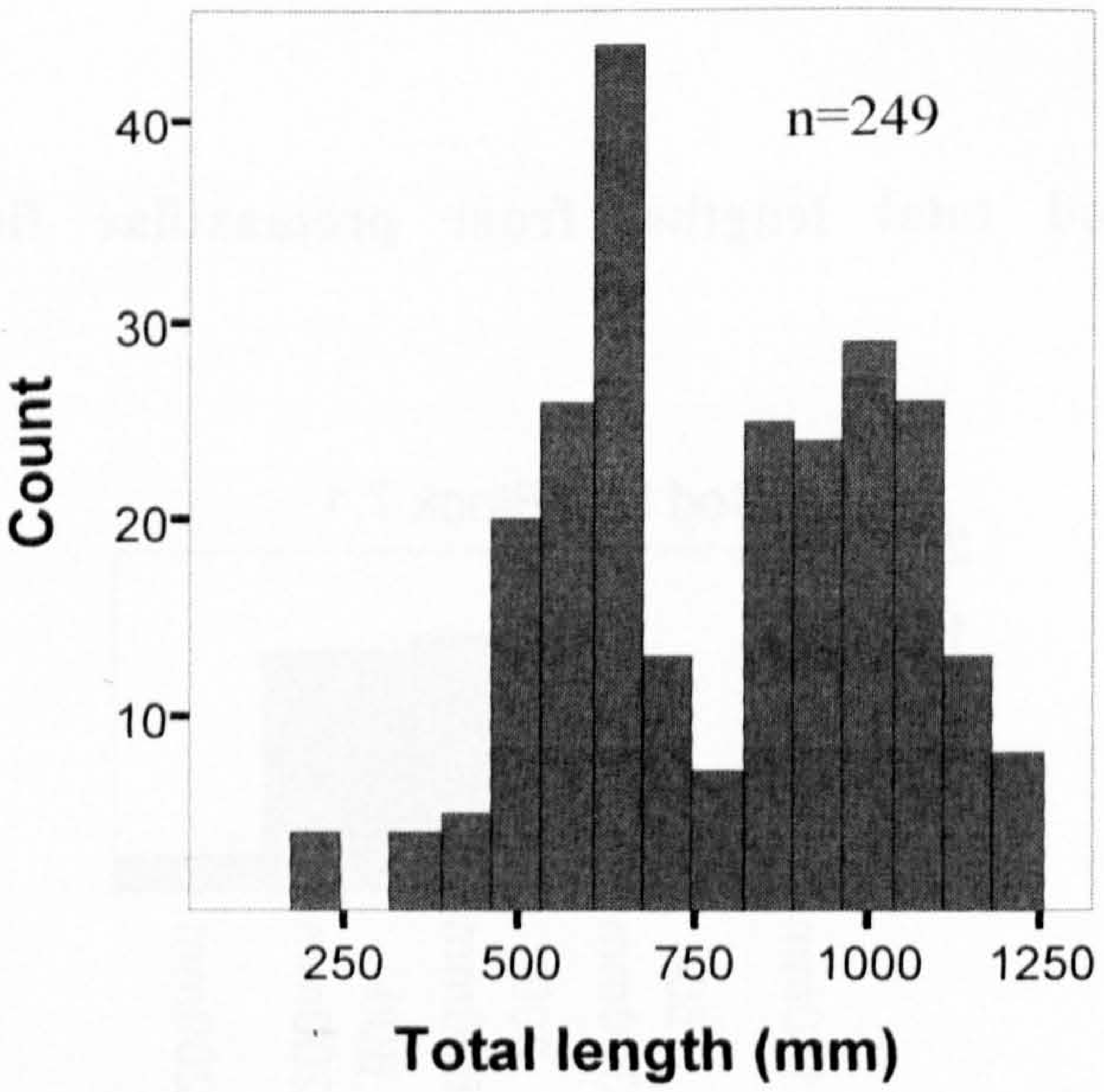
Appendix Figure 6.4: Sandwick cod total lengths, from premaxillae first measurements



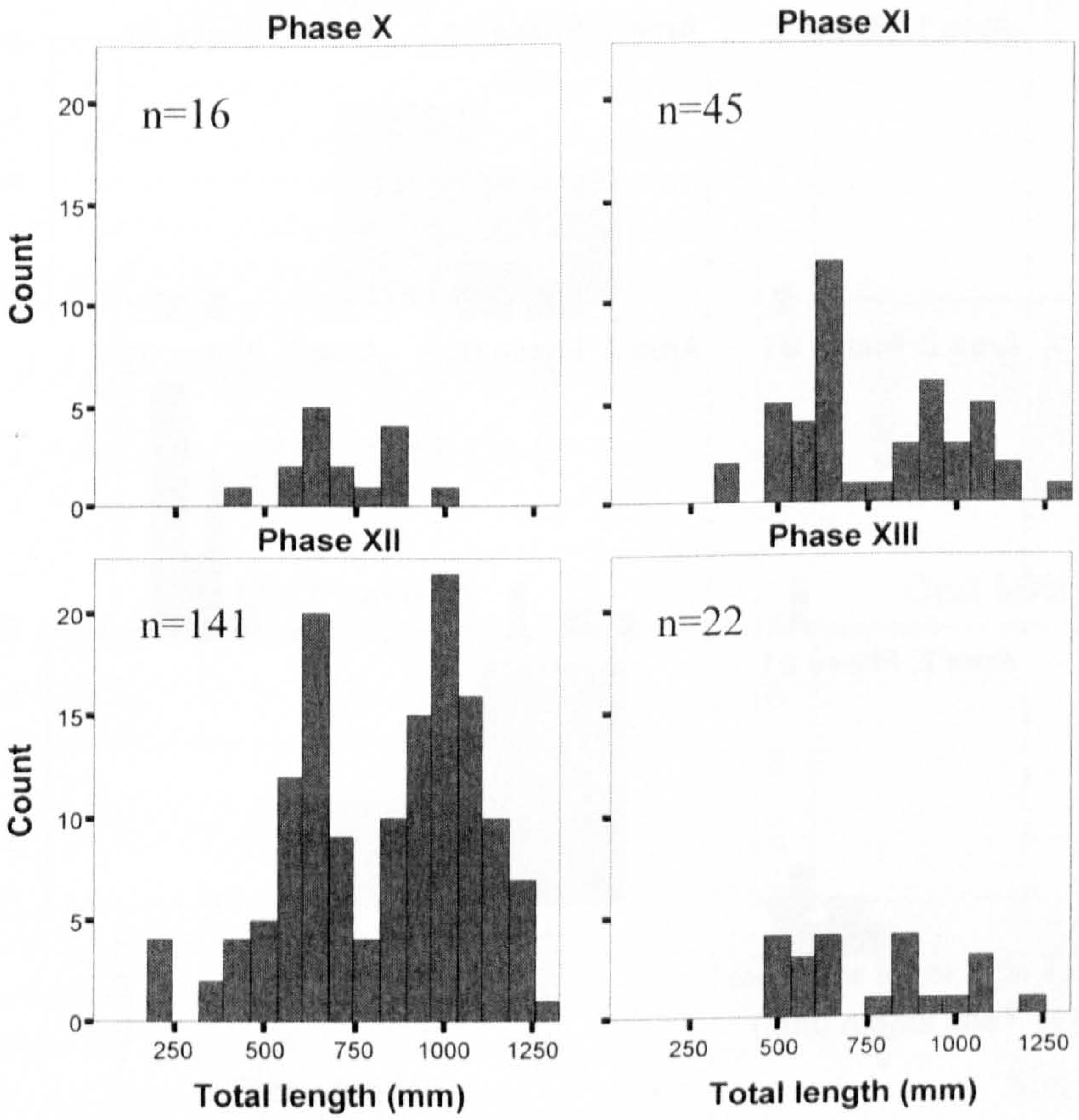
Appendix Figure 6.5: Scalloway cod sizes (based on MNI, not NISP)



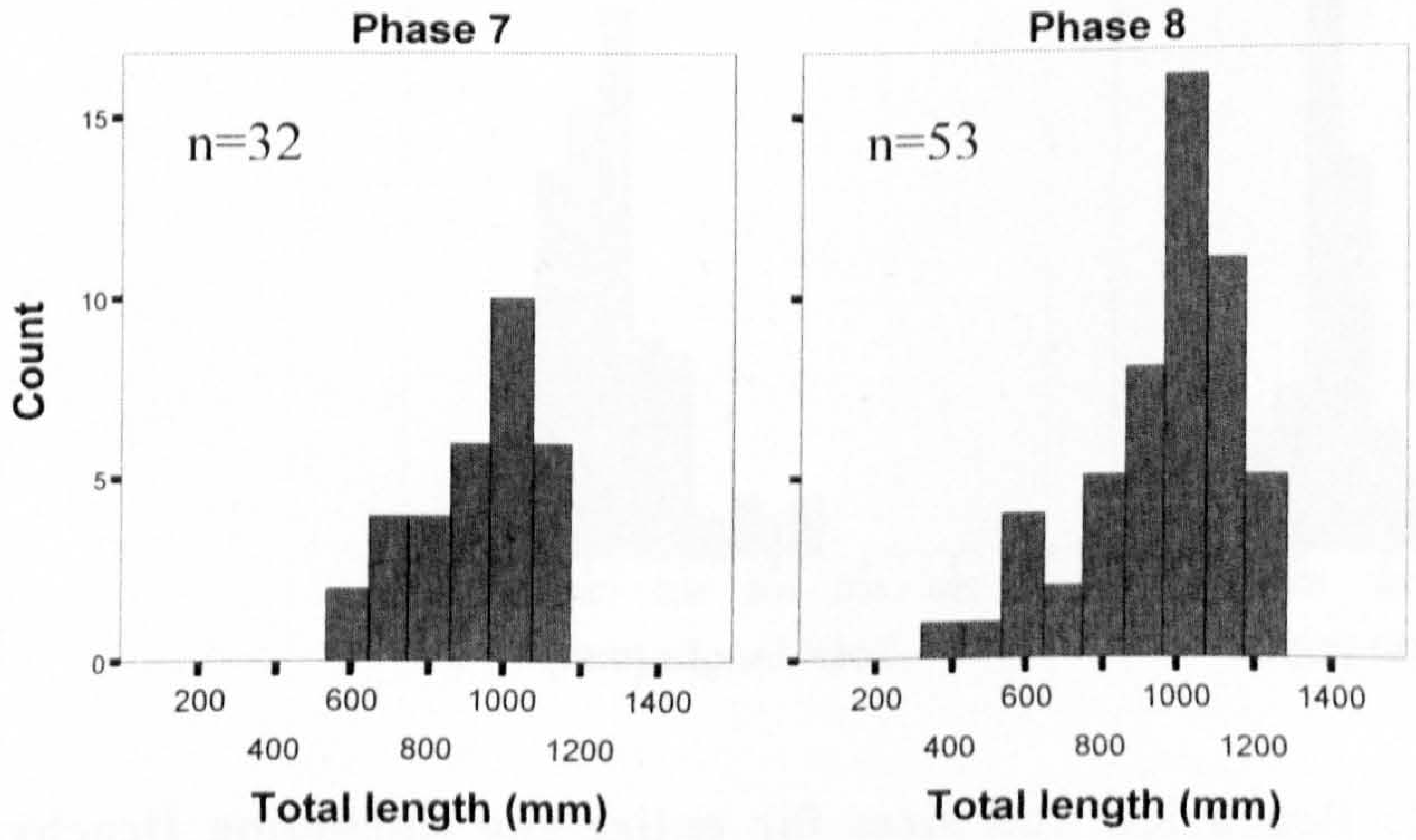
Appendix Figure 6.6: St. Boniface cod sizes



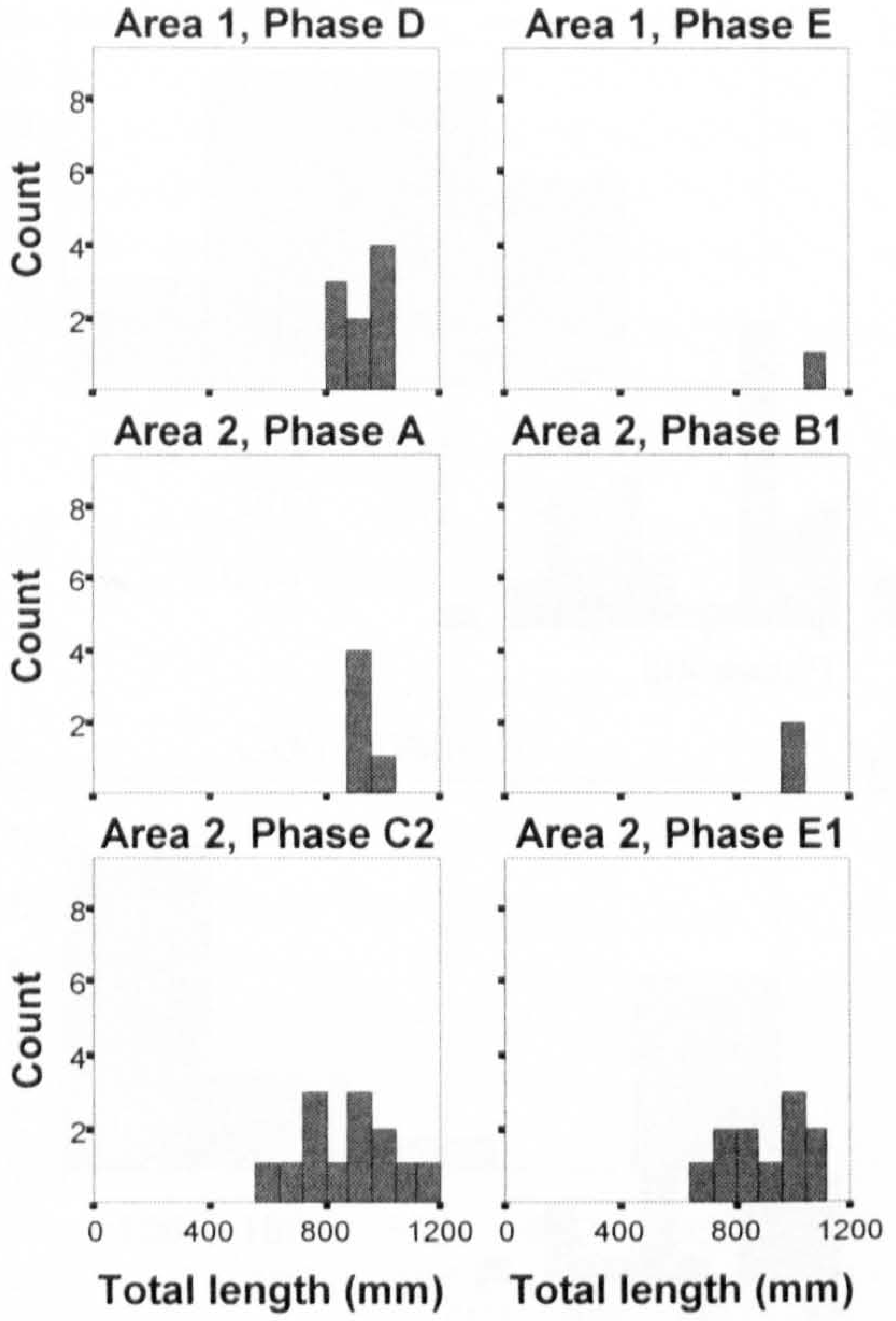
Appendix Figure 6.7: Tuquoy cod total lengths for entire site, from first premaxillae measurements



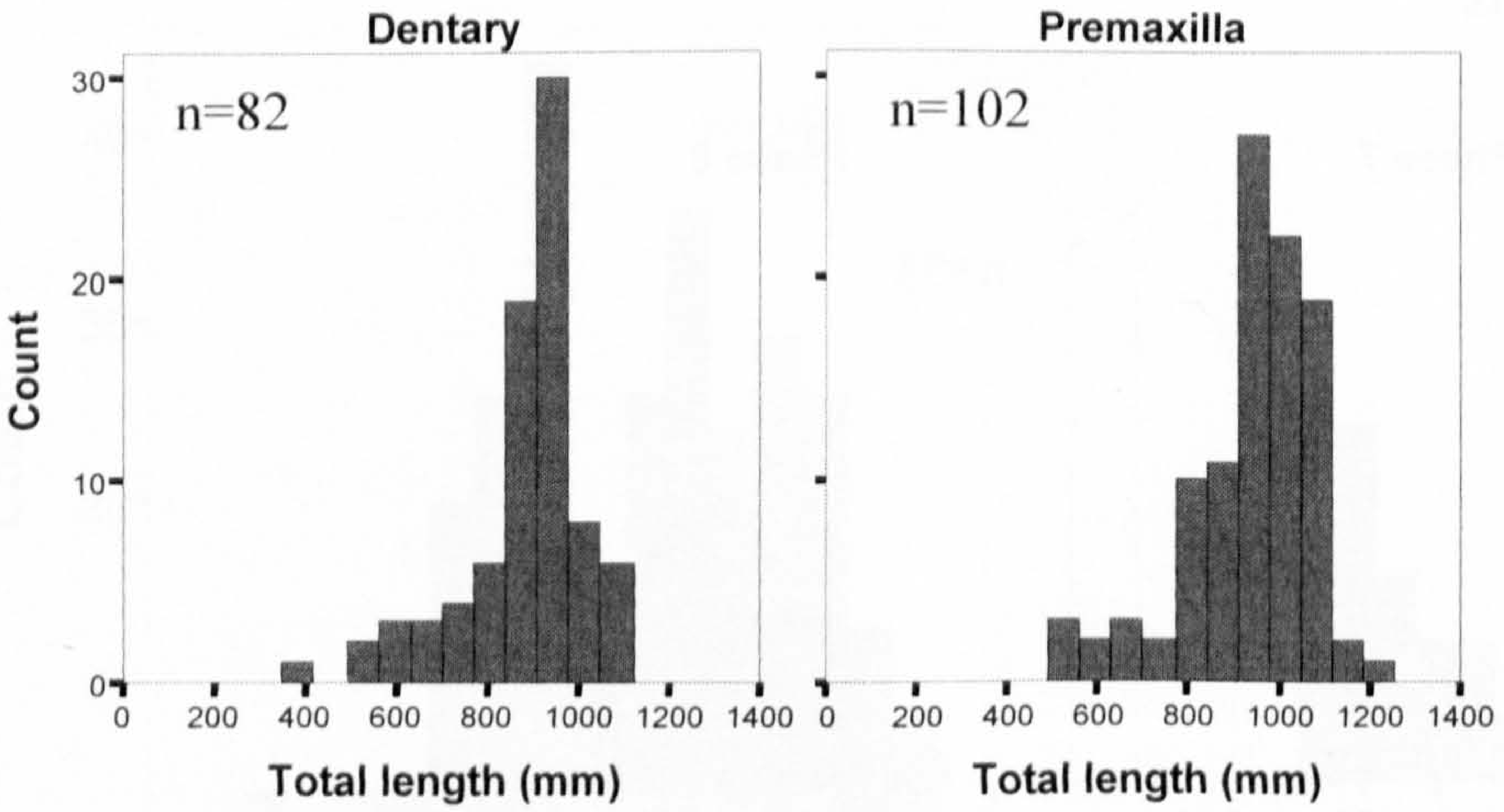
Appendix Figure 6.8: Tuquoy cod total lengths, for major phases, from premaxillae first measurements



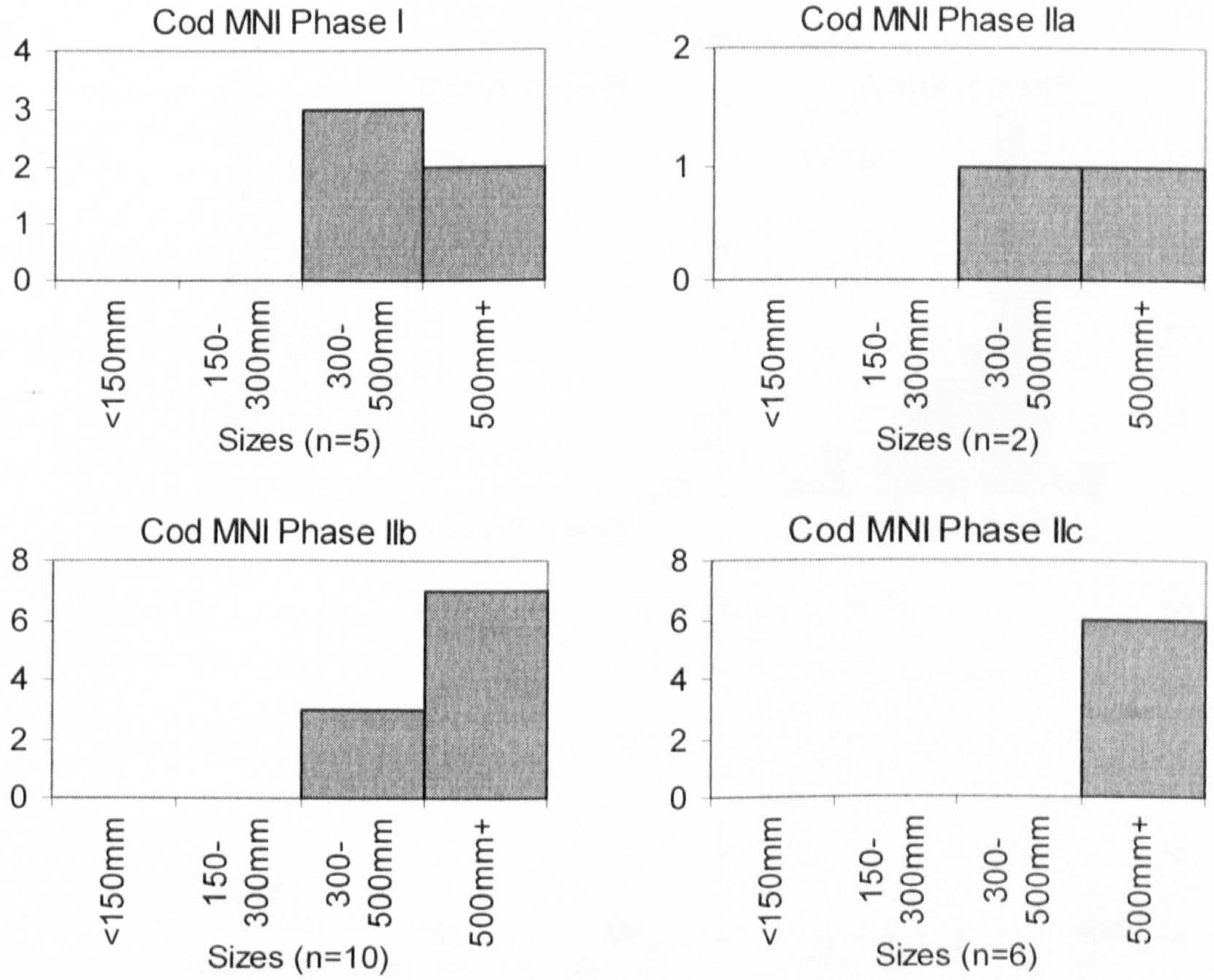
Appendix Figure 6.9: Pool cod total lengths, from premaxillae first measurements



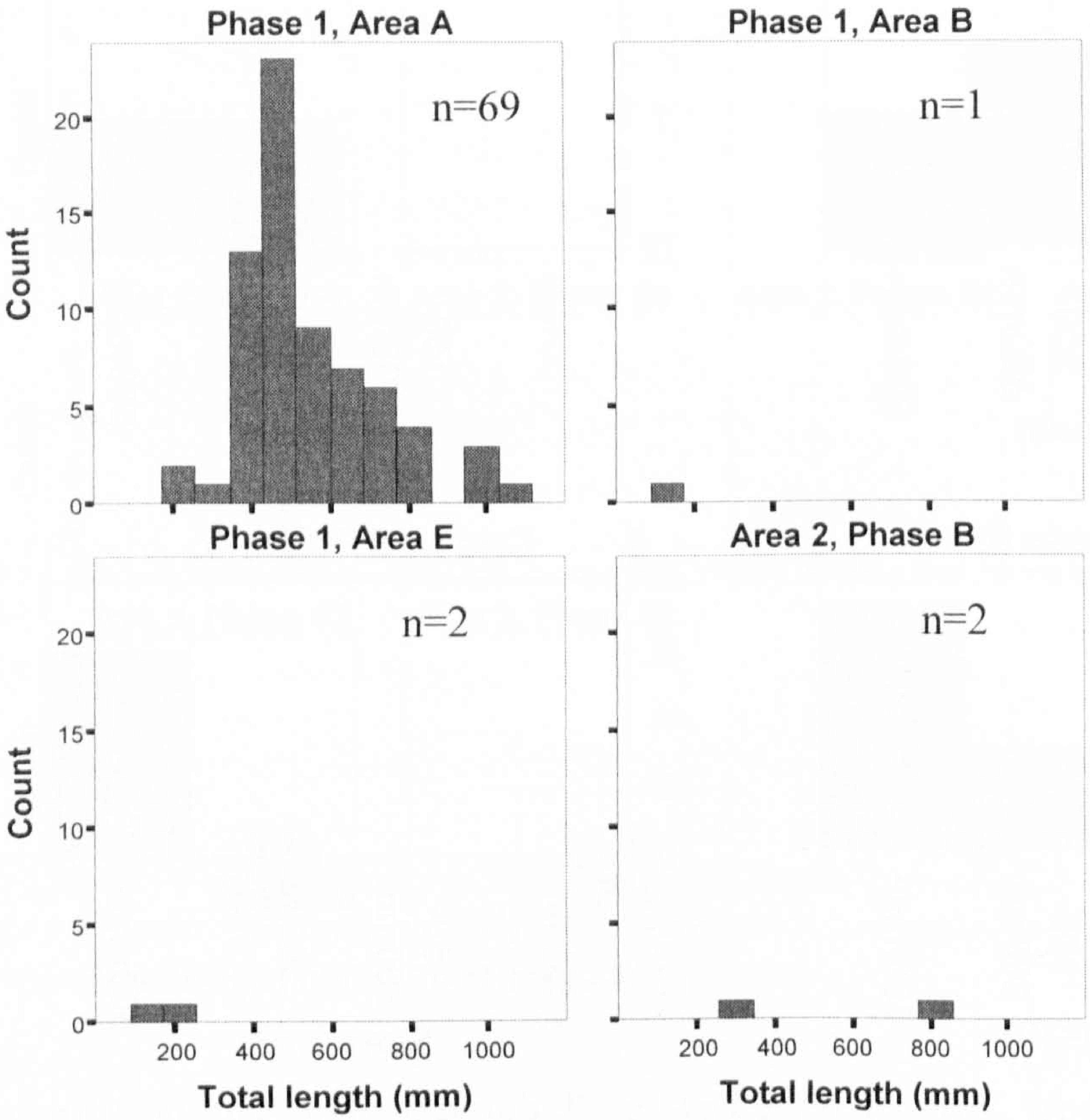
Appendix Figure 6.10: Brough Road cod total lengths, from premaxilla, dentary and otolith measurements



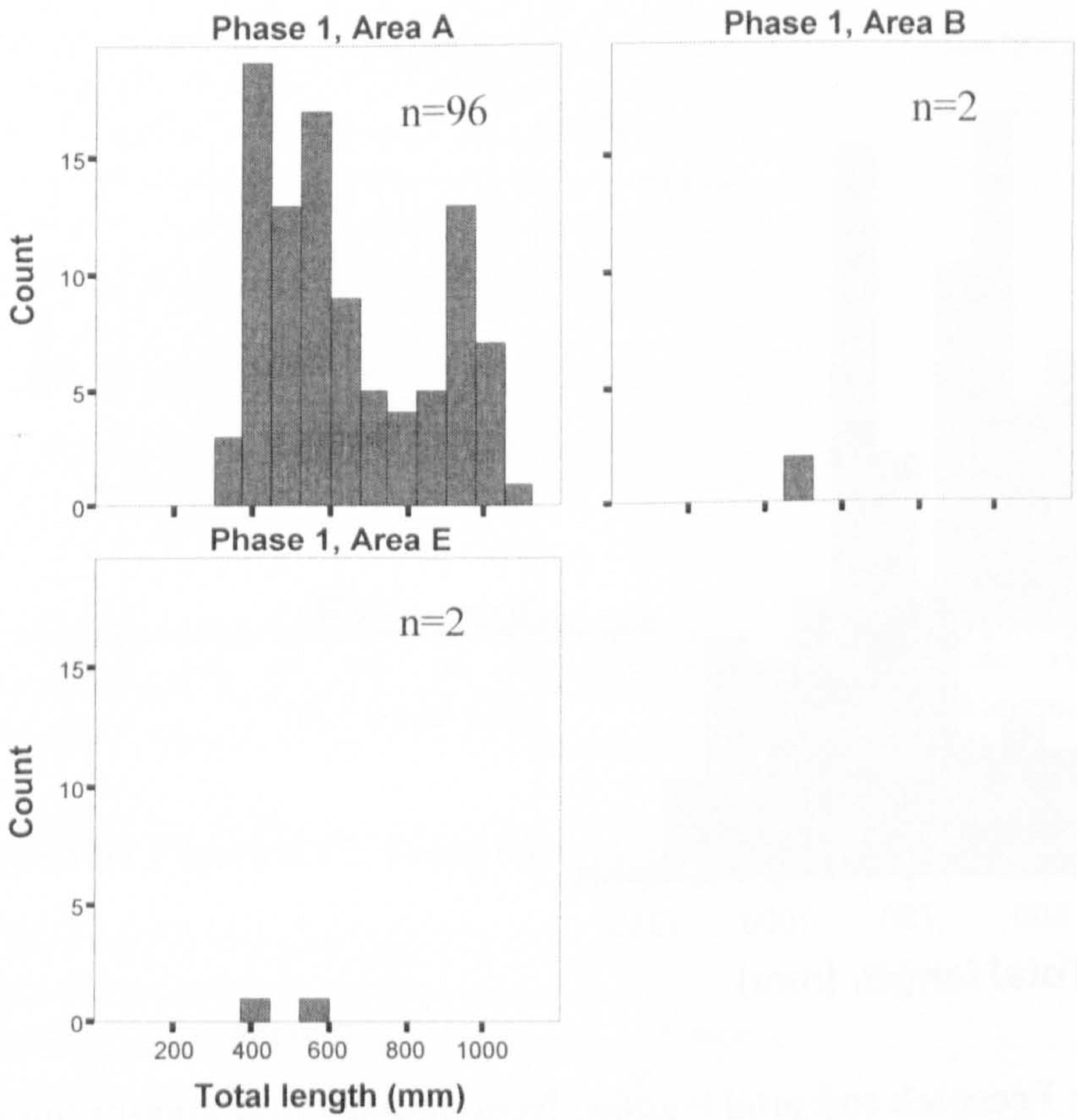
Appendix Figure 6.11: Beachview cod sizes for entire site (including Beachview Studio), based on regression data for premaxillae and dentaries



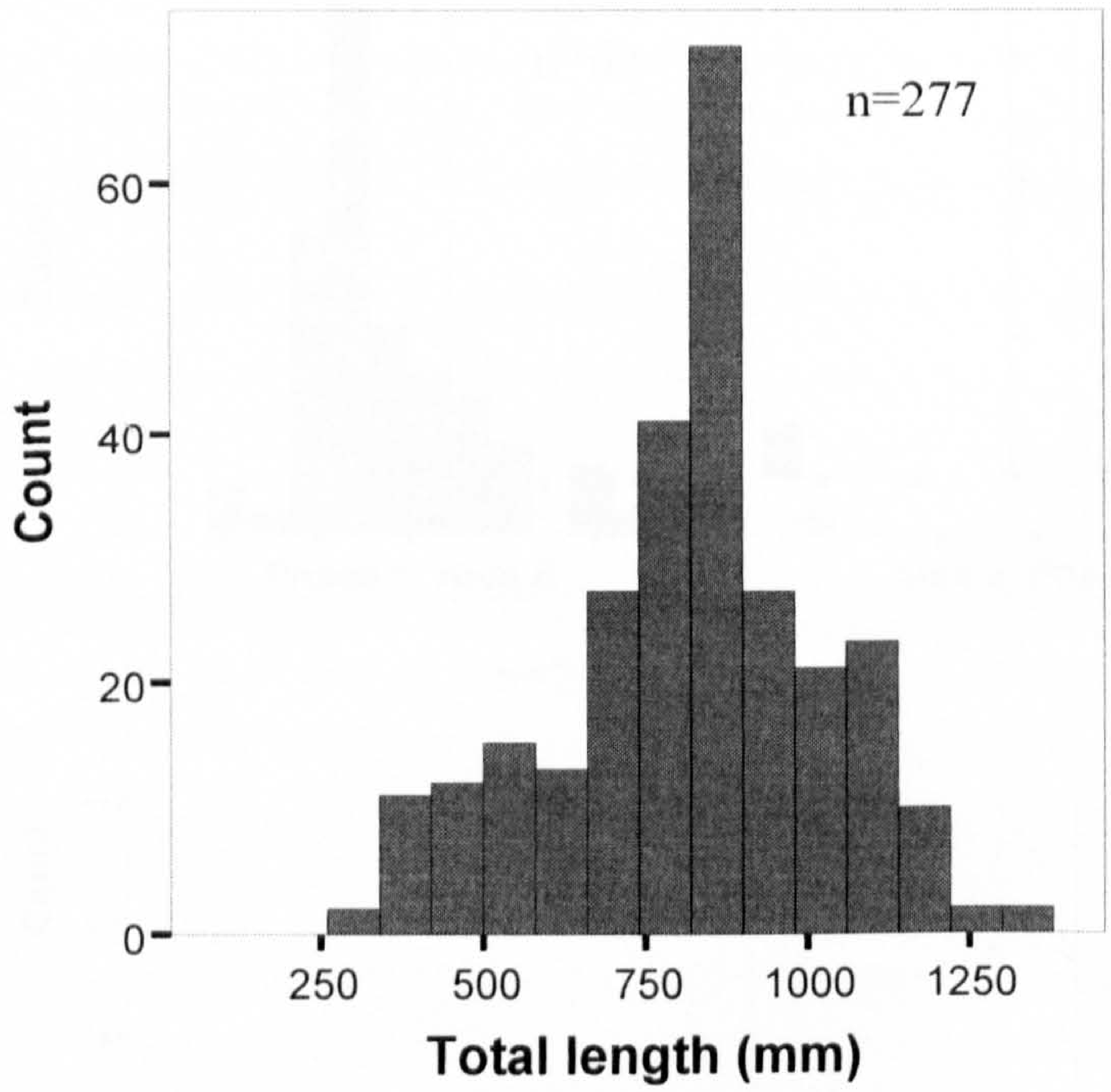
Appendix Figure 6.12: Saevar Howe fish sizes (based on MNI not NISP)



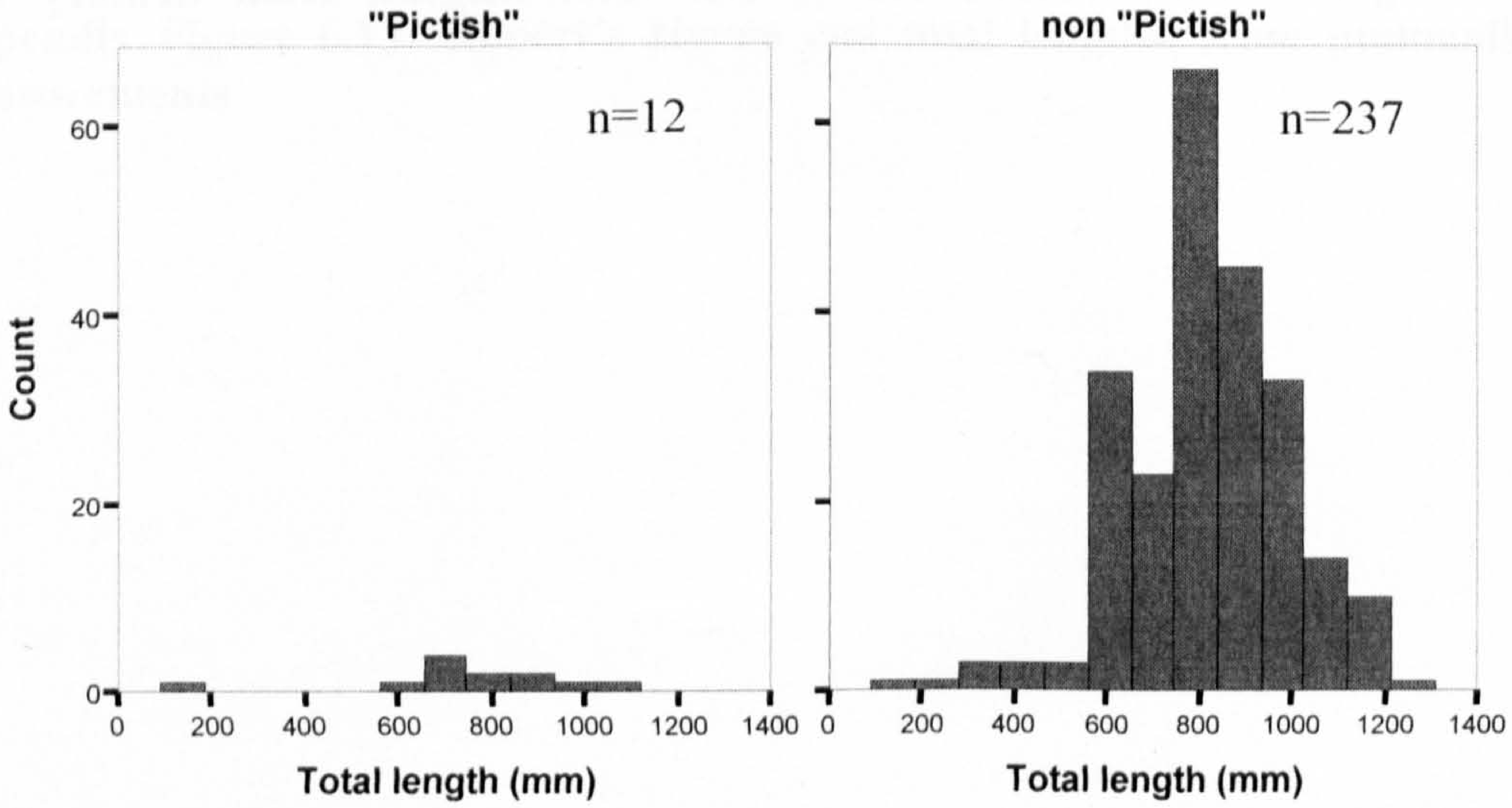
Appendix Figure 6.13: Robert's Haven cod total lengths, from premaxillae first measurements



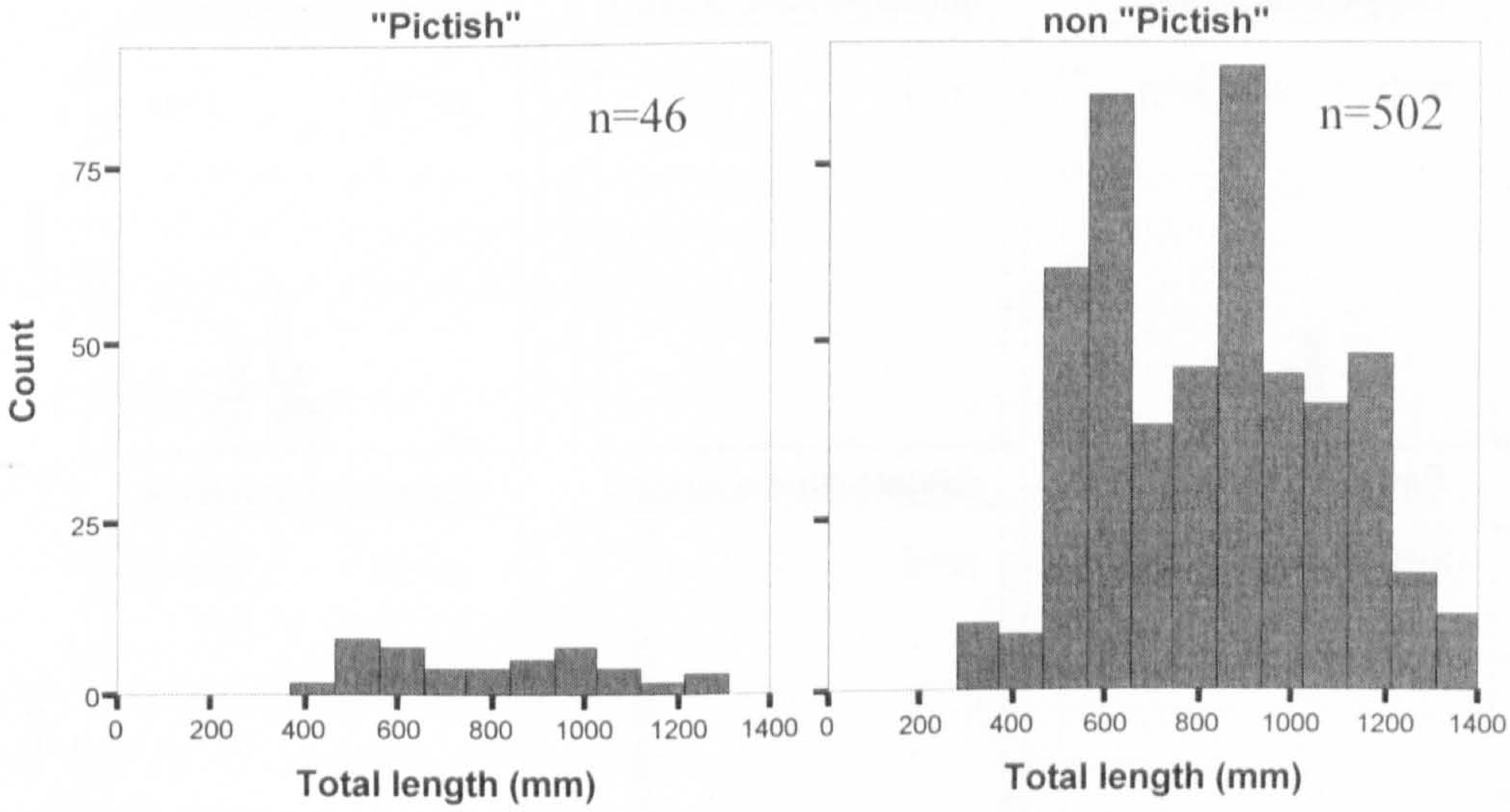
Appendix Figure 6.14: Robert's Haven cod total lengths, from dentary first measurements



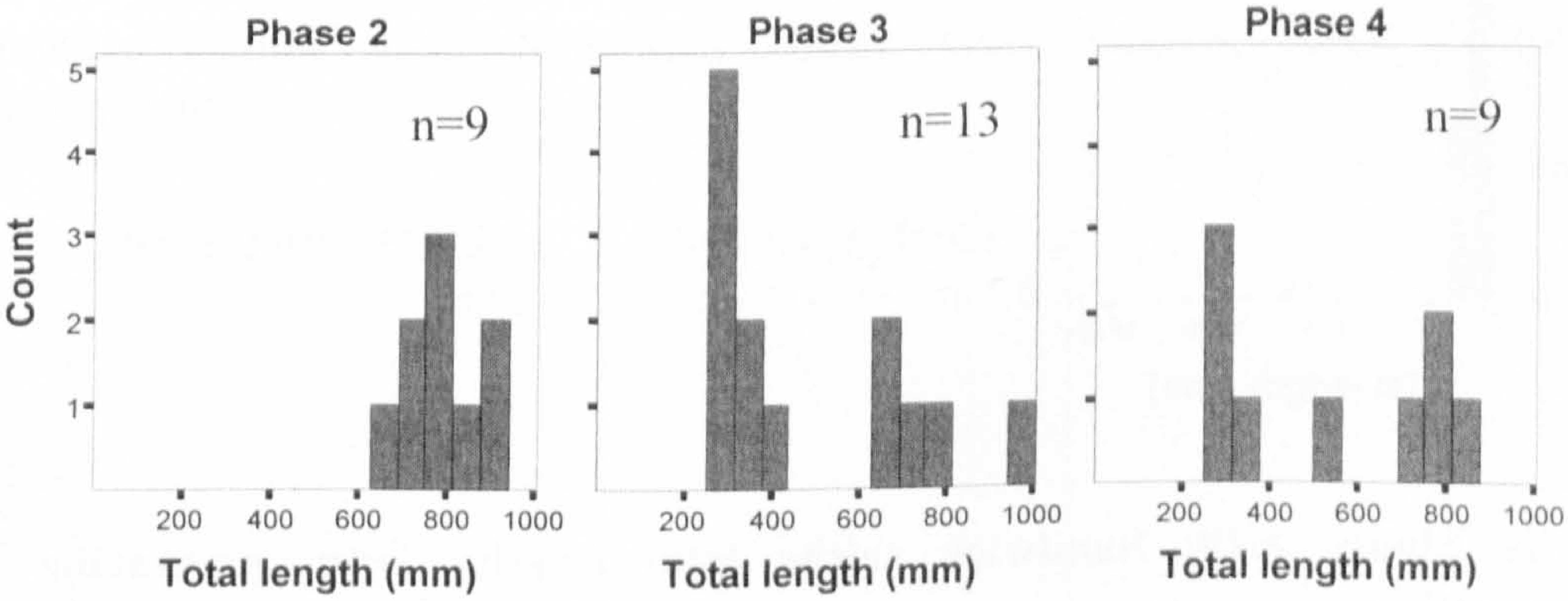
Appendix Figure 6.15: Freswick cod total lengths, from dentary first measurements



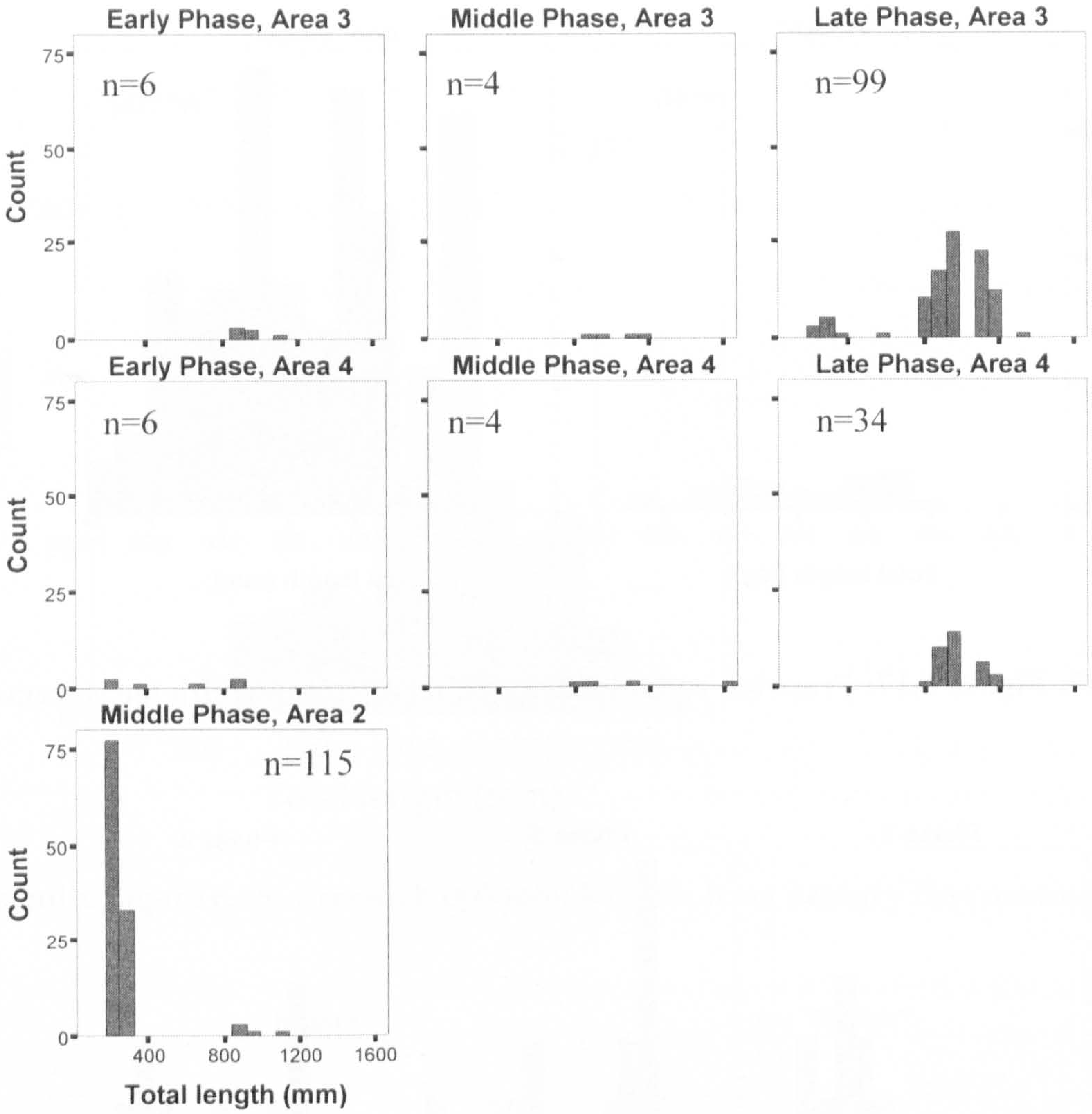
Appendix Figure 6.16: Freswick cod total lengths, from otolith length measurements



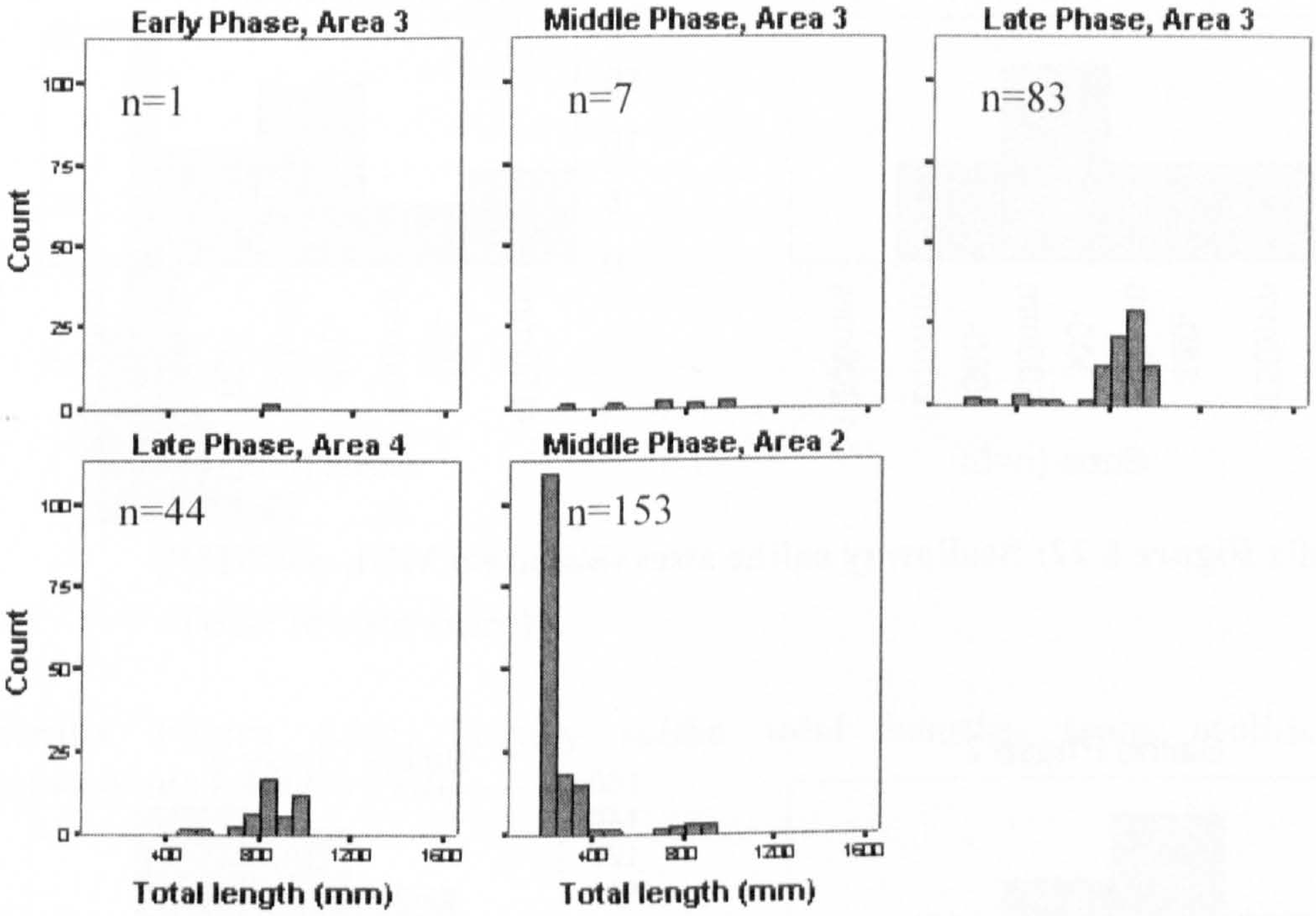
Appendix Figure 6.17: Freswick cod total lengths, from otolith width measurements



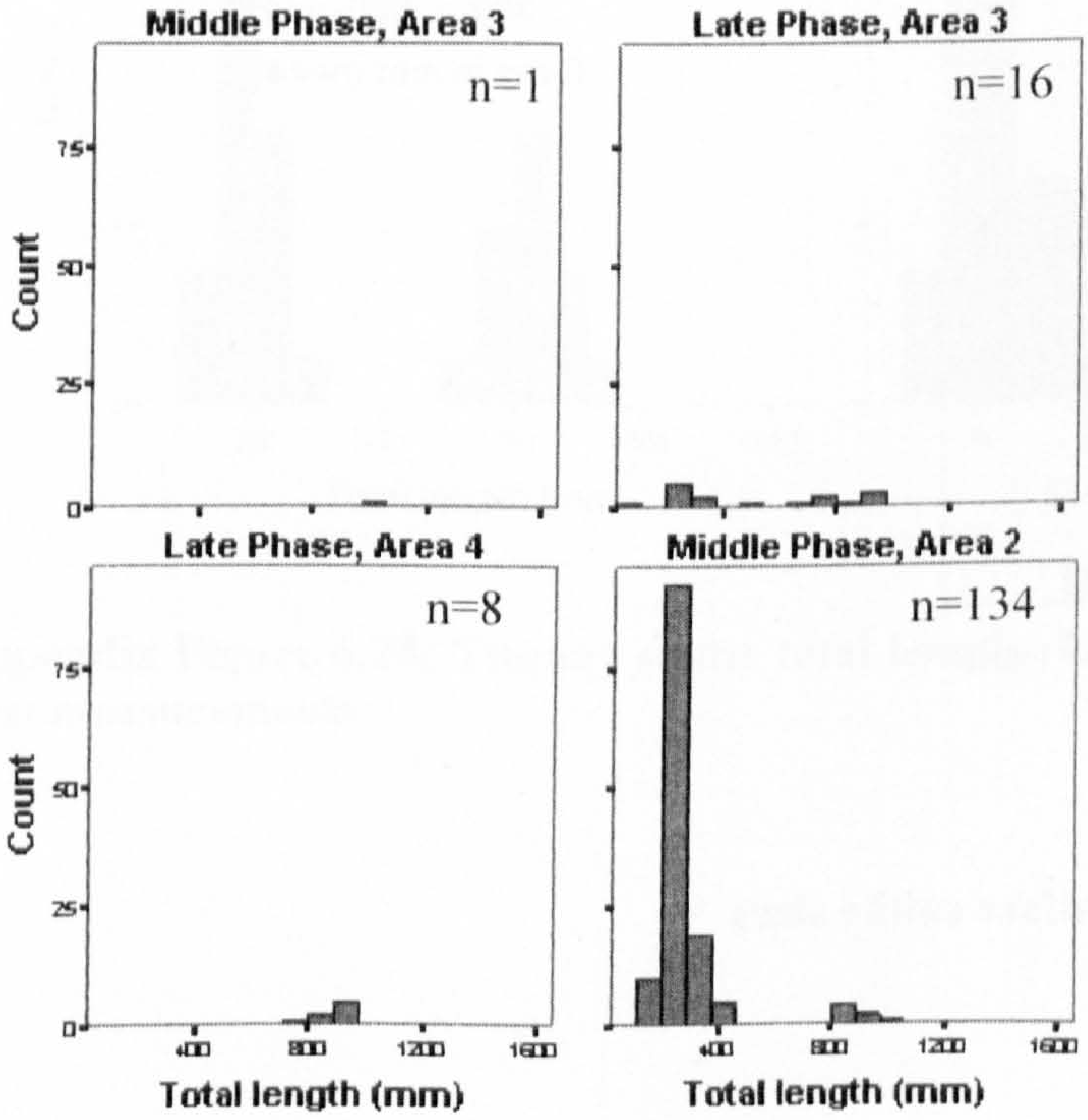
Appendix Figure 6.18: Sandwick North saithe total lengths, from dentary first measurements



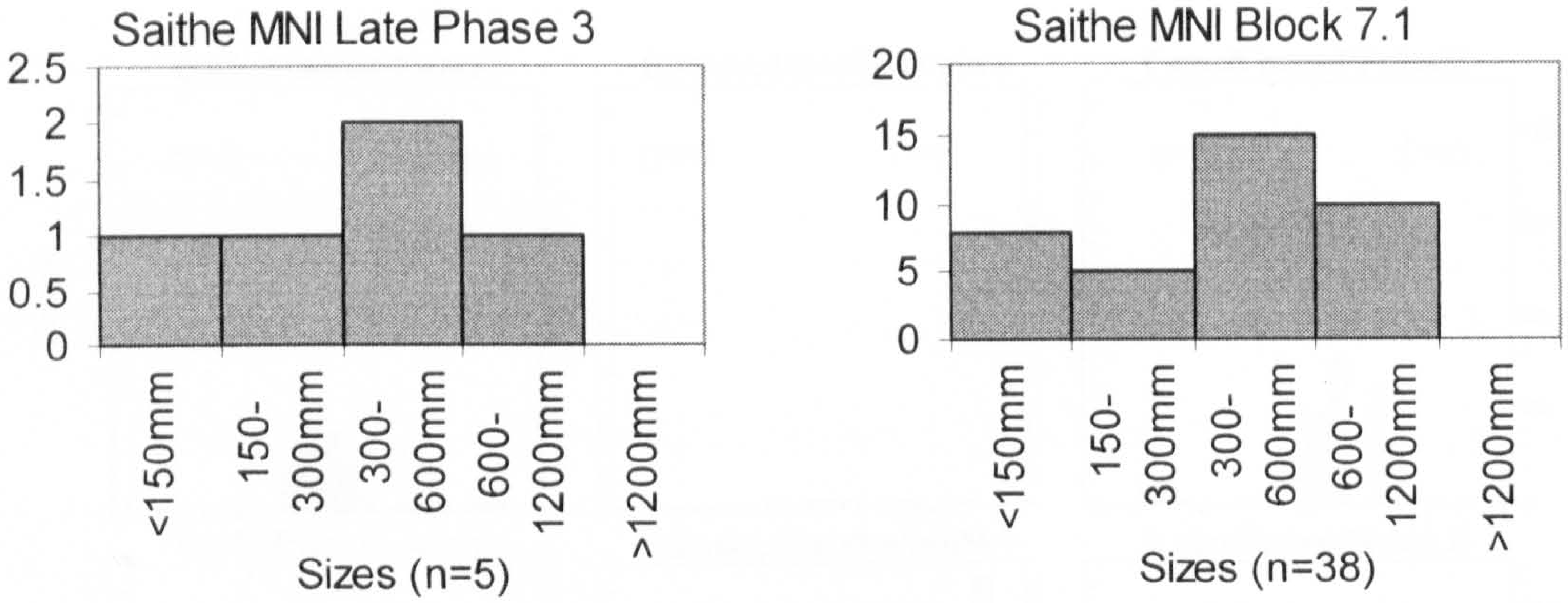
Appendix Figure 6.19: Sandwick saithe total lengths, from premaxilla first measurements



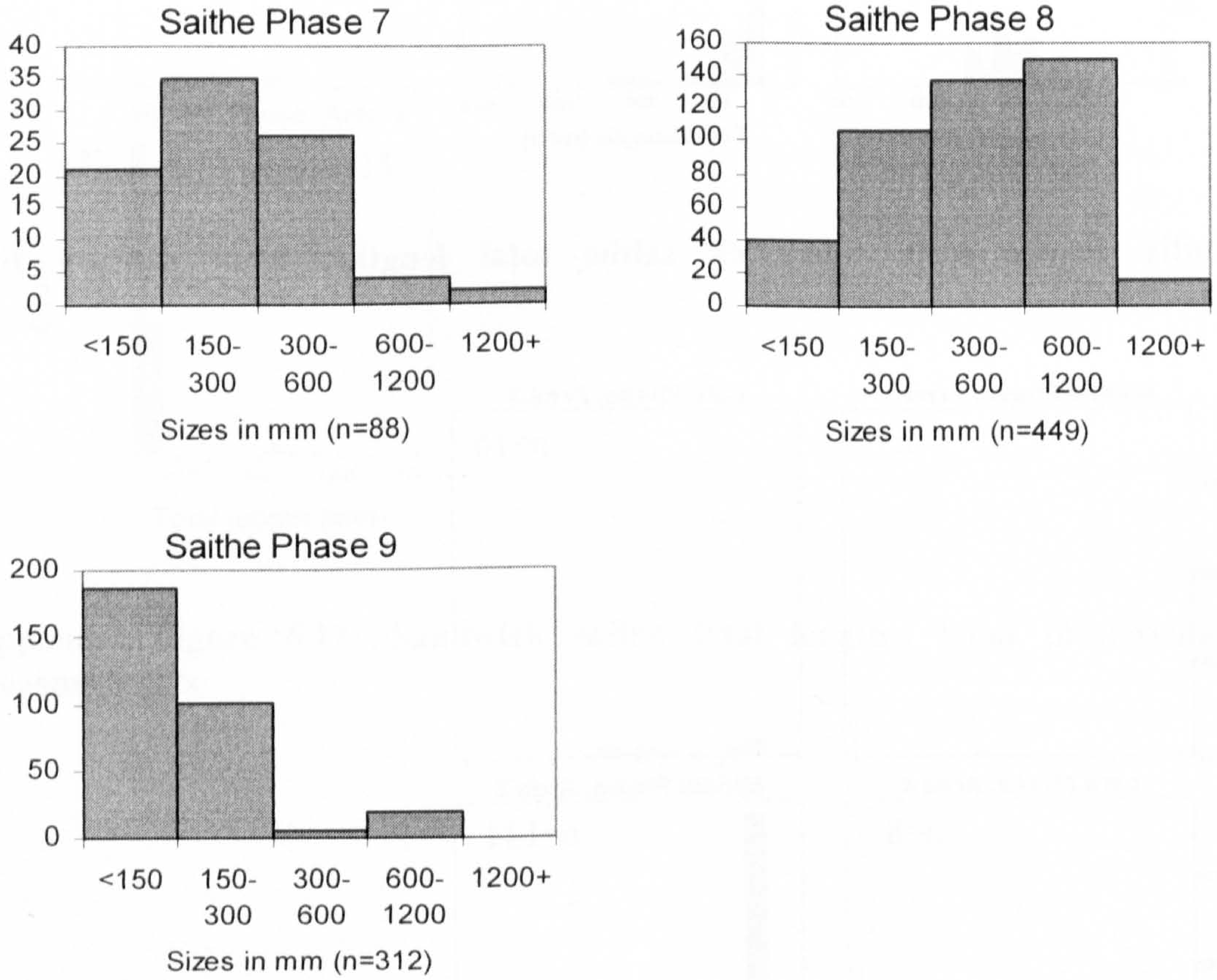
Appendix Figure 6.20: Sandwick saithe total lengths, from dentary first measurements



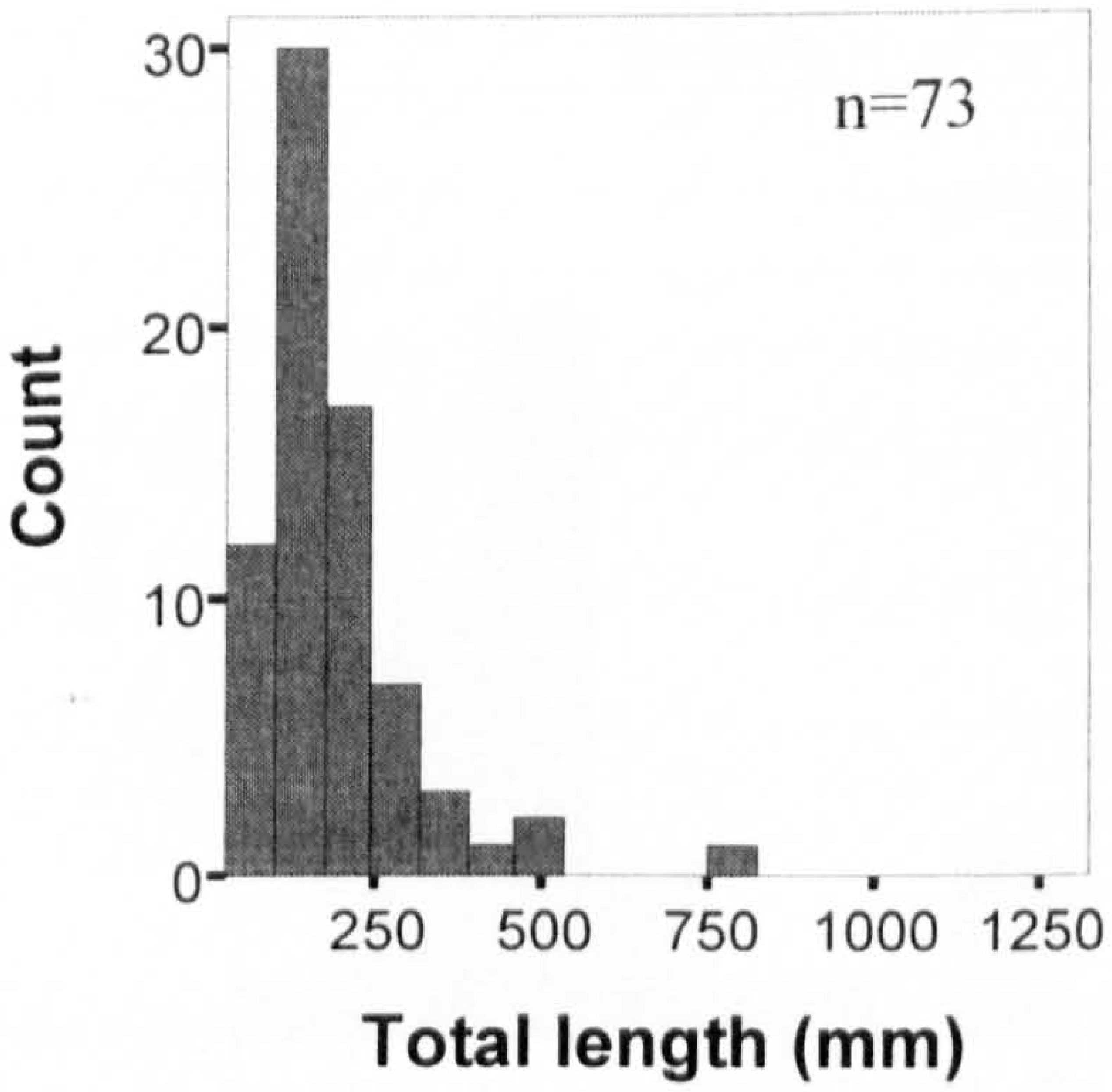
Appendix Figure 6.21: Sandwick saithe total lengths, from otolith measurements



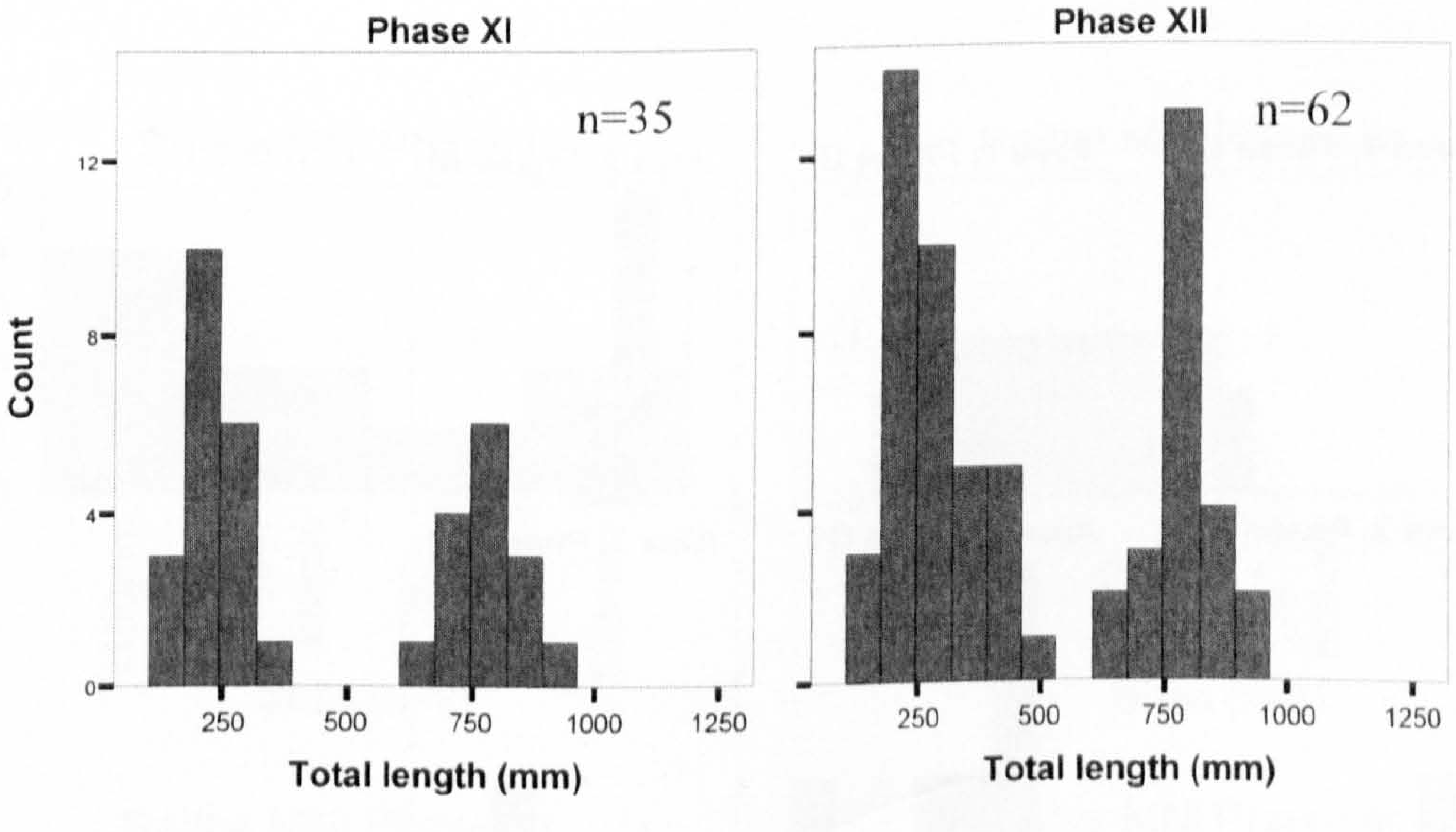
Appendix Figure 6.22: Scalloway saithe sizes (based on MNI, not NISP)



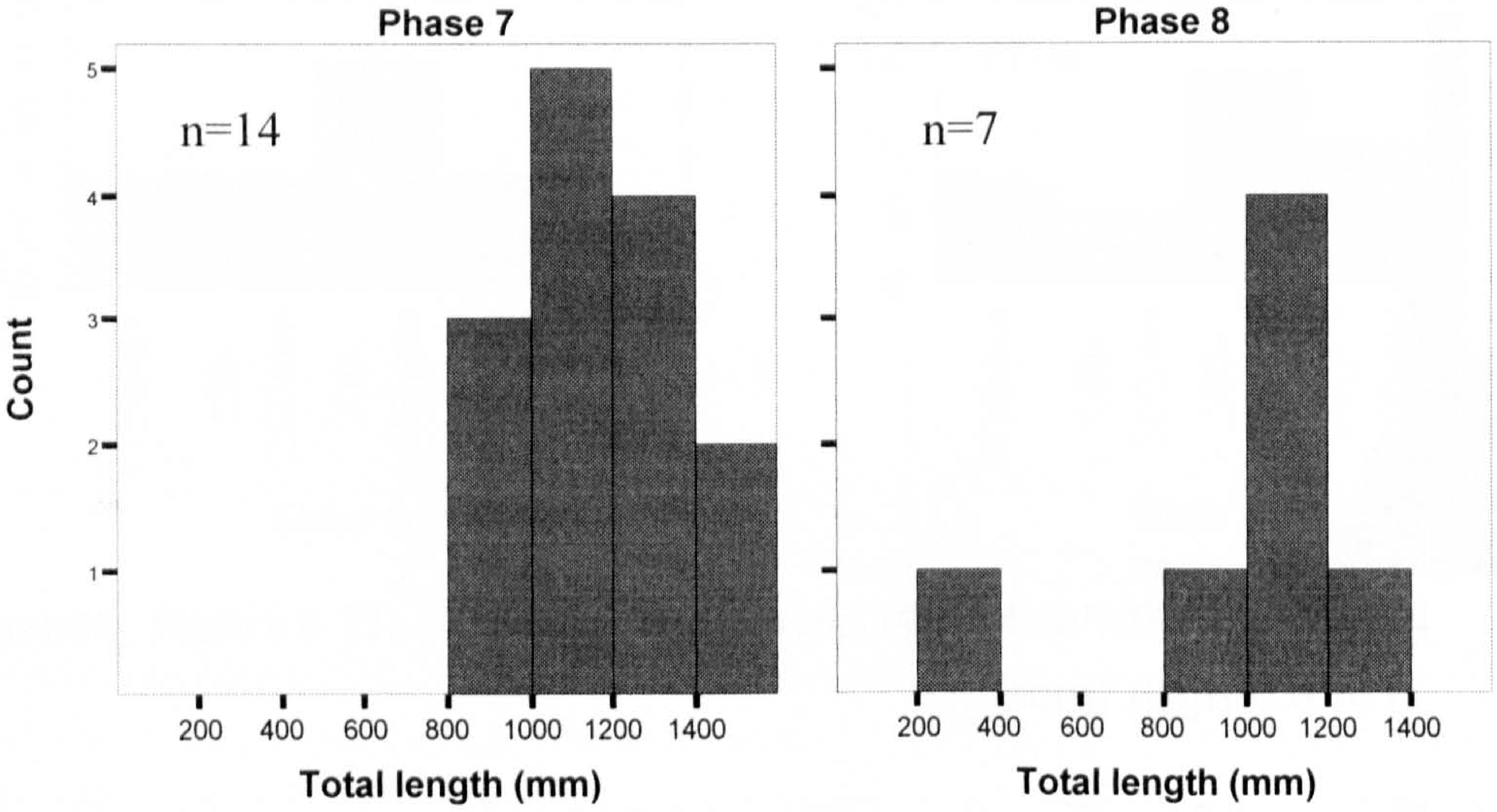
Appendix Figure 6.23: St. Boniface saithe sizes



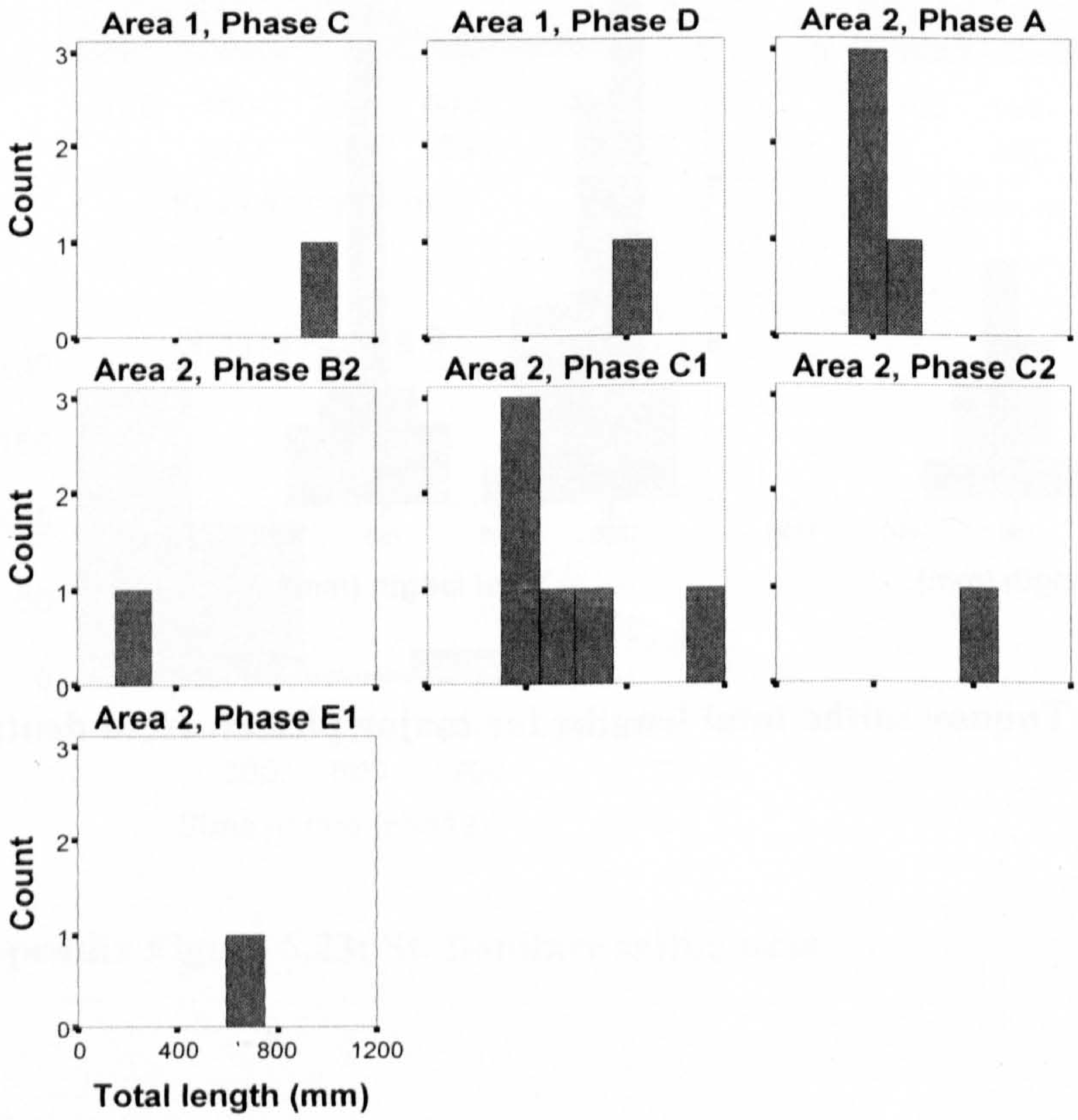
Appendix Figure 6.24: Tuquoy saithe total lengths, from otolith length measurements for entire site



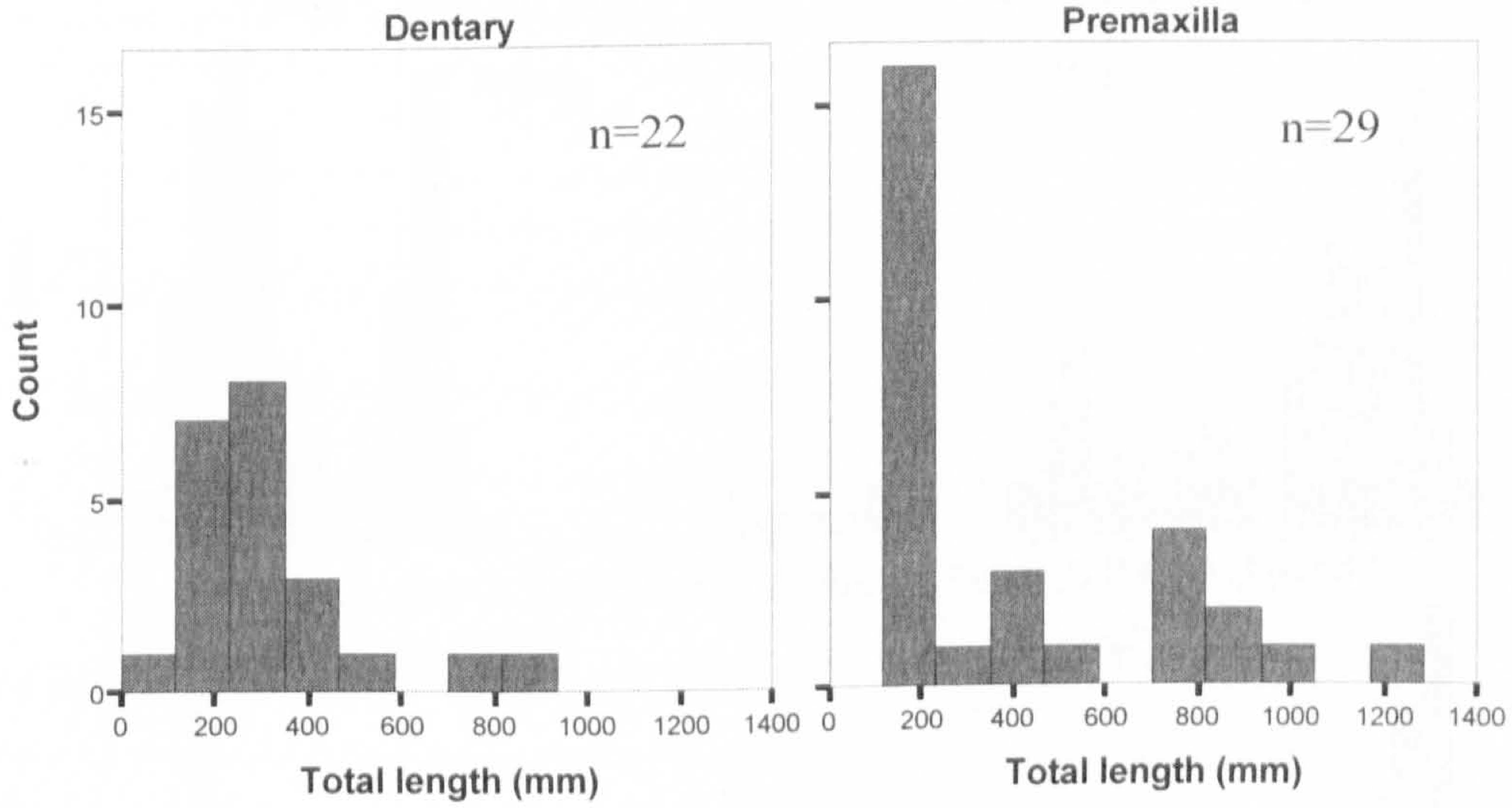
Appendix Figure 6.25: Tuquoy saithe total lengths for major phases, from dentary first measurements



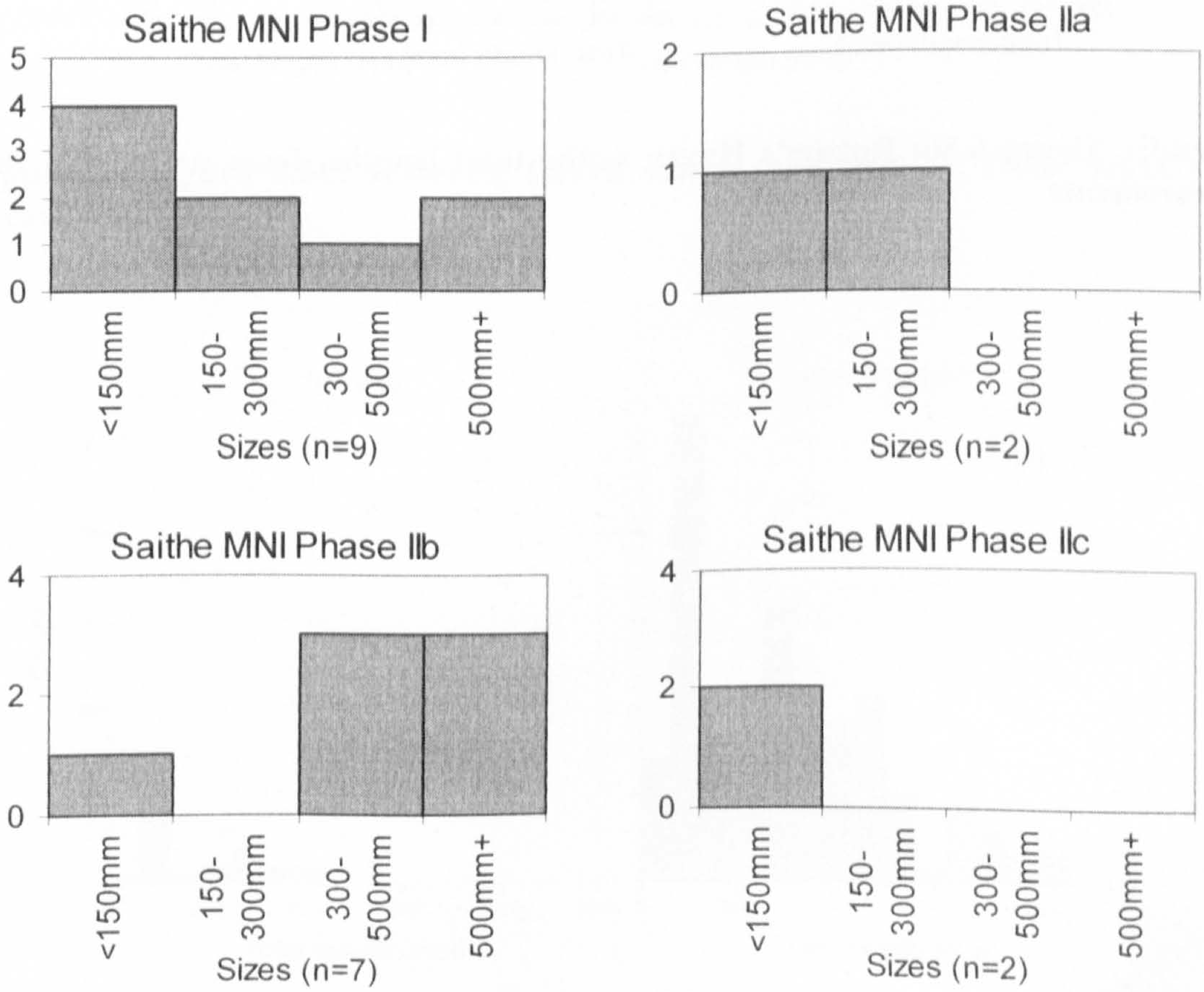
Appendix Figure 6.26: Pool saithe total lengths, from premaxillae first measurements



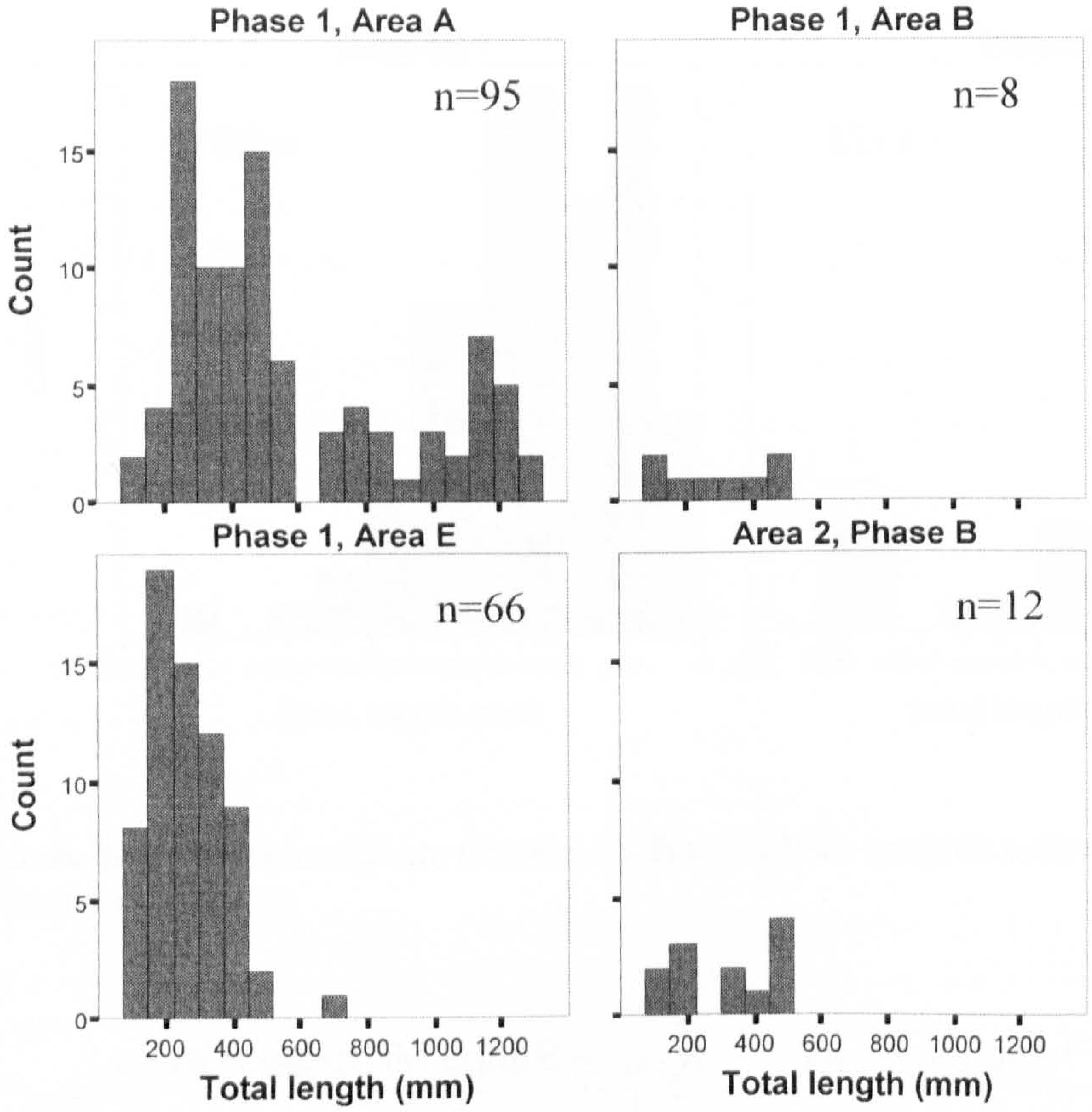
Appendix Figure 6.27: Brough Road saithe total lengths, from premaxilla, dentary and otolith measurements



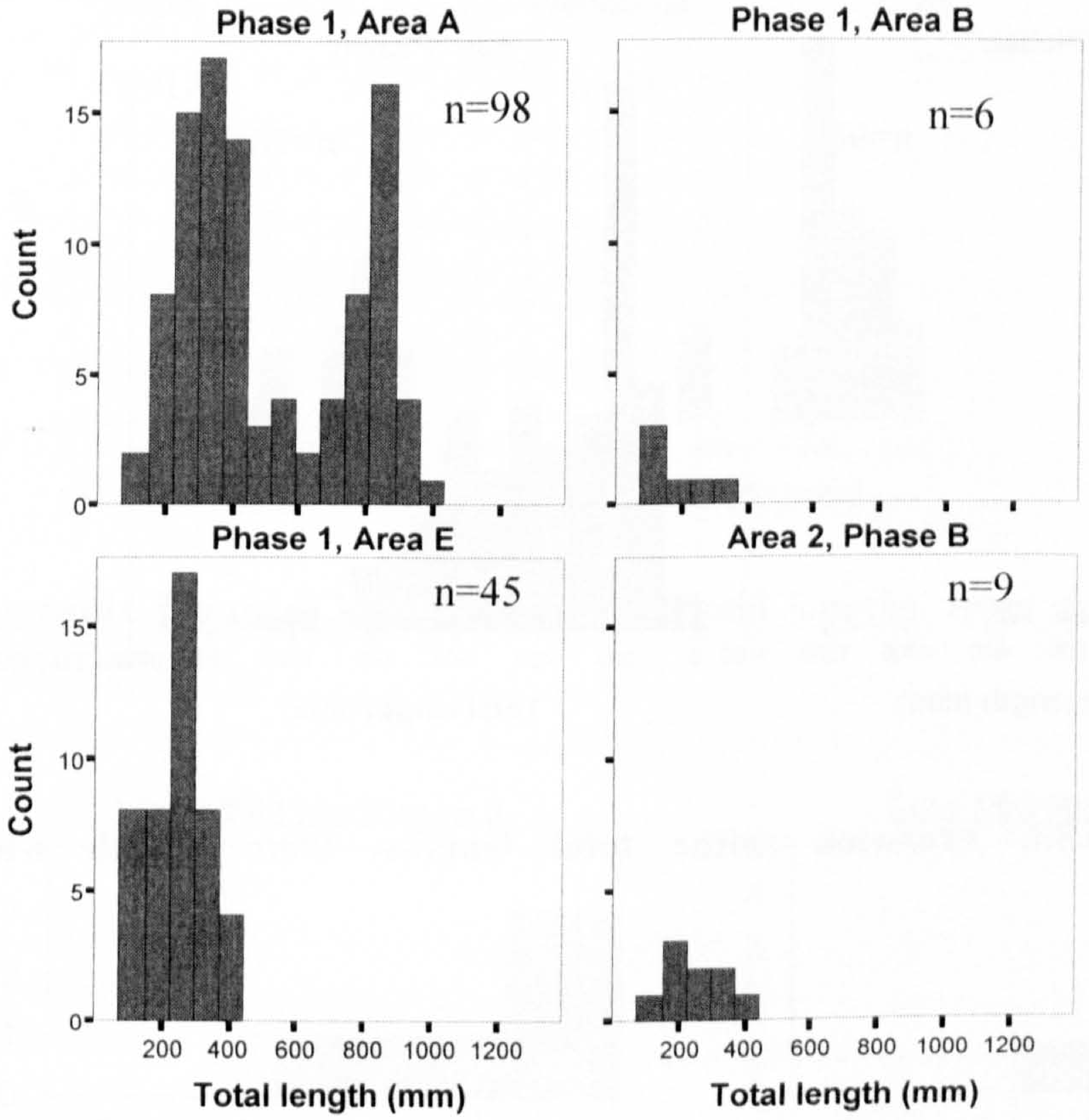
Appendix Figure 6.28: Beachview saithe total lengths, from premaxilla and dentary measurements



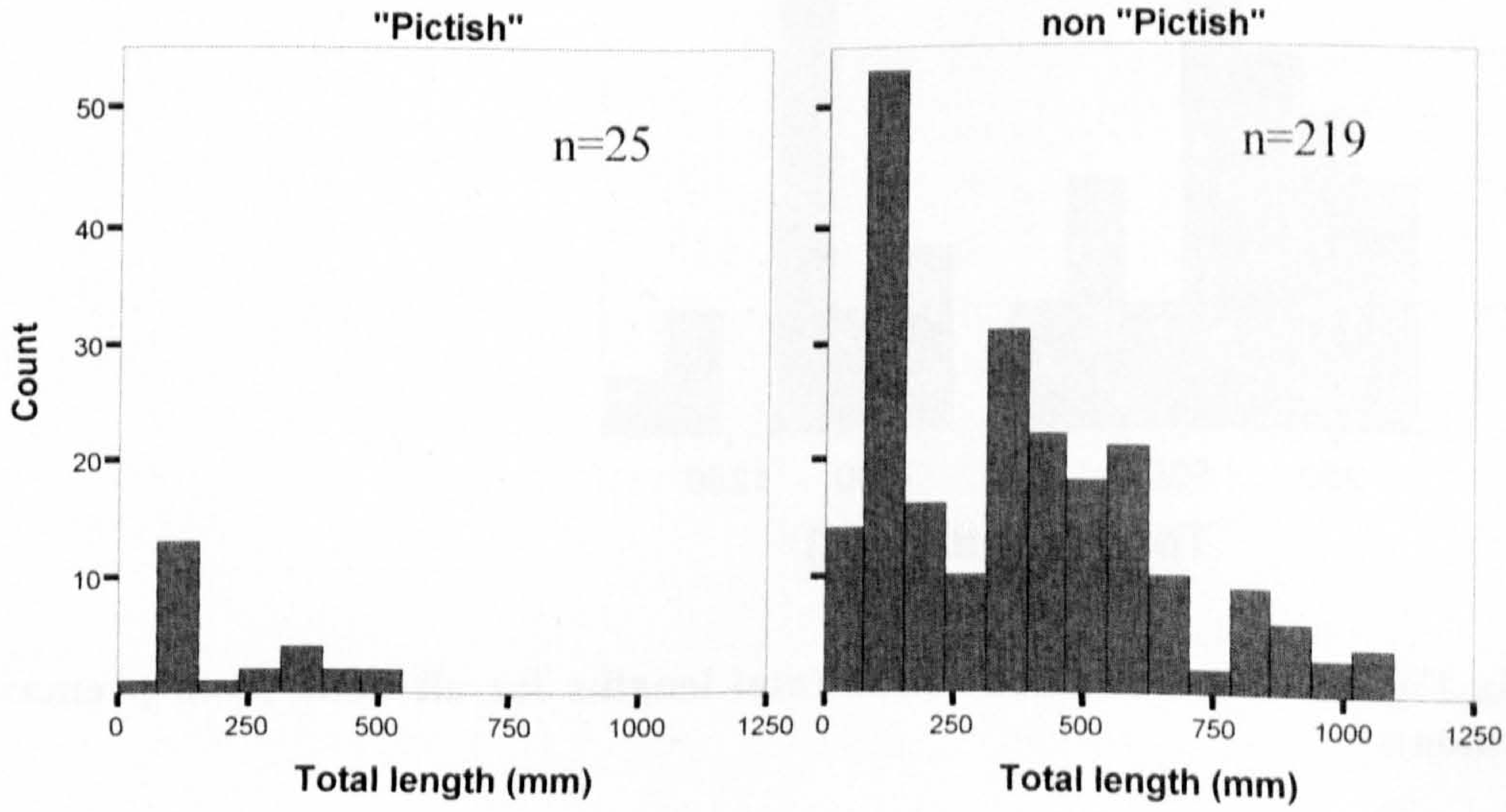
Appendix Figure 6.29: Saevar Howe saithe sizes (based on MNI not NISP)



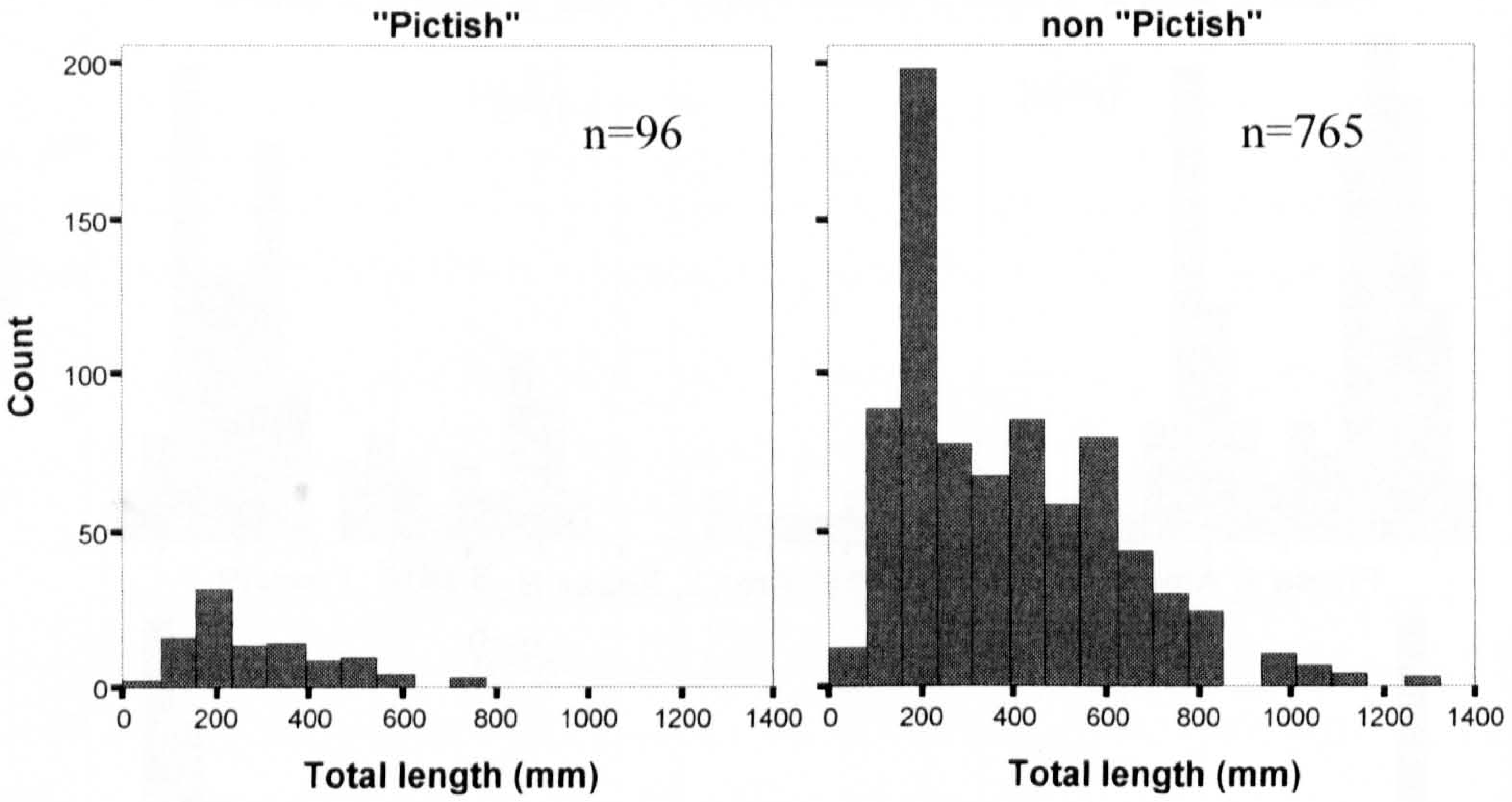
Appendix Figure 6.30: Robert's Haven saithe total lengths, from premaxilla first measurements



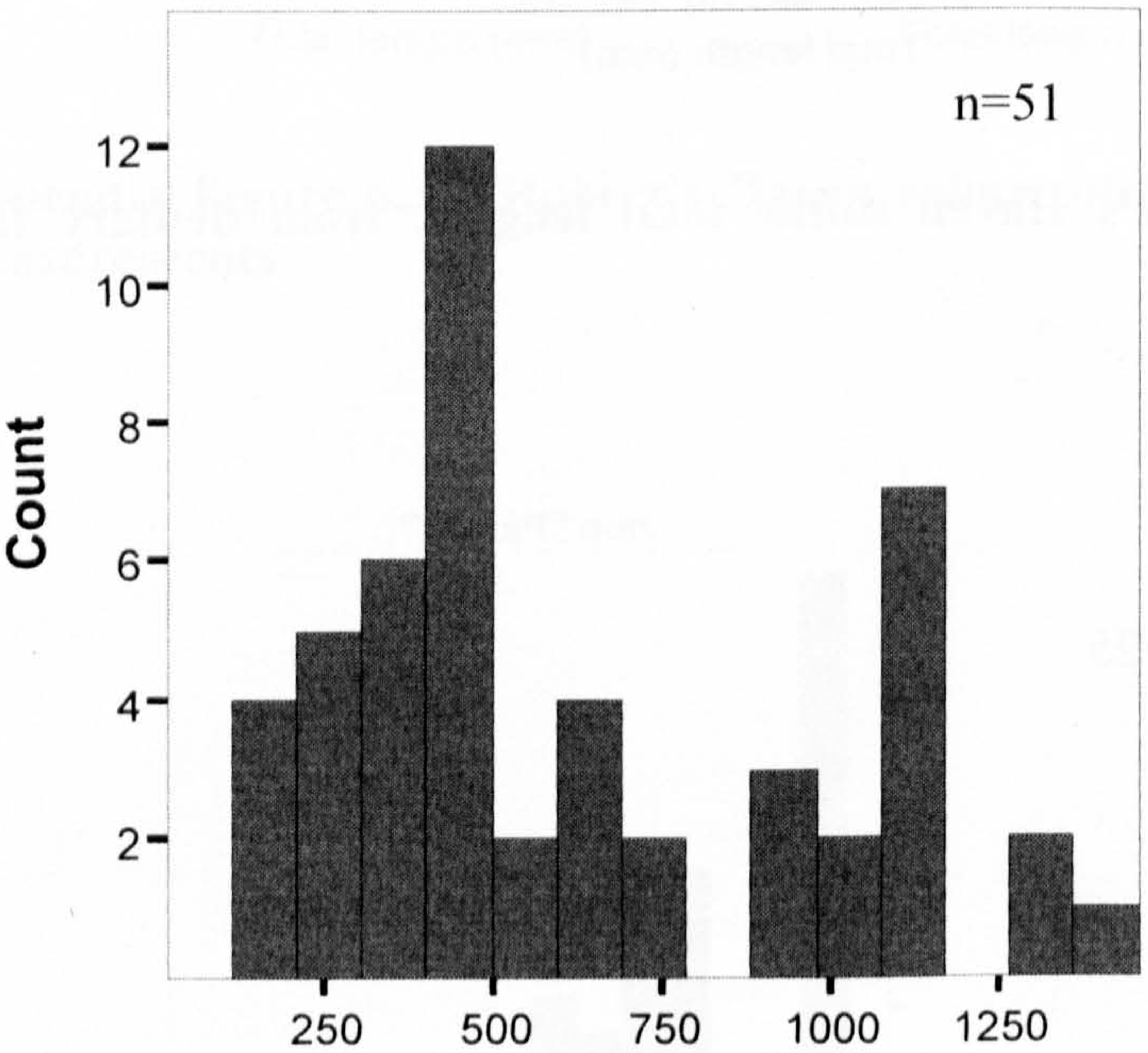
Appendix Figure 6.31: Robert's Haven saithe total lengths, from dentary first measurements



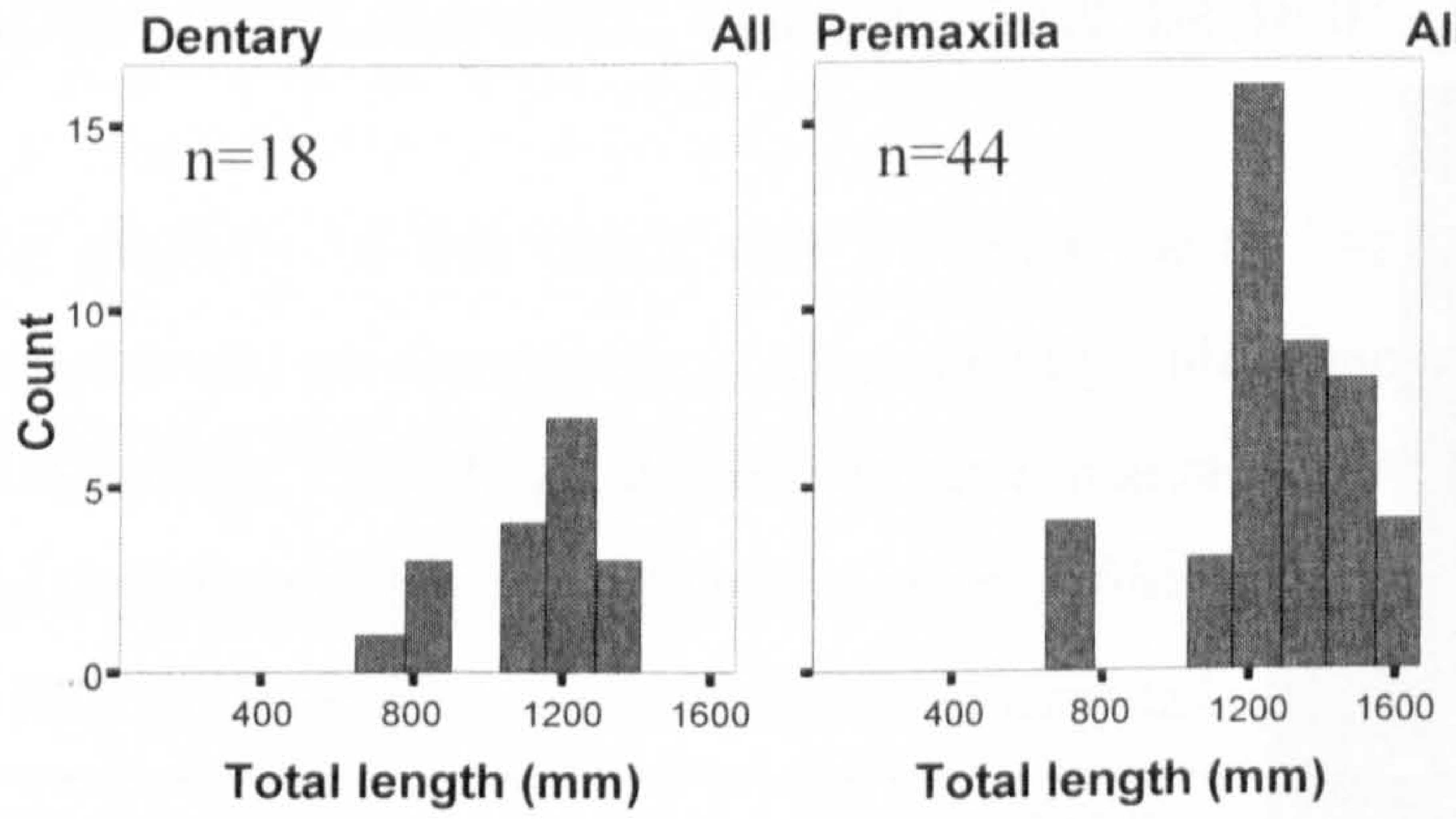
Appendix Figure 6.32: Freswick saithe total lengths, from otolith length measurements



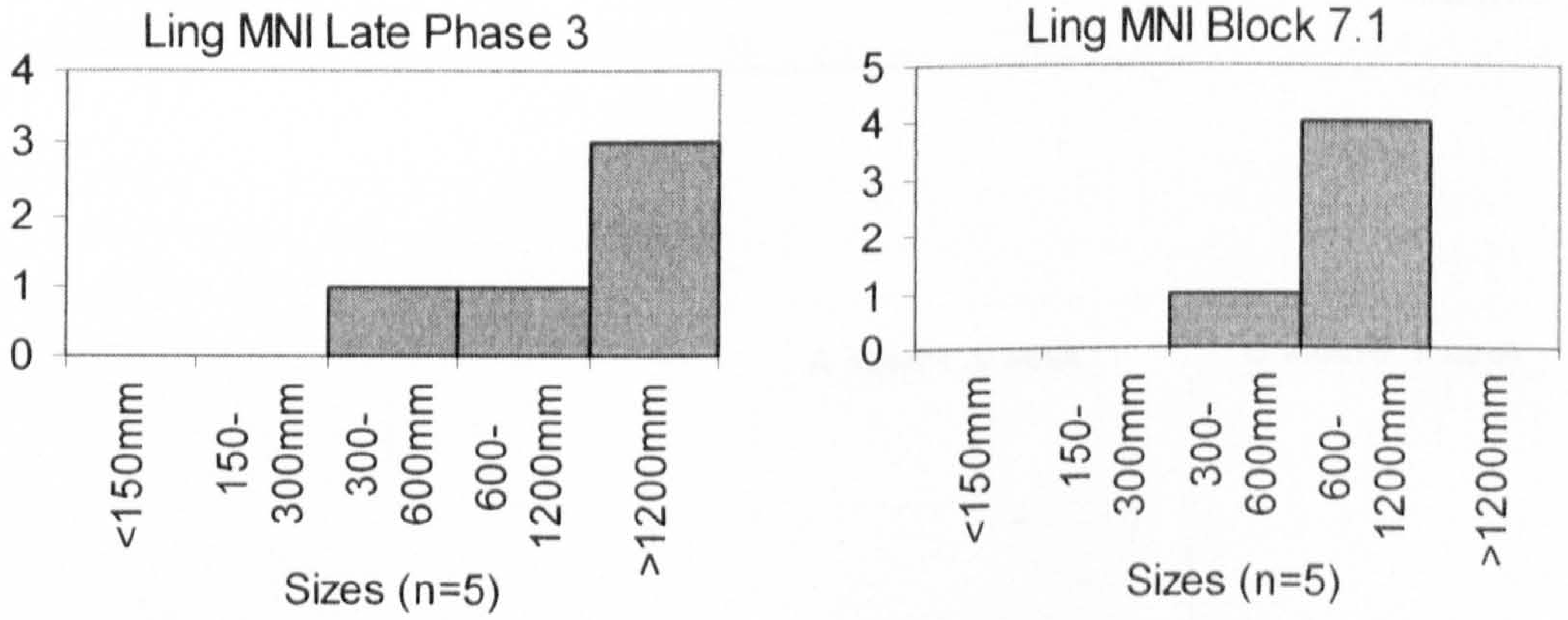
Appendix Figure 6.33: Freswick saithe total lengths, from otolith width measurements



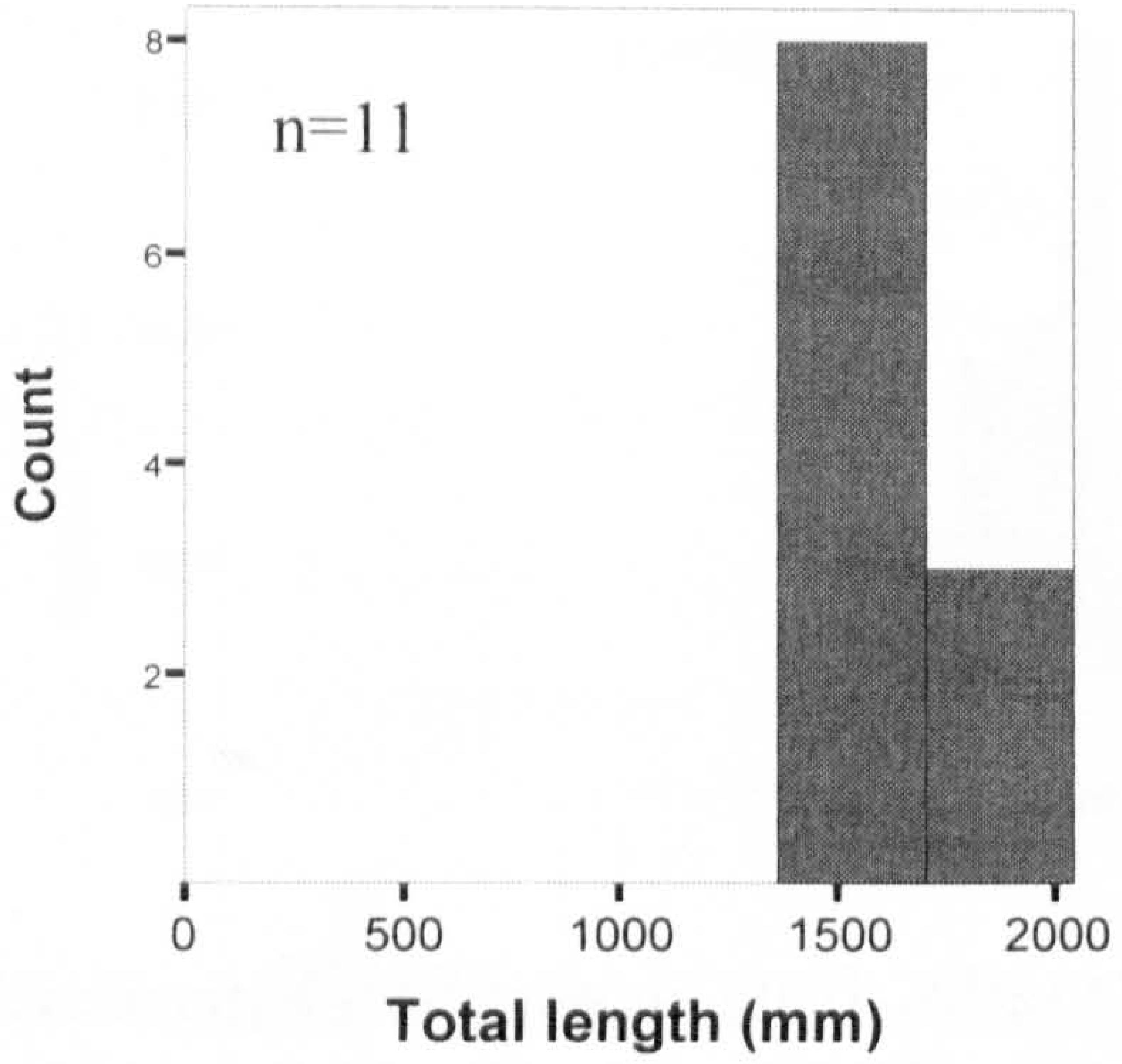
Appendix Figure 6.34: Freswick saithe total lengths for all data, from premaxilla measurements



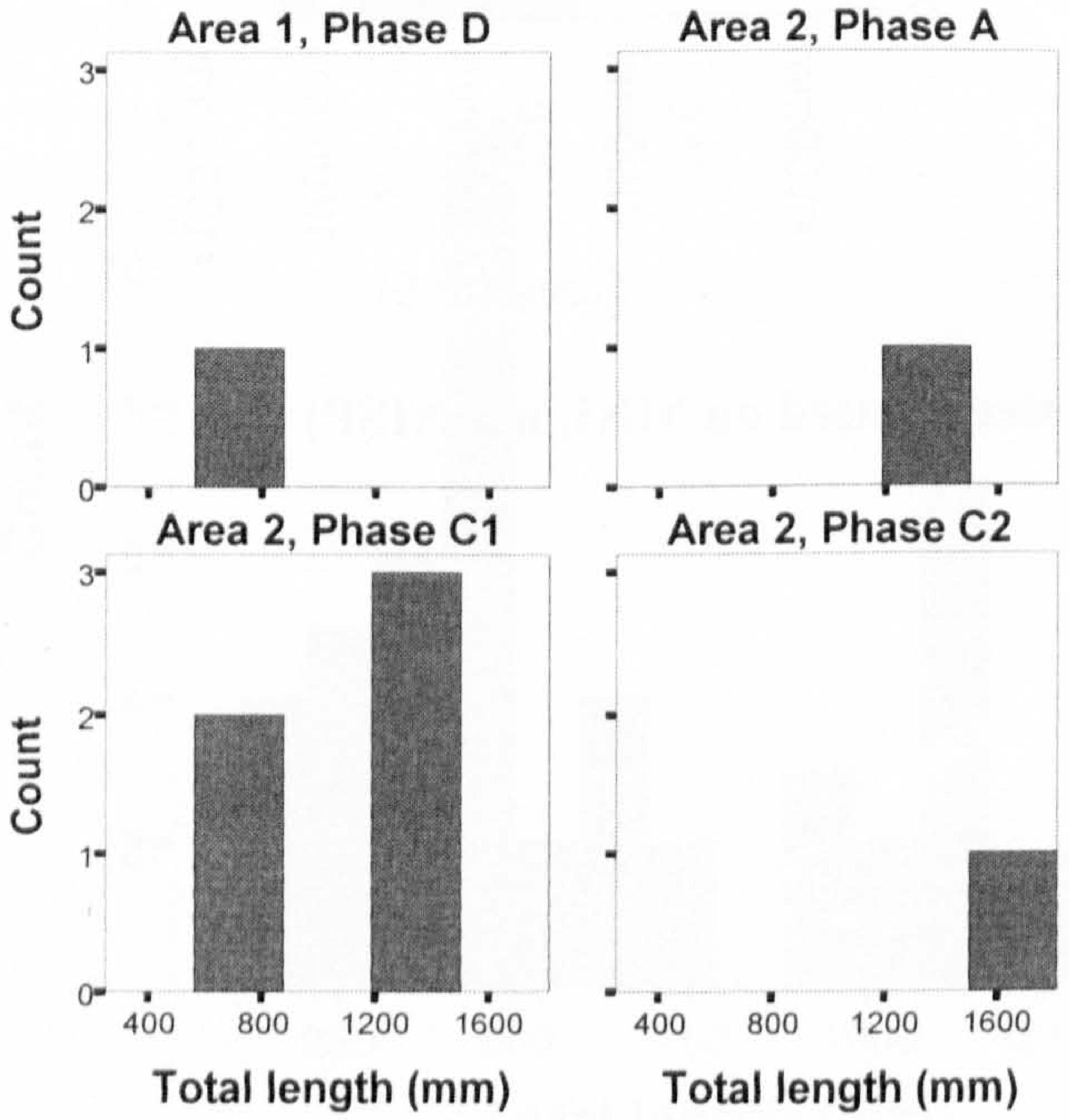
Appendix Figure 6.35: Sandwick ling total lengths, from dentary and premaxilla measurements



Appendix Figure 6.36: Scalloway ling sizes (based on MNI, not NISP)



Appendix Figure 6.37: Pool ling total lengths, all data combined, from premaxilla measurements



Appendix Figure 6.38: Brough Road ling total lengths, from premaxilla, dentary and otolith measurements

Appendix Seven: Quoygrew phasing concordance

The majority of this thesis was written prior to final phasing becoming available for excavations at Quoygrew. Consquently, all chapters refer to the interim phase terminology. The final phasing became available towards the completion of this work, and therefore rather than changing every reference, the following table has been provided to link the interim phases with the final terminology:

Area	Interim phase	Final phase
Fish midden, coastal column A	1	0
	2	2-3
	7	7
Farm mound, area G	i	1.1
	ii	1.2
	iii	2-3

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