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The early history of seals in the northern Baltic

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All available data, both from geological stray finds and archaeological refuse faunas, of the early occurrence of seals in the northern Baltic were summarized. Ten subfossil seals found in different parts of the Finnish coast were radiocarbon dated. The ringed seal (*Phoca hispida*), a resident species in the area, colonized the Baltic at 9500 BP, at the latest. The harp seal (*Phoca groenlandica*), which currently does not inhabit the Baltic, was part of the northern Baltic fauna from 5900 BP to 2800 BP, at least. Based on both geological and archaeological bone finds the harp seal was during this time common even in the northernmost parts of the Gulf of Bothnia, whereas the grey seal (*Halichoerus grypus*), today a common species in the area, seems to have been extremely rare in the whole northern Baltic. Identification of seals to species level is — to some extent — possible even from burnt and highly fragmented bone material found at prehistoric dwelling sites in Finland.

Introduction

Today, there are two resident seal species in the northern parts of the Baltic Sea, the ringed seal (*Phoca hispida*), and the grey seal (*Halichoerus grypus*). During prehistory, the harp seal (*Phoca groenlandica*) was also part of the northern Baltic fauna, either as a breeding population or as migrating herds. Another species, the common seal (*Phoca vitulina*), lives today in the southern parts of the Baltic, but its distribution may have fluctuated northwards during earlier Baltic stages.

A summary of the faunal history of seals in the Baltic area has been given by Lepiksaar (1986). Seals and seal hunting in Latvia and Lithuania have been discussed by Zagorska (2000) and Daugnora (2000), respectively. An extensive study on seals in central and southern Baltic and especially their occurrence along the Estonian coast has been done by Lõugas (1997a). Danish finds have been discussed by Aaris-Sørensen (1989), and Swedish finds by Liljegren and Lagerås (1993), and Lindqvist and Possnert (1997).

The history of seals in the northernmost

Fig. 1. The Baltic Sea.

parts of the Baltic has previously been discussed by Ekman and Iregren (1984) on the basis of Swedish finds, and on the basis of Finnish finds by Korvenkontio (1936), Sauramo (1937), Salmi (1944, 1948, 1949, 1963), Alhonen and Forstén (1976), Forstén (1979), Forstén and Alhonen (1975, 1977), Ukkonen (1993) and Ylimaunu (2000). Ericson (1989) has discussed the distribution of different seal species in the Baltic from an archaeological point of view. Recently, an extensive archaeo-osteological study on seals and seal hunting in the Åland archipelago was published by Storå (2001).

Since the aforementioned reviews, a wealth of new information has accumulated both about the dates of the subfossil stray finds and about the archaeological bone finds, known as refuse faunas, in Finland. In this paper, I summarize the Finnish (exclusive Åland) subfossil seal finds, both geological and archaeological, and discuss the history of the different species in the northern parts of the Baltic on the basis of radiocarbon dates and isotope studies of the finds. For the first time, an attempt is made to systematically identify selected skeletal elements of the archaeological seal material to species level. The results are discussed in the light of the Baltic history and the ecology of the different seal species.

The history of the Baltic Sea and the immigration routes of seals

The deglaciation of the Scandinavian Ice Sheet led to the formation of the Baltic Ice Lake during the Late Weichselian (Eronen 1983, Björck 1995; Figs. 1 and 2). The basin was initially not connected to the Arctic Sea or the North Sea, and the only possible immigration routes for seals would at that time have been either through the outlet in Öresund (Lindqvist & Possnert 1997), or, theoretically, through ice-dammed lakes and rivers along the ice border from the White Sea.

Around 10 300 BP a direct connection to the ocean was opened through central Sweden. This led to a drop in the water level of the Baltic basin, marking the beginning of the Yoldia stage. The channel was still a relatively narrow one, with only a short termed saline water flow to the Baltic basin around 10 000 BP (Björck 1995). However, it most probably offered an immigration passage for seals into the Baltic.

The connection between the Baltic basin and the ocean was cut again about 9500 BP, following the glacio-isostatic land uplift, and the Baltic entered the Ancylus Lake stage (Eronen & Haila 1982, Björck 1995). The water still covered the main part of southern and central Finland.

Around 8200 BP, at the latest, the eustatic rise of ocean level led to the opening of a new connection to the ocean through the Danish straits. Fully brackish conditions were not established in the basin until after the so called Mastogloia stage (*see* discussion in Hyvärinen 2000), around 7500 BP (Eronen 1983), and the Baltic entered its Litorina stage. At the beginning of this stage the straits were broader than today and the salinity of the basin was higher, ca. 10‰ in the southern, and ca. 8‰ in the northern parts of the Gulf of Bothnia, in contrast to the present ca. 6‰ and 2‰, respectively (*see* Segerstråle 1957). This time period would have offered the best opportunity for pelagic seals like the harp seal and the grey seal to enter the Baltic basin.

Lakes

Two lakes in the area are inhabited by the ringed seal: Lake Ladoga in northwestern Russia, and

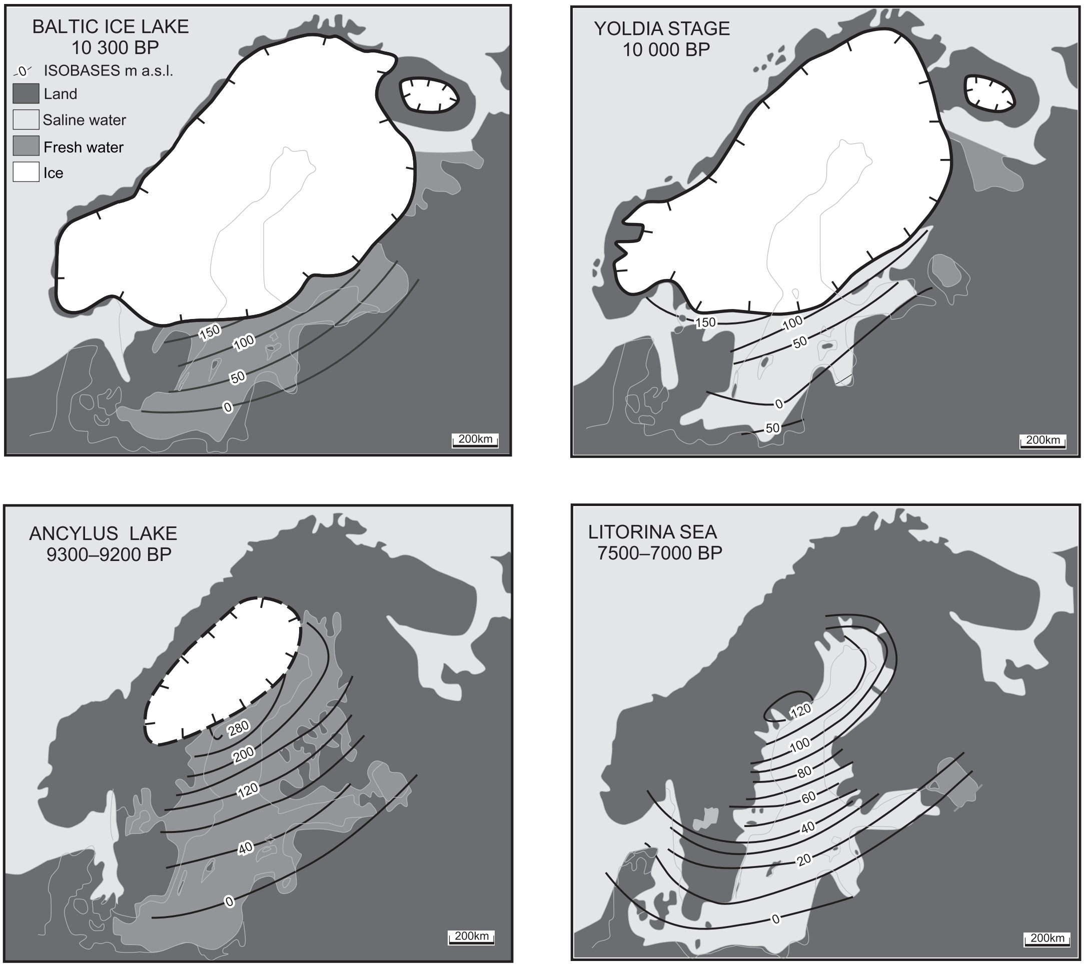

Fig. 2. The Deglaciation of Fennoscandia. Reprinted from *Rates of Holocene isostatic uplift and relative sea-level lowering of the Baltic in SW Finland based on studies of isolation contacts* by Eronen *et al.* from Boreas, www.tandf.no/boreas. 2001, 30, p. 18, by permission of Taylor & Francis AS.

Lake Saimaa in southeastern Finland. According to latest research (Saarnisto *et al*. 1999) it is not clear whether Lake Ladoga became isolated from the Baltic basin at all before the Ancylus stage. During the Yoldia stage a broad connection existed between the lake and the Baltic. This connection may have continued to exist until and during the Ancylus transgression ca. 9600 BP (Saarnisto *et al*. 1999). Consequently, seals may have entered Lake Ladoga and re-entered the Baltic basin at any time during this period, and even later during the Litorina stage.

Southern parts of Lake Saimaa were covered by the Baltic Ice Lake and isolated either directly from it, or after a short connection with Yoldia (Saarnisto 1970). The ringed seal may have entered the area during this interval. Later, during the Ancylus Lake stage, northwestern parts of the current Saimaa lake complex were part of the Baltic basin, which would have enabled the immigration of seals into Saimaa from the west, the present Gulf of Bothnia. The large Finnish lake basins became isolated from the Baltic around 9000–8000 BP (Saarnisto 1970), owing to the continuing land uplift. The uneven uplift led to inclination of the land, which caused merging of lakes and the formation of large water bodies, such as Lake Päijänne and Ancient

Lake Saimaa, including the previously isolated lakes of southeastern Finland. The ringed seal, which is able to even swim up rivers, could theoretically have immigrated to Lake Saimaa as long as an indirect connection to the Baltic existed through lakes Päijänne and Pielavesi.

The ecology of the different seal species

The ringed seal is primarily an arctic species with a circumpolar distribution (Helle 1983, Novak 1991). The nearest populations outside the Baltic and the lakes Saimaa and Ladoga can be found in the Barents Sea and the White Sea. The ringed seal lives in areas of fast ice and maintains breathing holes open through the winter. Its breeding season is currently in March–April and the pups are born in lairs. The species is solitary and fairly stationary. The ringed seals live not only in open waters, but also near the coast and in shallow bays, and they can even swim up rivers.

The harp seal is currently not found in the Baltic. It has presently three breeding regions: off Newfoundland, off Jan Mayen and in the White Sea (Lavigne & Kovacs 1988, Novak 1991), which is the nearest breeding area to the Baltic Sea. The harp seal is pelagic and depends on pack ice. The pups are born in February–March among hummocks of ice on floe. The harp seal is gregarious and highly migratory.

The Baltic grey seals breed generally in February–March on the ice (Helle 1983, Novak 1991), during mild winters also on land. This differs from the breeding habits of the other grey seal populations in the North Sea and in the North Atlantic. This pelagic species cannot maintain breathing holes and lives outside the fast ice. The grey seal is gregarious. No regular migratory movements are known.

The different ecology and behaviour of the three seal species have affected their distributions in the Baltic at different times. The most important limiting factor may have been the ice conditions during the Holocene, but their reconstruction is difficult. The freezing over of the Baltic basin is a complex process, depending on winter temperatures, sea currents, the salinity of the basin, and even prevailing winds. The understanding of the faunal history of the seals would greatly benefit from a reliable model of ancient ice conditions.

The behaviour of the various species has certainly had a major influence on the hunting strategies of prehistoric people, which again affect the archaeological data used in this study (e.g. Forstén & Alhonen 1975, 1977, Ylimaunu 2000). In spite of this, hunting and seal utilization will not be discussed further in this paper.

Material and methods

Subfossil seal finds

The study area comprises the Finnish coasts of the Gulf of Bothnia (Fig. 1) and the Gulf of Finland, as well as the Finnish inland. The Åland archipelago was not included in the study, but the finds are discussed below on the basis of the available literature. The subfossil seal finds consist of two data sources: stray finds found in geological contexts, and bones from refuse faunas found at prehistoric sites.

The geological stray finds are listed in Table 1. More detailed descriptions of the finds can be found in the papers referred to in the table. A summary of Finnish seal finds has previously been given by Forstén and Alhonen (1975, 1977).

Archaeological sites with seal finds are listed in Appendix 1. The majority of the osteological analyses of these refuse faunas are unpublished, but the original lists can be found in the archives of the Finnish National Museum in Helsinki. The present study included 222 refuse faunas with seal bones, representing ca. 155 archaeological sites along the Finnish coast and in the inland (Appendix 1). They constitute over 25% of all analysed refuse faunas in Finland. The number of fragments identified as seals amounts to over 14 000.

The two datasets are treated separately because of the different taphonomic history of the finds. The division is, however, not clear-cut. Some of the geological finds, for instance the harp seal find from Närpiö (NM 10087:2, *see* Table 1), have been found together with harpoons or show other signs of human hunting. Generally, the subfossil stray finds derive from seals that have died at or near the locality where their remains have been found. The possible drifting of the carcasses after death may have caused some displacement, but is here considered insignificant. All the archaeological finds, on the other hand, derive from animals hunted by prehistoric people, and the location where they lived and died can not be exactly determined. The majority of the archaeological sites where seal bones have been recovered lie on ancient shores or islands, which makes it probable that the animals were caught in the vicinity of the site. The possibility of longer hunting trips has to be considered mainly as regards dwelling sites located in the inland, far away from the respective ancient shorelines. Here, also the existence of lake populations must be taken into account.

Identification of burnt bones

Seal bones have very characteristic shapes and structures, and are relatively easy to identify also among the burned, fragmented bone material found at Finnish archaeological sites (more about taphonomy, *see* Ukkonen 1996). It is, however, very difficult to distinguish the different seal species. The problem is that the shapes of the articular surfaces, on which the analysis of burnt bone fragments is mainly based, are not diagnostic for the different seal species. The individual and size-dependent morphological variation is greater than are the interspecific differences. Diagnostic features can be seen mainly in the shapes of the long bones, skull, and teeth. Since these parts of the skeleton are not found whole and intact in the Finnish bone

Table 1. Subfossil stray finds of seals found on the Finnish coast. ZM = Finnish Museum of Natural History in Helsinki, NM = National Museum of Finland in Helsinki, Laihia = secondary school in Laihia, NOM = The Northern Ostrobothnia Museum in Oulu, SM = Satakunta Museum in Pori.

Locality	Museum	Reference
Phoca groenlandica		
1. Alatornio, Liekanjoki	ZM 6951	Forstén & Alhonen 1977
2. Pietarsaari, Sundby	ZM 6970	Salmi 1963
3. Vaasa, Roparnäs	ZM 6971	Forstén & Alhonen 1975
4. Laihia, Potila	Laihia	Salmi 1963
5. Laihia, Ruto	ZM 6973	Forstén & Alhonen 1975
6. Närpiö	NM 10087:2	Korvenkontio 1936, Sauramo 1936
7. Närpiö, Pjelax	ZM 6966	Salmi 1963
8. Pori	–	Forstén & Alhonen 1975
9. Espoo or Kirkkonummi	ZM 6952	Forstén & Alhonen 1977
Phoca hispida		
10. Kuivaniemi, Vakkurink.	NOM	Forstén & Alhonen 1975
11. Oulujoki	ZM 6980	Korvenkontio 1936, Sauramo 1936
12. Muhos, Honkalankylä	ZM 6965	Forstén & Alhonen 1975
13. Ruukki	ZM 6977	Salmi 1944
14. Oulainen, Tiitjärvi	ZM 6957	Forstén & Alhonen 1977
15. Ähtävä, Yliähtävä	ZM 6945	Forstén & Alhonen 1975
16. Kovjoki (Uusikarlepyy)	ZM 6974	Forstén & Alhonen 1975
17. Vähäkyrö, Rekilänkylä	ZM 6963	Salmi 1948
18. Lapua, Tiistejoki	ZM 6953	Forstén & Alhonen 1977
19. Ylistaro, Kaukolankylä	ZM 6976	Salmi 1949
20. Ylistaro, Rintamattila	ZM 6972	Forstén & Alhonen 1975
21. Nurmo, It. Kimpimäki	ZM 6978	Forstén & Alhonen 1975
22. Ilmajoki Palonkylä	ZM 6968	Forstén & Alhonen 1975
23. Ulvila, Harjunpää	SM16.400	Forstén & Alhonen 1975
Halichoerus grypus		
24. Teuva	ZM 6942	Forstén 1979

material, most of the archaeological seal finds presented in this paper have not been identified to species.

To establish the feasibility of reliable species identification even of burnt and fragmented seal bones, a specific analysis of the archaeological bone material was carried out. The study was based on a few characteristics of the skull (*meatus acusticus externus*, *crista temporalis*), the mandible (*alveola*) and particular bones (*humerus*, proximal end) described by Lepiksaar (1991). These elements were chosen of all diagnostic features described by Lepiksaar (1991) and by Storå (2001) since the parts are found intact and in relatively large numbers in the Finnish burnt and fragmented material. The harp seal has a very characteristic thick and arched *meatus acusticus externus* (Appendix 2). The ringed seal, the harbour seal and the grey seal all have a flat *meatus acusticus externus*, but the latter can be separated from the others by a blunt *crista temporalis*, as well as by the size of the skull. The tooth sockets (*alveola*) are very similar in the harp and ringed seal, but in the harbour seal the sockets form a zigzag pattern, and in the grey seal the sockets are single instead of double. The proximal end of the *humerus* of the harp seal is different from that of the ringed seal in having a broad plateau between the *sulcus intertubercularis* and *caput humeri*.

All available lists of osteological analysis of prehistoric sites in Finland containing seal bones were checked for diagnostic anatomical parts. Species identifications mentioned in the original analyses were ignored, and all fragments were initially treated as Phocidae. Altogether one unburnt and 104 burnt bone samples, representing 64 archaeological sites, were chosen for a separate study. Of these samples the chosen diagnostic elements were re-analysed in order to identify the fragments to species level. Collections of the Zoological Museum of the Finnish Museum of Natural History in Helsinki were used as reference material. The prehistoric bone materials are stored at the National Board of Antiquities in Helsinki. Samples in other museum and university collections could not be

Table 2. Subfossil seal finds from the Finnish coast with radiocarbon dates and/or δ ^{13}C values. Assumed dates from the literature (*see* Table 1). The possible reservoir effect has not been evaluated. The numbers refer to Table 1 and Fig. 4.

Locality	Sample	Assumed date	Lab.nr.	AMS-date	δ ^{13}C
Phoca groenlandica					
6. Närpiö	phalanx	Litorina	Hela-441	5890 ± 70	–16.85
9. Espoo or Kirkkonummi	phalanx	Litorina	Hela-433	5290 ± 175	–16.41
1. Alatornio, Liekajoki	fibula	Litorina	Hela-432	4810 ± 70	–16.26
3. Vaasa, Roparnäs	cranium	Litorina	Hela-438	2995 ± 70	–16.90
2. Pietarsaari, Sundby	radius	subboreal	Hela-437	2800 ± 65	–16.50
7. Närpiö, Pjelax	radius	subboreal	–	–	–15.87
5. Laihia, Ruto	radius	subboreal	–	–	–16.75
Phoca hispida					
21. Nurmo, It. Kimpimäki	radius	Ancylus	Hela-440	9505 ± 85	–19.77
20. Ylistaro, Rintamattila	radius	Ancylus	Hela-439	8495 ± 80	–19.72
16. Kovjoki (Uusikaarlepyy)	fibula	Yoldia/Ancylus	Hela-434	8270 ± 80	–19.12
15. Ähtävä, Yliähtävä	radius	Ancylus	Hela-435	8195 ± 135	–19.25
22. Ilmajoki Palonkylä	costa	Ancylus	–	–	–19.65
18. Lapua, Tiistejoki	femur	Ancylus	–	–	–19.85
13. Ruukki	costa	Ancylus	–	–	–18.39
12. Muhos, Honkalankylä	cranium	Litorina	Hela-436	5115 ± 75	–15.93
19. Ylistaro, Kaukolankylä	radius	Litorina	–	–	–16.57
14. Oulainen, Tiitjärvi	fibula	Litorina	–	–	–19.79
11. Oulujoki	pelvis	Litorina	–	–	–18.36
17. Vähäkyrö, Rekilänkylä	radius	Litorina	–	–	–18.00

included in this separate study.

It should be emphasized that the method used reveals only the presence of certain species in different bone collections, and does by no means exclude the possibility of the presence of other species in the areas from which those collections derive.

Dating and isotope analyses

Of the 24 reported subfossil seal remains found in marine and fresh water sediments in western and southern Finland 10 samples of harp and ringed seal, five of each, were chosen for AMS radiocarbon analysis (Table 2). All samples were prepared in the Dating Laboratory of the University of Helsinki in Finland. Bone collagen was used for all datings. The collagen extraction method used was modified from the combined technique described by Berglund *et al.* (1976). The possible reservoir effect, where the old water in a basin effects radiocarbon ages of the organisms (Lindqvist & Possnert 1997) has not been considered in the interpretation of the results.

Stable carbon isotope analysis was made for all radiocarbon dated samples. The δ^{13}C values reflect the diet of the animals and indirectly the salinity of the environment where they have lived (Lindqvist & Possnert 1997). In addition, samples were taken from seven undated ringed seal and two harp seal bone samples. The analyses of these samples were made on collagen. The extraction method applied was the same as that used for radiocarbon dating, except that the transformation to gelatine was omitted, since a test showed that the δ^{13}C values (the relative ratio between the stable isotopes ^{13}C and ^{12}C) for gelatine and collagen were comparable (E. Sonninen, pers. comm.).

The burnt bone fragments in the archaeological material could not be radiocarbon dated, since there is no collagen left in the bones (but *see* Lanting *et al.* 2001). All radiocarbon dates of archaeological finds mentioned in this paper (BP; uncalibrated) are based on radiocarbon dates of charcoal, unburnt wood, and organic crusts on ceramics recovered from the immediate vicinity of the bone finds. The remaining dates derive from the archaeological dating of the sites in question and are based on artefact typology (Fig. 3) and shore displacement. Most of the

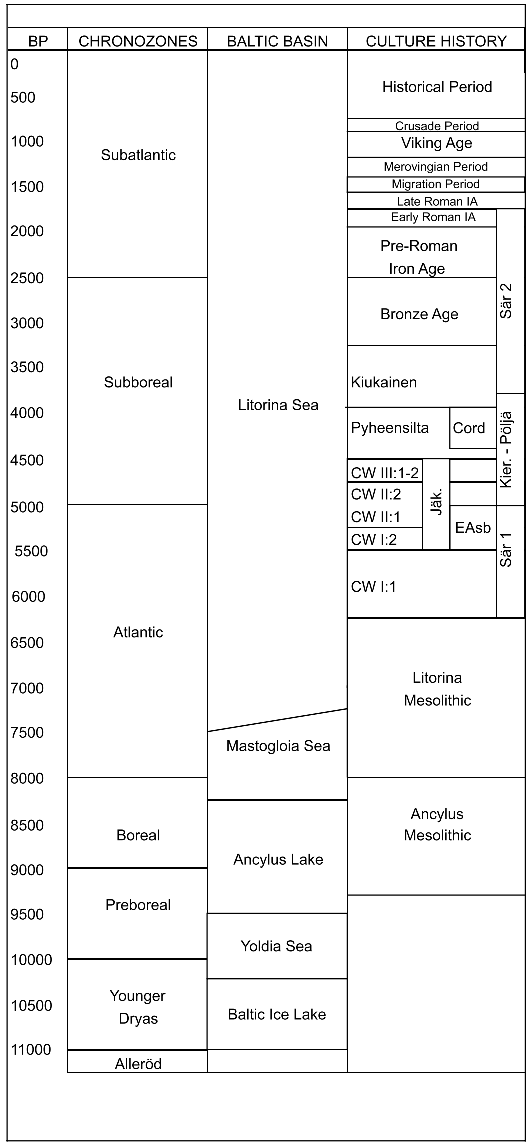

Fig. 3. General chronological framework for the Holocene in southern and central Finland. Time scale in radiocarbon years BP. Various sources (modified after Rankama & Ukkonen 2001). Key to culture historical phases: CW I = Early Comb Ware; CW II = Typical Comb Ware; CW III = Late Comb Ware; Jäk. = Jäkärlä Group; EAsb = Early Asbestos Ware; Sär 1 = Säräisniemi 1 Ware; Kier.-Pöljä = Kierikki – Pöljä Wares; Cord = Corded Ware; Sär 2 = Late Neolithic and Early Metal Period (Säräisniemi 2 Wares).

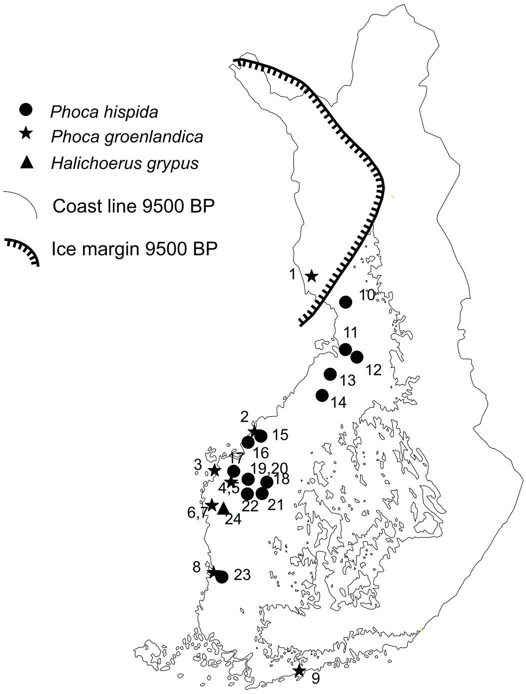

Fig. 4. Subfossil stray finds of seals from the Finnish coast. The numbers refer to Tables 1 and 2. Coastline: 9500 BP (after Eronen *et al.* 1995).

prehistoric sites have been occupied repeatedly or for longer periods (e.g. Rankama & Ukkonen 2001, cf. Huurre 1995). In coastal areas the settlement was typically of relatively short duration because of the retreating shoreline, but in the interior sites were often used for longer periods. This means that different cultural remains are found mixed, which makes it difficult to separate the different settlement stages and the bone remains tied with them.

Because of the continuous land uplift the coastline of Finland has changed through time. Sites located today in the interior of the country were earlier coastal dwelling sites. To find out whether the seals found in the refuse faunas were originally caught in the sea or in an inland lake, the archaeological finds must be examined in relation to time. This can be done with the help of distribution maps revealing the sites and the time-dependant coastlines, and comparing them with the information gained from the datable archaeological material from the sites themselves. Placing all seal finds in their proper cultural contexts would require an extensive archaeological study, and only some general remarks can be made here.

Results

Geological finds, their dates and isotope values

The subfossils were originally dated on the basis of diatom and pollen analyses of the surrounding sediment, and shore displacement (*see* references in Table 1). The radiocarbon dates correspond quite well with these assumed dates (Table 2 and Fig. 4). The earliest date for the presence of the ringed seal on the Finnish west coast is ca. 9500 BP, i.e. the very beginning of the Ancylus Lake stage of the Baltic Basin. The harp seal dates range from ca. 5900 BP to ca. 2800 BP, i.e. they belong to the Litorina stage.

The δ^{13}C values are well in accordance with the salinity of the Baltic stages suggested by the radiocarbon dates and/or other dating methods. Low values (δ^{13}C between –19.85 and –18.00) are interpreted here as indication of a fresh water environment, high values (δ^{13}C between –16.90 and –15.87) a marine or brackish water environment (*see* values for sea and terrestrial mammals given by Lindqvist and Possnert 1997).

The ringed seal samples from Muhos (δ^{13}C –15.93) and Ylistaro (δ^{13}C –16.57) show clear marine signals, all others indicate a fresh water environment. Three of the samples, Oulainen, Oulujoki and Vähäkyrö, were originally dated to the Litorina Stage of the Baltic, but gave signals related to fresh water conditions. All δ^{13}C values measured from harp seals were between –16.90 and –15.87 indicating marine environment with a relatively high salinity.

Refuse faunas

Species identification

A total of 54 ringed seal bone fragments were identified in 24 samples from 18 archaeological sites (Appendix 1). The number of identified harp seal bone fragments was 48 (28 samples,

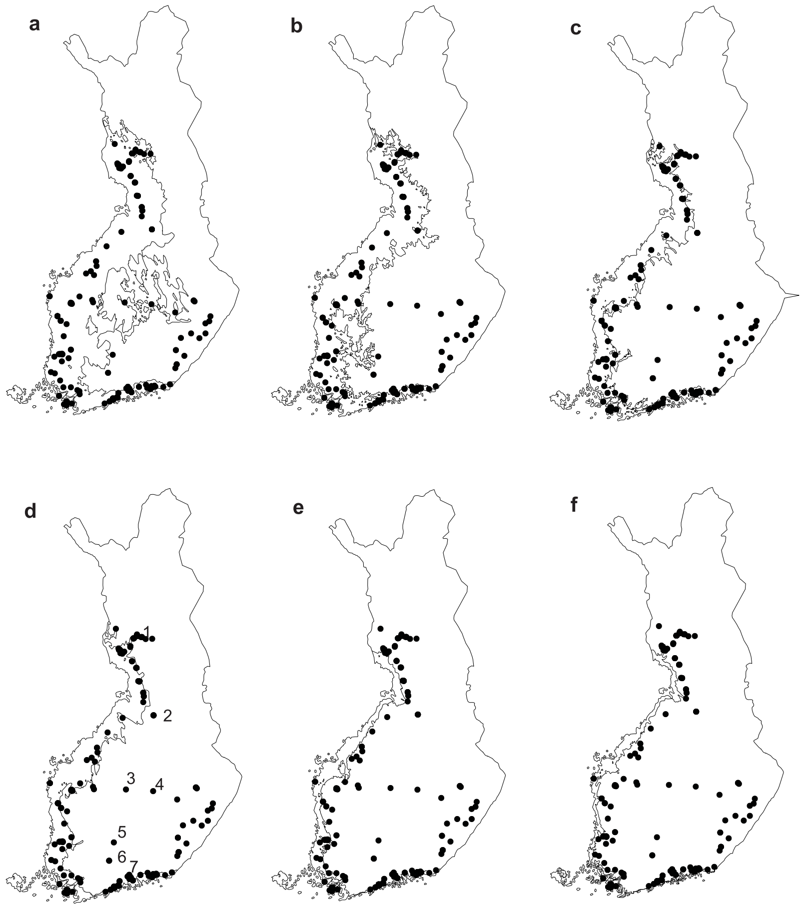

Fig. 5. Prehistoric sites in Finland with refuse faunas including seal bones. Coastlines: — **a**: 9200 BP, — **b**: 8500 BP, — **c**: 7500 BP, — **d**: 6500 BP, — **e**: 3500 BP, — **f**: 1800 BP (after Eronen *et al.* 1995). Site groups mentioned in the text: 1) Rovaniemi, 2) Säräisniemi (Vaala), 3) Saarijärvi, 4) Rautalampi, 5) Luopioinen, 6) Janakkala, 7) Askola.

20 sites). Only 4 grey seal fragments from two sites on the southern coast were identified among all burnt seal remains. No remains of harbour seal were present.

In comparing the species-characteristic anatomical parts found in the archaeological material with the reference material of the Zoological Museum, *meatus acusticus externus* of the skull proved to be the most powerful diagnostic feature in separating different seal species in burnt and fragmented bone material. The bone in this part of the skull is very compact and resistant to both biological and chemical decomposition. All identified harp seals were recognized on the basis of this feature, and so was the majority of the ringed seals. In seven cases the ringed seal could be separated from the harp seal by the shape of the proximal end of the *humerus*. The species determination of the grey seals was based on the shape and size of the *meatus acusticus externus* together with the bluntness of the *crista temporalis*. *Alveola* of the mandible would have been effective in separating grey seals and harbour seals from other species, but all examined mandibles were from the ringed or harp seal, which were not distinguishable.

Distribution of the archaeological seal finds in time and space

Seal bones are found in refuse faunas from all prehistoric periods, from the Mesolithic to the Late Iron Age (*see* chronology in Fig. 3). The sites seem to concentrate on the coastline of 6500 BP and on the contemporaneous islands (Fig. 5). Sites above this coastline are found in

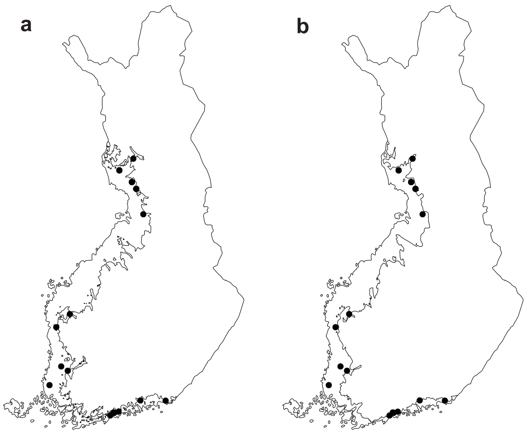

Fig. 6. Prehistoric sites with bones of ringed seal. Coastlines: — a: 7500 BP, and — **b**: 6500 BP (after Eronen *et al.* 1995).

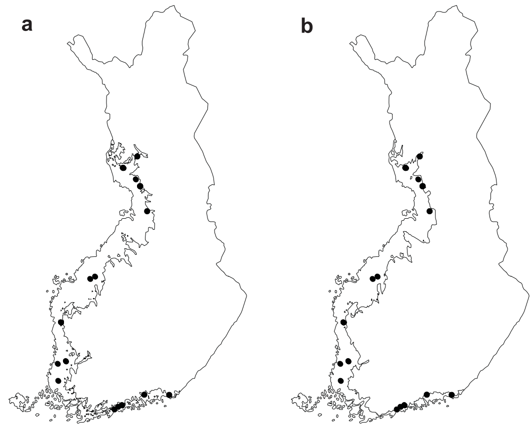

Fig. 7. Prehistoric sites with bones of harp seal. Coastlines: — **a**: 7 500 BP, and — **b**: 6 500 BP (after Eronen *et al.* 1995).

Rovaniemi in Lapland, in Säräisniemi (Vaala) southeast of Oulu, in Saarijärvi and Rautalampi in central Finland, and in Luopioinen, Janakkala and Askola in southern Finland (Fig. 5). In eastern Finland the Saimaa lake complex can clearly be seen in the site distribution.

All archaeological sites with finds that could be identified as ringed seal (Fig. 6) or harp seal (Fig. 7) lie on or below the 7500 BP and 6500 BP coastlines.

Discussion

Phoca hispida

According to Liljegren and Lagerås (1993) the history of the ringed seal in the northern Baltic can be traced to the Yoldia stage of the Baltic basin, but no actual dates are mentioned. From the island Gotland off the Swedish east coast several dated ringed seal finds have been reported by Lindqvist and Possnert (1997), the earliest dating to ca. 8000 BP .

In Estonia, one sample of the species has been radiocarbon dated (Lõugas *et al.* 1996). The cranium fragment from Kudruküla gave an age of 4750 BP. Ringed seal bones have, however, been recovered also from Mesolithic sites on the Estonian coast and on the islands Hiiumaa and Saaremaa. The radiocarbon dates from the sites vary, but the earliest ringed seal finds from Estonia derive from the time of the Ancylus Lake, ca. 8500 BP (Lõugas 1997a).

The radiocarbon date from the ringed seal found in Nurmo on the Finnish west coast (9500 BP) is the earliest so far in the northern Baltic. All archaeological finds that could be determined to species level are situated on or below the 7500 BP and 6500 BP coastlines. Seals found at sites above this coastline — earlier coastal dwelling sites or more recent inland sites — may, however, also belong to this species. This is most likely the case at least in the Ancient Lake Saimaa area discussed below.

Based on these data it can be concluded that the ringed seal was present in the northern Baltic at 9500 BP at the latest, i.e. from the very beginning of the Ancylus Lake stage of the basin. The species probably entered the Baltic basin from the North Sea through the connection via central Sweden during the Yoldia stage. An earlier immigration during the Baltic Ice Lake stage through the outlet in Öresund (Björck 1995), or along ice-dammed lakes and rivers can, however, not be entirely excluded. The Baltic ringed seal has been considered a separate subspecies, mainly based on its alleged effective isolation from the Atlantic populations since early Holocene. Recent genetic studies suggest, however, a recurrent gene flow from the ocean to the Baltic (Palo *et al.* 2001).

Whether the ringed seal immigrated into the Baltic basin during the Baltic Ice Lake stage or the Yoldia stage cannot be solved on the basis of the available data. Anyway, there is no direct evidence for the former, and even evidence for the latter is inferential, i.e. from the subsequent Ancylus Lake stage. Subfossil ages older than Yoldia would solve the problem in favour of the former possibility.

Lake populations

Archaeological seal remains are found in the entire Ancient Lake Saimaa area, from Outokumpu in the north to Lappeenranta in the south and Leppävirta in the west. Although none of the finds could be identified to species they all probably represent the ringed seal, still living in Lake Saimaa.

The question whether the Saimaa seals were trapped in lake basins isolated from the present Gulf of Finland already during the Yoldia stage, or entered the area later from the Gulf of Bothnia along bays and lake systems, remains open. Datable subfossil stray finds from central and eastern Finland together with exact isolation chronologies of the respective lakes would help to solve the question. Archaeological finds are more difficult to interpret, since the possibility of longer hunting trips and transportation of the quarry must always be taken in consideration. These problems apply also to the existence of isolated lake populations in Finland apart from Saimaa, which cannot be conclusively proven with the present data.

Due to the problems in dating prehistoric inland sites, many of the seal finds that could give evidence of ancient lake populations of seals elsewhere in Finland are difficult to interpret. Near Rovaniemi in southern Lapland a bay or fjord still stretched deep into the inland at ca. 7500/6500 BP. Seal bones found at sites near this bay may represent animals caught at the coast. Alternatively, a seal population may have existed for a short period in the so-called ancient Lake Kolpene (Ukkonen 1993), depending on the context of the finds. The site Säräisniemi (Vaala) southeast of Oulu lies in an area that at 8200 BP was still an island in the Gulf of Bothnia. If, however, the seal bones belong to an archaeological context younger than this, an isolated seal population can be assumed to have existed in Lake Oulujärvi (Ukkonen 1993). A single seal fragment has been found at the Voudinniemi 7 site in Saarijärvi in central Finland. The site was used for a long time between 9000 BP and 5000 BP (8000 and 4000 cal BC; Schulz 1996), and the interpretation of the find depends entirely on its context. At 9200 BP the area lay by the Anclylus Lake, but had changed into an inland location already at 8500 BP. The context of the two stray finds from Rautalampi is even more problematic. Both Saarijärvi and Rautalampi are located within the range of the ancient Saimaa-Päijänne lake system.

The seal bearing archaeological sites in Luopioinen and Janakkala in southern Finland both lie above the 9200 BP coast line of the Ancylus Lake. Hietaniemi in Luopioinen is reported to be associated with the Combed Ware cultural context (Taavitsainen 1980), in Janakkala Virala the occupation period spans from the Pre-Ceramic to the Middle Ages. In both cases the existence of a lake population seems improbable (Ukkonen 1993) for such a long time after isolation from the Baltic. Here one should consider the possibility that the seals were hunted on the coast and then transported to the dwelling site (Ailio 1909).

In Sweden parts of a ringed seal have been found at a site on Lake Siljan (Ekman & Iregren 1984), about 100 km from the coast. Lake Siljan was part of the Baltic during the Ancylus Lake stage, and seals may have been trapped in it when the lake was isolated. Ekman and Iregren (1984) emphasize, however, that the seal may have been hunted elsewhere and transported to the site, as in their opinion probably is the case with two other Swedish inland seal finds near the rivers Umeälven and Ångermanälven in Norrland.

Phoca groenlandica

All prehistoric dwelling sites that have yielded harp seal bones lie below the 7500 BP coast line and are therefore probably younger than this. Furthermore, nearly all of the archaeological sites with harp seal finds represent Neolithic Combed Ware and other contemporaneous cultural contexts, post-dating 6500 BP.

The date of the harp seal stray find from Närpiö on the southeastern part of the Gulf of Bothnia (5890 BP) is the earliest so far in the northern Baltic. The earliest radiocarbon date that can be reliably tied to archaeological harp seal finds is very similar, 5800 ± 110 BP (Hel-2107). It derives from Tainiaro in Simo (Jungner & Sonninen 1996) further north on the coast of the Gulf of Bothnia. The stray find from Alatornio (4810 BP) shows that the species reached even the northernmost corner of the Gulf of Bothnia. Similar dates exist also from archaeological sites in this region, from Törmävaara 48 in Tervola (4900 ± 110 BP; Hel-2469; Jungner & Sonninen 1996), Törmävaara 30 in Tervola (4850 ± 110 BP; Hel-2151; Jungner & Sonninen 1996) and Kuuselankangas in Yli-Ii (4695 ± 85 BP; Hela-163; Halinen *et al*. 1998).

Archaeological harp seal finds from sites further south, from Kristiinankaupunki and Laitila, can not be tied to exact radiocarbon dates, but in general they represent the same age range or are slightly younger. Of the dates from the site Rävåsen in Kristiinankaupunki (4660 ± 100 BP, Hel-4331; 4440 ± 75 BP, Hela-337; 4030 ± 180 BP, Hel-4310) the youngest one represents most probably the context of the harp seal finds (M. Miettinen, pers. comm.). The same applies (M. Miettinen, pers. comm.) to the dates from Nästinristi in Laitila (4910 ± 130 BP, Hel-1349; 4850 ± 130 BP, Hel-1350; 4740 ± 100 BP, Hel-1346; 4710 ± 100 BP, Hel-1347; 4460 ± 160 BP, Hel-1348; Jungner 1979).

In the Gulf of Finland area, the earliest stray find is from Espoo/Kirkkonummi (5290 BP) west of Helsinki. The harp seal bones from the prehistoric site Vantaa Stenkulla can be tied with the date 5000 ± 120 BP (Hel-3962; K. Katiskoski, pers. comm.). The earliest dated Estonian find is 4835 BP (Lõugas *et al*. 1996).

In the Åland archipelago the harp seal dominates the archaeological refuse faunas of Pitted Ware sites (Storå 2000), dated to ca. 4650–4050 BP (Núñez & Storå 1991). At the youngest of these sites the dominance of the harp seal slightly decreases and the frequency of grey seal increases. At the end of the Neolithic the relative frequency of harp seals decreases, but the species is still present in the fauna during the Iron Age (Storå 2000).

The youngest harp seal date from the Finnish west coast derives from a stray find from Pietarsaari and is 2800 BP. The relatively late presence of the harp seal in northern Baltic is also indicated by the skull found in a burial mound of the “Lapp cairn” type in Kempele (Mäkivuoti 1985), archaeologically dated to pre-Roman Iron Age or the Roman period. Harp seal remains have also been found in Iron Age contexts on the island Saaremaa in Estonia (Lõugas 1994).

It can be concluded that the harp seal entered the northern Baltic during the Litorina stage, at 5900 BP at the latest. The species was present in the northern Baltic at least until 2800 BP, but probably a thousand years later still. The large number of both geological and archaeological harp seal finds disproves earlier views of the rarity of the species in the northern parts of the Baltic (Ekman & Iregren 1984, Storå 2001) and the alleged dominance of the ringed seal in refuse faunas (Ukkonen 1993).

Three main hypotheses have been put forth concerning the history of the harp seal in the Baltic (Lepiksaar 1986): the species may be a relic from the Yoldia stage (Ekman 1922), it may have established breeding populations in the Baltic (Forstén & Alhonen 1975, Lindqvist & Possnert 1997), or the finds may derive from periodical migrations of harp seals (Salmi 1963, Lõugas 1997a, 1998). Recently, Storå (2001) has concluded on the basis of epiphyseal fusion data and osteometry of archaeological harp seal finds that a breeding ground of this species existed near Gotland island during the Subboreal Chron. The burnt and highly fragmented seal bone material from Finnish prehistoric dwelling sites does not allow any osteometric analyses, but the apparent abundance and the long presence of the species in the northern Baltic — at least 3000 radiocarbon years — certainly suggests stable residence rather than just sporadic or even regular migrations.

The factors affecting the dispersal of the harp seal into the Baltic and disappearance from it cannot be deduced from the available data.

It is doubtful whether the question ever can be solved on the basis of subfossil finds. Since ice conditions play a vital role in the life and breeding of seals, it may be profitable to approach the question from this angle.

The harp seal did not enter the Baltic basin until the Danish straits opened, offering a suitable (im)migration route for this pelagic species. The marine waters of the North Sea increased the salinity of the Baltic, especially in the early part of the Litorina stage. Several authors (Forstén & Alhonen 1975, Lõugas 1997a, 1998, Lindqvist & Possnert 1997) explain the appearance of the harp seal in the Baltic fauna with the enrichment of the fish fauna caused by the increasing salinity of the sea. The confirmation or rejection of this hypothesis would, however, require additional data both on the former salinity conditions of the Baltic Sea and on the ancient fish and harp seal populations of the area.

Halichoerus grypus

Lindqvist and Possnert (1997) report grey seals from Gotland dated at the late Ancylus Lake stage. This would mean that it entered the Baltic basin already during the Yoldia stage, since no suitable connection existed between the ocean and the Baltic basing during the Ancylus Lake stage. Lepiksaar (1986) and Lõugas (1997a) doubt the suitability of the Yoldia-time Närke strait as a migration route for this pelagic seal. The Danish straits at the beginning of the Litorina stage would seem a considerably more probable immigration route, as also discussed by Lindqvist and Possnert (1997).

Grey seal is extremely rare in the Finnish subfossil fauna, as well as in the northern parts of the Baltic in general (Ekman & Iregren 1984, Ericson 1989). The stray find from Teuva on the Finnish west coast is dated to the Litorina stage on the basis of stratigraphy (Forstén 1979). The two refuse fauna finds derive from the south coast, from the Mesolithic (Ancylus or Litorina) site Dragsfjärd Bötesberget and the Combed Ware (Litorina) site Liljendal Kvarnbacken. Forstén and Blomqvist (1977) report some possible grey seal remains from Vantaa, but the species identification was based on other skeletal elements than those used in this study.

In Estonia grey seal remains have been found in Early Neolithic contexts at several dwelling sites (Lõugas 1997a, 1997b), and also in the Bronze Age/Iron Age dwelling site Asva (Lõugas 1994).

In the Åland archipelago the earliest grey seal finds derive from the Combed Ware sites, dated to ca. 6000 BP (Núñez & Storå 1991). At Pitted Ware sites the species is found only sporadically, even though it becomes more common at younger sites (Storå 2001). Grey seal is abundant only in the refuse fauna of the Bronze Age dwelling site on the island Kökar in the Åland archipelago (Forstén 1977).

An interesting question is, whether the low abundance of grey seals in prehistoric times could be explained through competition with other seal species, through environmental factors like ice cover or food resources, or perhaps through a delay in the adaptation of the species in the new conditions that it met in the Baltic Sea. As stated above, the present grey seals in the Baltic sea have different breeding habits than the grey seals in the North Sea and in the North Atlantic. When and why this change took place may be a relevant question when studying the history of the grey seal in the Baltic Sea.

Phoca vitulina

Seger (1987) reports fragments of the harbour seal from the prehistoric site Trofastbacken in Korsnäs in Otrobothnia. The fragments were not re-examined, but the species identification is highly questionable, since it is based on metatarsal and tarsal bones, which can not be considered as diagnostic elements.

Conclusions

The ringed seal was the first seal species to disperse into the Baltic basin after the last glaciation. It was present in the northern Baltic at 9500 BP, at the latest, and had probably entered the area already during the Yoldia stage of the Baltic. The species was very common in the northern parts of the Baltic, but did not necessarily dominate the area, especially during the peak occurrence of the harp seal around 5000 BP.

The occurrence of the harp seal in the northern Baltic lasted from at least 5900 BP to 2800 BP, but probably a thousand years later. The species was common even in the northernmost parts of the Baltic basin.

The grey seal, on the other hand, was rare in the northern Baltic during prehistoric times. Due to the scarcity of its remains it is not possible to pinpoint the exact time when the species reached the northernmost parts of the Baltic, or what was the cause of the increase of its abundance.

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Appendix 1. Prehistoric occupation sites in Finland (exclusive Åland) that have yielded seal bone. Archives: NM = National Museum, Helsinki; TYA = Archaeology, University of Turku; TMM = Turku Provincial Museum; SatM = Satakunta Museum, Pori; Oulu = Archaeology, University of Oulu. Museum catalogue number. Number of identified seal bone fragments. Species: Ph = *Phoca hispida*, Pg = *Phoca groenlandica*, Hg = *Halichoerus grypus.* Excavation/Survey: the name of the excavation director and the year of the excavation; the majority of the excavations are unpublished and the field reports can be found in the respective archives. Osteologists: AF = Ann Forstén, JJ = Jukka Jernvall, PU = Pirkko Ukkonen, MF = Mikael Fortelius, TF = Tarja Formisto, KM = Kristiina Mannermaa, SN = Sirpa Nummela, SF = Stella From, HW = Herluf Winge, LB = Leif Blomqvist, NS = Niklas Söderholm, AO = Arvo Ohtonen.

Site	Mus.	Nr.	Fr.	Ph	Pg	Hg	Excavation/Survey	Ost.
Alavus Rantatöysä Rantalanvainio	NM	12583	3	–	–	–	Luho 1950	AF*
Askola Nalkkila Rahkaissuo	NM	13302	9	–	–	–	Luho 1953	AF*
Askola Nalkkila Ruoksmaa	NM	13067	5	–	–	–	Luho 1952	JJ*
Askola Nalkkila Ruoksmaa	NM	13303	2	–	–	–	Luho 1953	JJ*
Askola Nalkkila Takalan Hopeapelto	NM	13064	3	–	–	–	Luho 1952	JJ*
Askola Nietoo Mattila Tallikäärö	NM	12934	41	–	–	–	Luho 1951	JJ*
Askola Pappila Saunapelto Perunamaa	NM	12603	2	–	–	–	Luho 1950	JJ*
Askola Pappila Saunapelto Perunamaa	NM	13068	2	–	–	–	Luho 1952	JJ*
Askola Pappila Siltapellonhaka	NM	12933	18	–	–	–	Luho 1951	JJ*
Askola Pappila Siltapellonhaka I	NM	12600	11	–	–	–	Luho 1950	JJ*
Askola Vahijärvi Siltala Kotopelto	NM	9213	1	–	–	–	Cleve 1930	JJ*
Askola Vakkola Toppinen	NM	12264	1	–	–	–	Luho 1949	JJ*
Askola Vakkola Toppinen	NM	12266	1	–	–	–	Luho 1949	JJ*
Askola Vakkola Toppinen	NM	12604	1	–	–	–	Luho 1950	JJ*
Dragsfjärd Hammarsboda 2	TYA	611	18	–	–	–	Asplund 1993	PU
Dragsfjärd Hammarsboda 3	TYA	588	6	–	–	–	Tuovinen 1991	PU
Dragsfjärd Hersböle Senatsberget	TYA	634	6	–	–	–	Sipilä 1996	PU
Dragsfjärd Hersböle Senatsberget 3	TYA	638	15	–	–	–	Sipilä 1996	PU
Dragsfjärd Jordbromalmen	TMM	14122	12	–	–	–	Cleve 1946	PU
Dragsfjärd Nordanå	NM	27002	19	–	–	–	stray finds	PU
Dragsfjärd Nordanå Bötesberget	NM	26616	271	–	–	3	Kankkunen 1991	PU
Elimäki Hämeenkylä	NM	13649	8	–	–	–	Luho 1954	MF
Espoo Bosmalm	NM	22026	2	–	–	–	Pykälä-aho 1983	TF
Espoo Bosmalm	NM	22396	10	–	–	–	Kankkunen 1984	TF
Espoo Bosmalm	NM	23045	20	1	1	–	Taskinen & Kankkunen 1985	TF

continued

Appendix 1. Continued.

Site	Mus.	Nr.	Fr.	Ph	Pg	Hg	Excavation/Survey	Ost.
Espoo Bosmalm	NM	23809	12	–	–	–	Kankkunen 1987	TF
Eura Yli-Nuoranne	NM	17251	4	–	–	–	Lehtosalo 1965	MF
Eurajoki Etukämppä	NM	17274	101	–	2	–	Lahtiperä 1967	MF
Evijärvi Jokela Koskimäki	NM	11904	1	–	–	–	Luho 1948	MF
Evijärvi Lahdenkylä Isokangas	NM	20603	78	–	2	–	Hiekkanen 1979	MF
Halikko Märy Riihikankare	NM	28386	2	–	–	–	Mikkola 1994	PU
Harjavalta Hiitteenharju Laurila	SatM	16.445	2	–	–	–	Salo	MF
Harjavalta Hiitteenharju Motocross-rata	NM	20493	322	–	3	–	Taavitsainen 1979	MF
Harjavalta Lyytikänharju	NM	13554	3	–	–	–	Kopisto 1959	MF
Harjavalta Lyytikänharju	NM	13842	77	1	1	–	Meinander 1955	MF
Harjavalta Nakkila Kaunismäki	NM	12816	1	–	–	–	Erä-Esko 1951	MF
Harjavalta Nakkila Kaunismäki	NM	11594	21	–	–	–	Meinander 1946	MF
Harjavalta Torttila Sievarintie	NM	28383	39	–	–	–	Schulz 1994	PU
Helsinki Etelä-Kaarela Malminkartano	NM	19902	1	–	–	–	Sarkki 1976	MF
Helsinki Haaga Kaupintie	NM	19319	9	–	–	–	Lönnberg 1974	MF
Helsinki Hakkilan tienhaara	NM	18502	51	2	–	–	Pohjakallio 1971	MF
Helsinki Kaarela Etelä-Vantaa 2	NM	18470	50	1	–	–	Purhonen 1971	MF
Helsinki Malminkartano Kårböle	NM	29890	118	–	2	–	Lesell 1996	PU
Helsinki Pitäjänmäki Leikkikenttä I	NM	15485	2	–	–	–	Waris 1962	MF
Honkajoki Lauhala Hietaranta	NM	12257	15	–	–	–	Luho 1949	AF*
Isojoki Villamo Rimpikangas	NM	26615	6	–	–	–	Kankkunen 1991	KM
Isojoki Villamo Rimpikangas	NM	28004	20	–	–	–	Kankkunen 1993	KM
Isojoki Villamo Rimpikangas	NM	31642	7	–	–	–	Kankkunen 1999	KM
Janakkala Virala	NM	24745	4	–	–	–	Schulz 1989	SN
Janakkala Virala Taurula	NM	26065	9	–	–	–	Schulz 1990	SN
Kalajoki 012 Rautio Kivimaa	NM	23381	68	–	–	–	Kotivuori 1986	SF
Kaustinen 2 Kangas	NM	29906	29	–	–	–	Halinen 1996	PU
Kemiö Branten	TYA	589	45	–	–	–	Asplund 1989	PU
Kerava Yli-Kerava Pisinmäki	NM	15432	36	–	–	–	Sarkamo 1962	AF*
Kerava Yli-Kerava Pisinmäki	NM	15832	"	–	–	–	Sarkamo 1963	AF*
Kesälahti 2 Purujärvi Sirnihta	NM	18910	1	–	–	–	Carpelan 1972	PU
Kiikoinen Uusi Jaara	NM	9269	2	–	–	–	Europaeus 1930	MF
Kiikoinen Uusi Jaara	NM	9409	9	–	–	–	Äyräpää 1931	MF
Kirkkonummi Pappila	NM	16289	3	–	–	–	Meinander 1964	MF
Kitee Karistaja	NM	29718	1	–	–	–	Pesonen 1996	PU
Kiukainen Uotinmäki	NM	3574	5	–	–	–	Heikel 1898	HW*
Kiukainen Uotinmäki	NM	4275	"	–	–	–	Ailio 1903	HW*
Kokemäki Kraviojankangas	NM	20584	1057	8	–	–	Heikkurinen 1979	MF
Kokkola Kallis Bläckis II	NM	22629	2	–	–	–	Seger 1984	TF
Kokkola Kallis Bläckis II	NM	22821	7	–	–	–	Seger 1985	TF
Korsnäs Harrström Trofastbacken	NM	22866	14	–	–	–	Seger 1985	TF
Korsnäs Harrström Trofastbacken	NM	22867	28	–	–	–	–	TF
Kristiinankaupunki Dagsmark Råvåsen	NM	28659	297	–	2	–	Vanhatalo 1994	PU
Kristiinankaupunki Dagsmark Råvåsen	NM	28863	479	3	7	–	Laulumaa 1995	PU
Kristiinankaupunki Dagsmark Råvåsen	NM	29610	181	–	1	–	Laulumaa 1996	PU
Kristiinankaupunki Dagsmark Råvåsen	NM	30588	219	–	–	–	Laulumaa 1997	PU
Kristiinankaupunki Dagsmark Råvåsen	NM	30970	89	–	–	–	Laulumaa 1998	PU
Kuivaniemi 003 Veskankangas	NM	24423	205	–	–	–	Wallenius 1988	PU
Kuivaniemi 003 Veskankangas	NM	24928	1061	7	–	–	Wallenius 1989	PU
Kuivaniemi 003 Veskankangas	NM	25800	260	1	–	–	Wallenius 1990	PU
Kuivaniemi 003 Veskankangas	NM	26699	8	–	–	–	Wallenius 1991	PU
Kuivaniemi 003 Veskankangas	NM	27365	370	1	–	–	Wallenius 1992	SN
Kuortane Ylijoki Lahdenkangas	NM	16856	1	–	–	–	Luho 1965	AF*

continued

Appendix 1. Continued.

Site	Mus.	Nr.	Fr.	Ph	Pg	Hg	Excavation/Survey	Ost.
Kurikka Kaistila II	NM	16555	1	–	–	–	Luho 1964	MF
Kurikka Mieto Kuivamäki	NM	17078	1	–	–	–	Luho 1966	MF
Kurikka Mieto Puska	NM	16738	29	1	–	–	Luho 1965	MF
Kurikka Mieto Rajala	NM	18134	12	–	–	–	Luho 1969	MF
Kurikka Myllykylä Topee	NM	17486	11	–	–	–	Luho 1968	MF
Kurikka Palomäki	NM	16880	1	–	–	–	Luho 1965	MF
Kurikka Tuiskula Jäniskallio	NM	16946	24	–	–	–	Luho 1965	MF
Kymi Juurikorpi I	NM	12750	5	–	–	–	Rosén 1950	MF*
Kymi Laajakoski Porkka	NM	17689	2	–	–	–	Kehusmaa 1969	MF*
Kymi Niskasuo	NM	17075	33	–	–	–	Luho 1966	MF*
Kymi Tavastila Tuuli	NM	17687	6	–	–	–	Kehusmaa 1968	MF*
Kymi Ylänummi Nikkarinmäki	NM	14682	5	–	–	–	Luho 1959	MF*
Kymi Ylänummi Nikkarinmäki	NM	15194	1	–	–	–	Waris 1961	MF*
Laitila Kotjala Nästinristi	NM	20606	20	–	1	–	Väkeväinen 1979	MF
Lappeenranta 1 Rutola Saksanniemi	NM	12169	3	–	–	–	Meinander 1949	MF
Leppävirta 2 Moninmäki Voutilainen	NM	25353	3	–	–	–	Kankkunen 1989	PU
Liljendal Andersby Kvarnbacken	NM	9273	22	–	–	1	Äyräpää 1930	MF*
Liljendal Andersby Kvarnbacken	NM	18900	87	–	–	–	Pohjakallio 1972	MF*
Liljendal Andersby Kvarnbacken	NM	19152	274	2	–	–	Pohjakallio 1973	MF*
Liperi Jyrinlahti 1	NM	31057	1(?)	–	–	–	Pesonen 1998	KM
Luopioinen Padankoski Hietaniemi	NM	X	40	–	–	–	Miettinen	LB
Miehikkälä Heikkilä	NM	4564	18	–	–	–	Rinne 1905	MF
Muhos 005 Pyhänsivu Honkala	NM	3871	7	–	–	–	Appelgren 1900	HW*
Nousiainen Koivumäki	NM	19349	3	–	–	–	Edgren 1970–72	MF
Outokumpu Sätös	NM	27704	7	–	–	–	Karjalainen 1992	PU
Outokumpu Sätös	NM	28153	17	–	–	–	Karjalainen 1993	PU
Paimio Toispuoloja	TYA	203	26	–	–	–	Luoto 1981	PU
Parainen Fagervik	TYA	641	25	–	–	–	Raike 1996	PU
Parainen Fagervik	TYA	666	8	–	–	–	Raike 1997	PU
Pello 24 Kaarane 1	NM	31377	2	–	–	–	Kankaanpää 1998	PU
Pomarkku Honkakoski Myllytörmä	NM	9560	65	–	–	–	Äyräpää 1932	MF
Porvoo Henttala	NM	11617	9	–	–	–	Luho 1946	AF*
Porvoo Henttala	NM	11617	13	–	–	–	Luho 1946	JJ*
Porvoo Munkby Böle	NM	17074	16	–	–	–	Edgren 1966	MF
Porvoo Munkby Böle	NM	17387	17	–	–	–	Edgren 1967	MF
Porvoo Munkby Böle	NM	19799	10	–	–	–	Ruonavaara 1975	MF
Porvoo Munkby Böle	NM	30321	8	–	–	–	Strandberg 1997	PU
Punkaharju Mustaniemi	NM	27829	1(?)	–	–	–	Pesonen 1993	PU
Purmo Hundbacka / Myllykangas	NM	20723	9	–	1	–	Miettinen 1980	MF
Puumala Kärmelahti	NM	31376	1	–	–	–	Katiskoski 1998	KM
Puumala Kärmelahti	NM	31879	3	–	–	–	Katiskoski 1999	KM
Pyhtää Siltakylä Brunamossen I	NM	20613	9	–	–	–	Bergström 1979	MF
Pyhtää Siltakylä Brunamossen II	NM	20614	8	–	–	–	Bergström 1979	MF
Pyhtää Susikopinharju	NM	30881	192	–	–	–	Lönnqvist 1998	KM, PU
Rautalampi Mäntyranta	NM	29442	2	–	–	–	stray finds	PU
Rovaniemi 061 Ollonen	NM	30438	1	–	–	–	Kankaanpää 1997	PU
Rovaniemi 123 Ala-Korkalo Siikaniemi Illi 1	NM	14410	8	–	1	–	Sarkamo 1958	MF
Rovaniemi 134 Vinnari	NM	14278	22	–	2	–	Sarkamo 1957	MF
Rovaniemi 135 Ylitalo/Toivola	NM	14278	3	–	–	–	Sarkamo 1957	MF
Rovaniemi 136 Ylitalo/Toivola	NM	14278	3	–	–	–	Sarkamo 1957	MF
Rovaniemi 138 Ylitalo Maikkunen	NM	14278	5	1	–	–	Sarkamo 1957	MF

continued

Appendix 1. Continued.

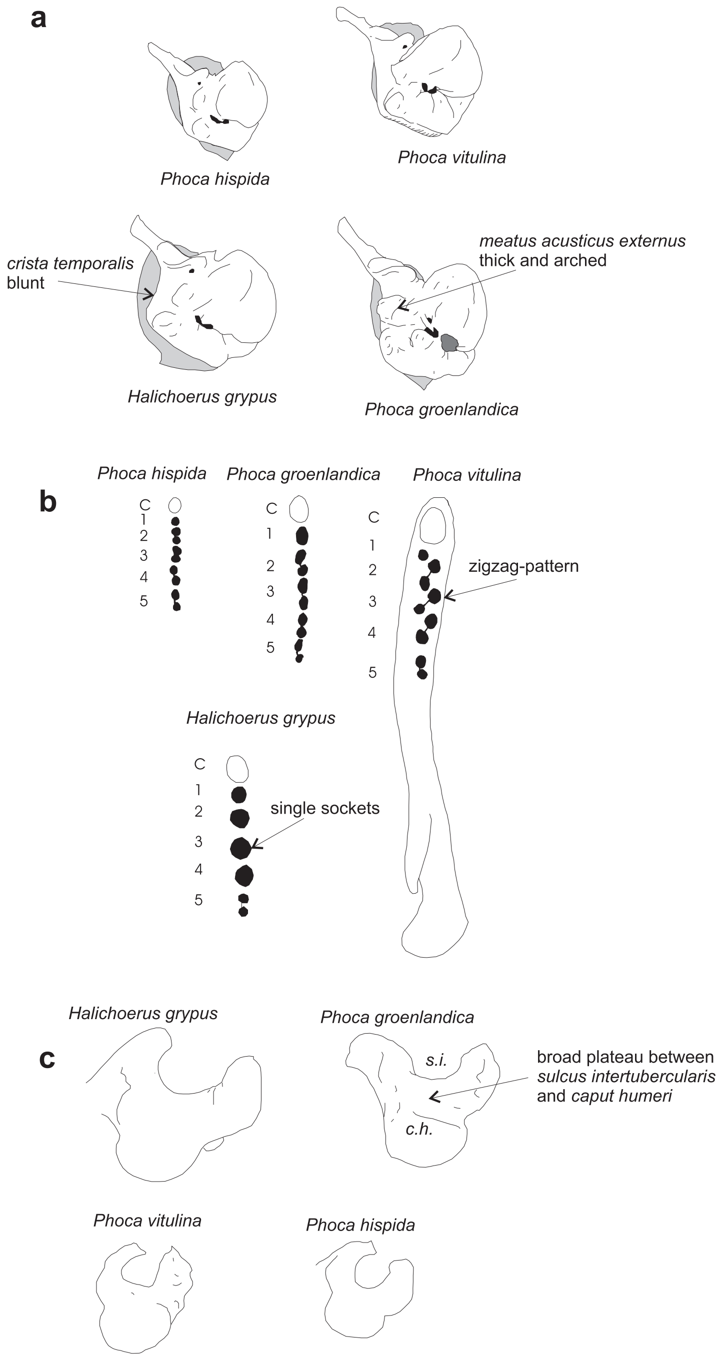
Site	Mus.	Nr.	Fr.	Ph	Pg	Hg	Excavation/Survey	Ost.
Rovaniemi 139 Rautiosaari Turpeenniemi	NM	14709	4	–	–	–	Sarkamo 1958	MF
Rovaniemi 236 Jaatila Ojala	NM	24065	15	–	–	–	Kotivuori 1987	PU
Rovaniemi 236 Jaatila Ojala	NM	25585	81	–	–	–	Kotivuori 1988	PU
Rovaniemi 253 Kolpene	NM	13985	16	–	–	–	Paloniemi 1956	PU
Rovaniemi 254 Kolpene	NM	13768	6	–	–	–	Kopisto 1955	PU
Rovaniemi 277 Saarenkylä Piirittävaara	NM	25334	7	–	–	–	Lavento 1989–90	PU
Rovaniemi 287 Kilpelä	NM	24615	1	–	–	–	Kotivuori 1988	PU
Rovaniemi 337 Tapulinpelto	NM	15502	6	–	–	–	Erä-Esko 1961	PU
Rovaniemi 340 Jokkavaara	NM	21307	3	–	–	–	Torvinen 1981	PU
Rovaniemi 340 Jokkavaara	NM	21834	113	–	–	–	Torvinen 1982	PU
Rovaniemi 340 Jokkavaara	NM	26610	9	–	–	–	Karjalainen 1991	PU
Rovaniemi 474 Sierijärvi Riitakanranta	NM	25374	2	–	–	–	Kotivuori 1990	PU
Ruokolahti Tuomaala Karoniemi	NM	31639	3	–	–	–	Kankkunen 1999	KM
Rääkkylä 45 Vihi 1	NM	30460	1	–	–	–	Pesonen 1997	PU
Rääkkylä 7 Pörrinmökki	NM	28013	6	–	–	–	Pesonen 1993	PU
Saarijärvi Voudinniemi 7	NM	28216	1	–	–	–	Schulz 1993	PU
Salo Isokylä Katajamäki	NM	20251	1	–	–	–	Carpelan & Uino 1978	MF
Salo Pukkila Sinivuori III	NM	20620	3	–	–	–	Hirviluoto 1979	MF
Savonlinna Tynkkylänjoki	NM	27178	1(?)	–	–	–	Sepänmaa 1992	PU
Seinäjoki Koskenala Aapraiminmäki	NM	28829	17	–	–	–	Seppälä 1995	PU
Simo 040 Tainiaro	NM	22398	322	6	1	–	Wallenius 1984	PU
Simo 040 Tainiaro	NM	24925	563	4	–	–	Wallenius1989	PU
Simo 040 Tainiaro	NM	25797	202	1	–	–	Wallenius 1990	PU
Simo 040 Tainiaro	NM	26698	208	4	–	–	Wallenius 1991	PU
Sulkava 2 Kapakkamäki	NM	20787	3	–	–	–	Huurre 1977	MF
Säräisniemi (Vaala 10) Niemelänmäki	NM	2378	1	–	–	–	Mustonen,Heikel,Ailio 1885	HW*
Säräisniemi (Vaala 10) Niemelänmäki	NM	3147	"	–	–	–	Mustonen,Heikel,Ailio 1895	HW*
Säräisniemi (Vaala 10) Niemelänmäki	NM	4080	"	–	–	–	Mustonen,Heikel,Ailio 1900	HW*
Säräisniemi (Vaala 13) Kökkölä	–	X	"	–	–	–	–	?*
Taipalsaari Vaateranta	NM	30322	1	–	–	–	Katiskoski 1997	PU
Taipalsaari Vaateranta	NM	30887	1	–	–	–	Katiskoski 1998	PU
Taipalsaari Vaateranta	NM	31494	1	–	–	–	Katiskoski 1999	KM
Tervola 030 Törmävaara	NM	19008	110	–	1	–	Lönnberg 1972	PU
Tervola 030 Törmävaara	NM	21599	116	2	1	–	Nieminen 1982	PU
Tervola 030 Törmävaara	NM	22070	54	–	–	–	Nieminen 1983	SF
Tervola 030 Törmävaara	NM	22070	63	–	1	–	Nieminen 1983	PU
Tervola 030 Törmävaara	NM	22481	144	1	1	–	Nieminen 1984	SF
Tervola 030 Törmävaara	NM	22481	43	–	2	–	Nieminen 1984	PU
Tervola 030 Törmävaara	NM	23399	23	–	–	–	Schulz 1986	SF
Tervola 030 Törmävaara	NM	23399	26	–	–	–	Schulz 1986	PU
Tervola 030 Törmävaara	NM	23816	80	–	1	–	Ruonavaara 1987	PU
Tervola 040 Törmävaara	NM	19007	132	–	2	–	Lönnberg 1972	PU
Tervola 042 Törmävaara	NM	19009	33	1	–	–	Lönnberg 1972	PU
Tervola 042 Törmävaara	NM	19010	2	–	–	–	Lönnberg 1972	PU
Tervola 042 Törmävaara	NM	20611	43	–	–	–	Ruonavaara 1979	PU
Tervola 047 Törmävaara	NM	23403	71	–	–	–	Heikkinen 1986	PU
Tervola 048 Törmävaara	NM	22911	173	–	5	–	Ruonavaara 1985	PU
Tervola 048 Törmävaara	NM	23400	6	–	–	–	Heikkinen 1986	PU
Tervola 049 Törmävaara	NM	20989	29	–	–	–	Ruonavaara 1980	PU

continued

Appendix 1. Continued.

Site	Mus.	Nr.	Fr.	Ph	Pg	Hg	Excavation/Survey	Ost.
Tervola 049 Törmävaara	NM	22073	1	–	–	–	Nieminen 1983	PU
Tervola 049 Törmävaara	NM	22779	2	–	–	–	Kotivuori 1984	PU
Tervola 094a Kauvonkangas	NM	31378	37	–	–	–	Kankaanpää 1998	PU
Tervola 100 Kolopetäjä	NM	23395	11	–	–	–	Kotivuori 1991	PU
Tervola 107 Lapinniemi Kuokkamaa	NM	25565	18	–	–	–	Kotivuori 1988	PU
Tervola 110 Lapinniemi Veittonen	NM	25566	3	–	–	–	Kotivuori 1989	PU
Tervola 116 Lapinniemi Myllyaho	NM	24587	20	–	–	–	Kotivuori 1988	PU
Tervola 117 Koivu Tynnyripäri	NM	25567	45	–	–	–	Kotivuori 1989	PU
Turku Räntämäki Orhinkarsina	TYA	639	1	–	–	–	Korkeakoski-Väisänen 1996	PU
Uusikaupunki Palppa III (Kalanti Kylähiisi)	NM	17795	1	1	–	–	Lehtosalo 1968	MF
Vantaa Etelä-Vantaa	NM	X	7	–	–	–	Purhonen	MF
Vantaa Etelä-Vantaa 3 (Kaarela Mätäoja 3)	NM	18978	212	1	–	–	Väkeväinen 1972	MF
Vantaa Gröndal 2	NM	31945	464	–	–	–	Saunaluoma 1999	PU
Vantaa Hakkila Stenkulla	NM	20660	2	–	–	–	Väkeväinen 1979	MF*
Vantaa Hakkila Stenkulla	NM	29954	599	–	1	–	Katiskoski 1996	PU
Vantaa Jokiniemi	NM	28065	38	–	–	–	Katiskoski 1993	PU
Vantaa Jokiniemi	NM	28382	12	–	–	–	Katiskoski 1994	PU
Vantaa Jokiniemi Sandliden	NM	28203	81	–	1	–	Fast 1993	PU
Vantaa Jönsas	NM	20087	2	–	–	–	Ojonen 1977	SN
Vantaa Jönsas	NM	21604	3	–	–	–	Rankama 1982	SN
Vantaa Jönsas	NM	23532	1	–	–	–	Wallenius & Arponen 1986	SN
Vantaa Jönsas (länsi)	NM	18836	1	–	–	–	Purhonen 1972	MF
Vantaa Jönsas (länsi)	NM	19274	3	–	–	–	Purhonen 1973	MF
Vantaa Jönsas (pohj.)	NM	19275	250	–	–	–	Purhonen 1973	MF
Vantaa Jönsas (pohj.)	NM	19383	63	–	–	–	Pajari 1974	MF
Vantaa Jönsas (pohj-itä)	NM	19914	63	2	–	–	Ojanen 1975	MF
Vantaa Maarinkunnas	NM	19992	395	–	1	–	Väkeväinen 1976	MF*
Vantaa Maarinkunnas	NM	30464	570	–	–	–	Leskinen 1997	NS, PU
Vantaa Myyrmäki Kilteri	NM	19231	3	–	–	–	Väkeväinen 1973–74	MF
Vihanti Pitkäsaari	NM	3759	2	–	–	–	Appelgren 1900	HW*
Virolahti Kattelus	NM	31786	136	1	–	–	Lesell 1999	KM
Yli-Ii 009 Karjalankylä Kierikki	NM	16554	1	–	–	–	Sarvas 1964	MF
Yli-Ii 028 Kierikinkangas	NM	31072	19	–	1	–	Pesonen 1998	PU
Yli-Ii 028 Kierikinkangas	NM	31829	48	–	–	–	Pesonen 1999	KM
Yli-Ii 043 Kuuselankangas	NM	28943	129	–	1	–	Katiskoski 1995	PU
Yli-Ii 043 Kuuselankangas Kierikki	NM	28370	36	–	–	–	Sarkkinen 1994	AO
Yli-Ii 043 Kuuselankangas Kierikki	Oulu	X	405	–	–	–	1994	AO
Yli-Ii Kuuselankangas	NM	29907	192	–	2	–	Halinen 1996	PU
Yli-Ii Purkajasuo	NM	29764	4	–	–	–	Schulz 1996	PU
Ylikiiminki Niemikylä Latokangas	NM	23715	100	–	–	–	Mäkivuoti 1987	PU
Ylikiiminki Niemikylä Latokangas	NM	25731	43	1	–	–	Mäkivuoti 1990	PU
Ylikiiminki Säävälä Latokangas	NM	24377	79	–	–	–	Sarkkinen 1988	PU
Ylikiiminki Vepsänkangas	NM	30561	31	–	–	–	Koivisto 1997	PU
Ylikiiminki Vepsänkangas	NM	31036	164	–	–	–	Koivisto 1998	KM

* Original analysis lists not available, *see* Ailio (1909; Kiukainen, Muhos, Säräisniemi, Vihanti), Forstén (1973; Alavus, Askola, Honkajoki, Kerava, Kuortane, Porvoo), Kokkonen (1978; Kymi), Matiskainen (1989; Askola, Porvoo), Rauhala (1977; Liljendal), Taavitsainen (1980; Luopioinen), Vikkula (1981; Vantaa).



Appendix 2. Diagnostic features used in species identification of burnt and fragmented seal bones found in archaeological contexts. — **a**: characteristics of the skull (*meatus acusticus externus*, *crista temporalis*); basal view, — **b**: the mandible (*alveola*), and — **c***: humerus*, proximal end; proximal view. The features are described in Lepiksaar (1991).