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**ANIMAL BONES AND HUMAN SOCIETY IN THE LATE  
YOUNGER STONE AGE OF ARCTIC NORWAY**

**VOLUME 2 OF 2  
FIGURES, APPENDICES AND BIBLIOGRAPHY**

**LISA MAYE HODGETTS**

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Thesis submitted for the degree of  
Doctor of Philosophy  
University of Durham  
Department of Archaeology  
1999

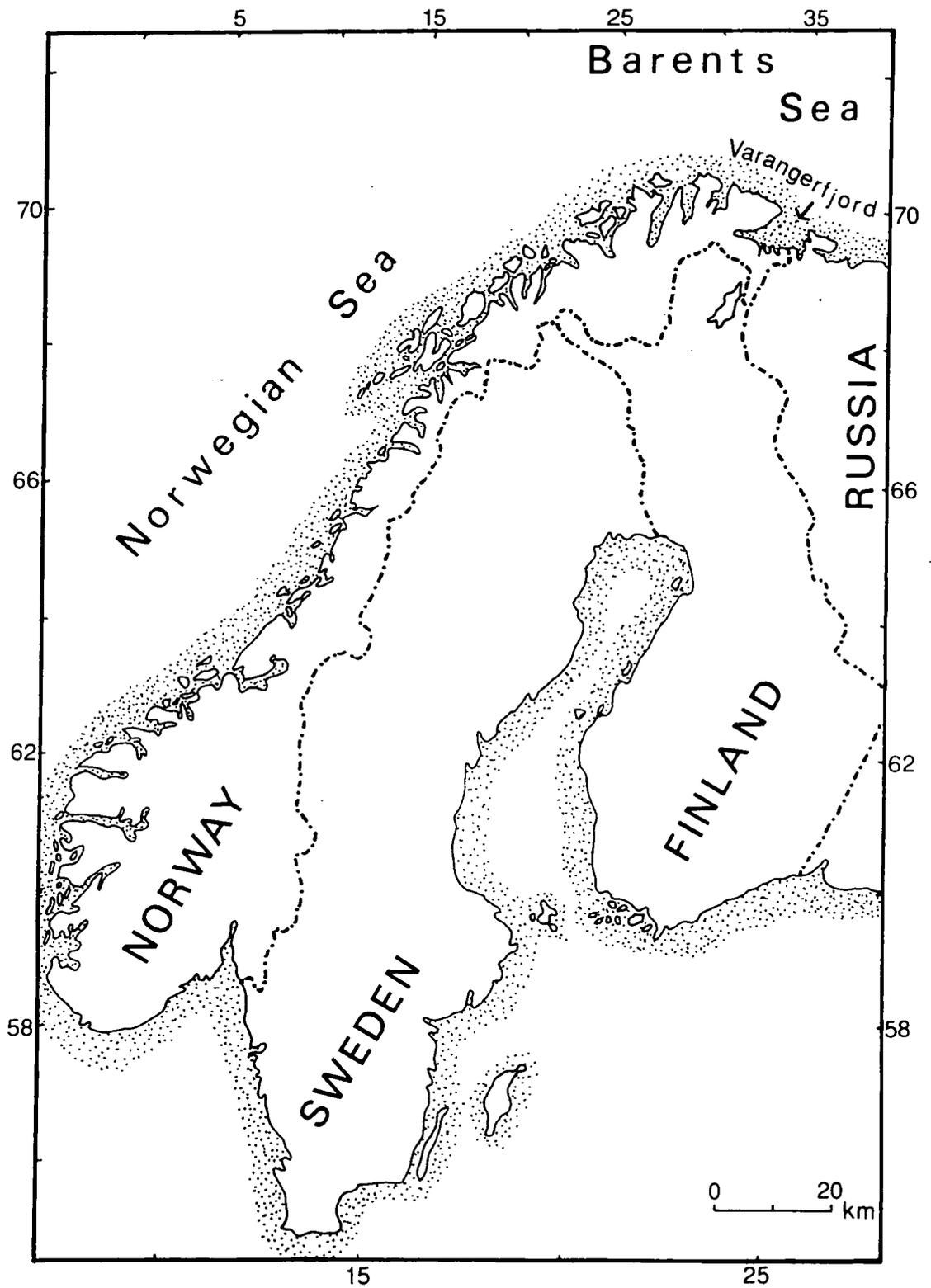


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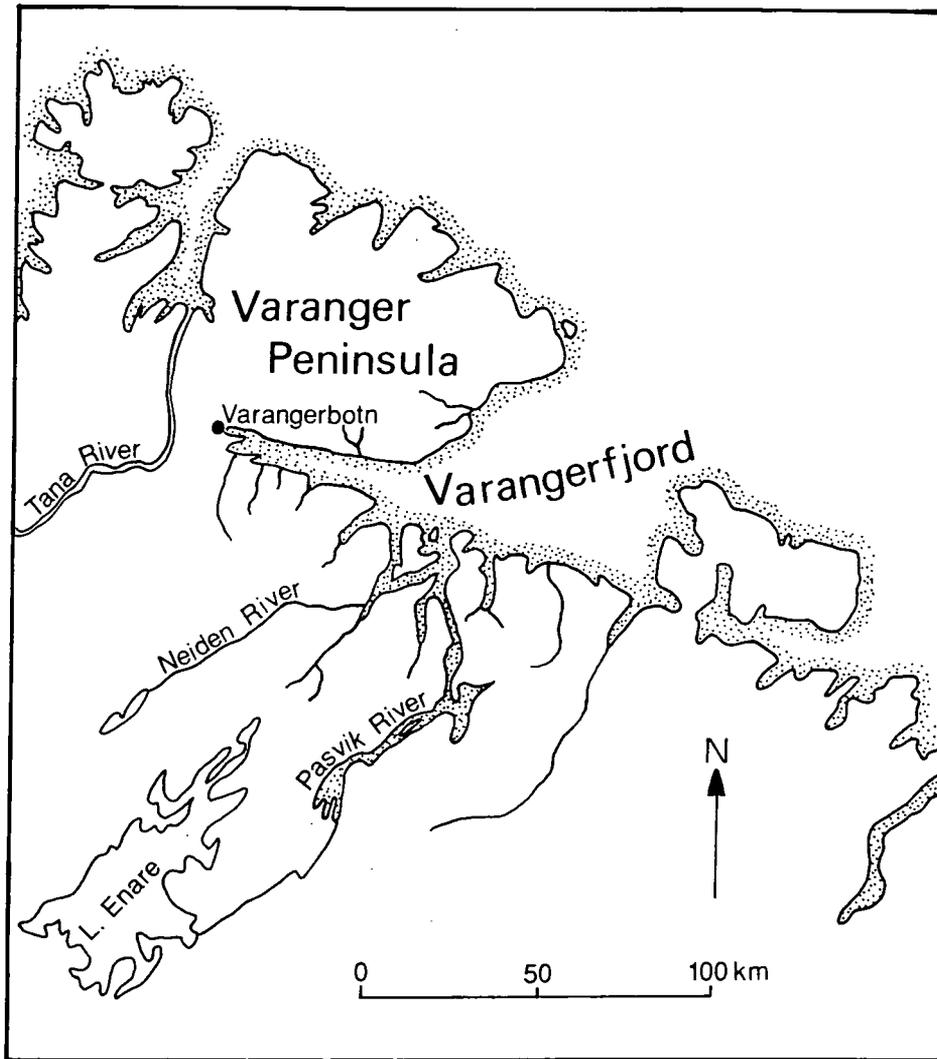
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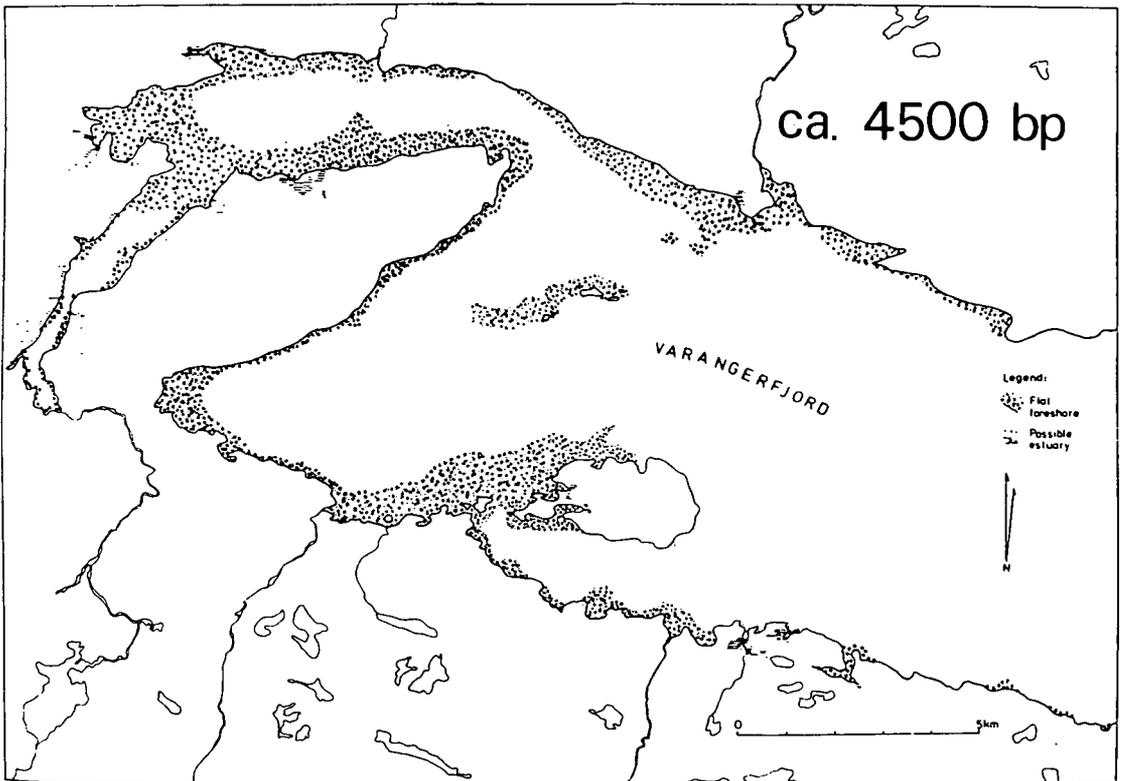
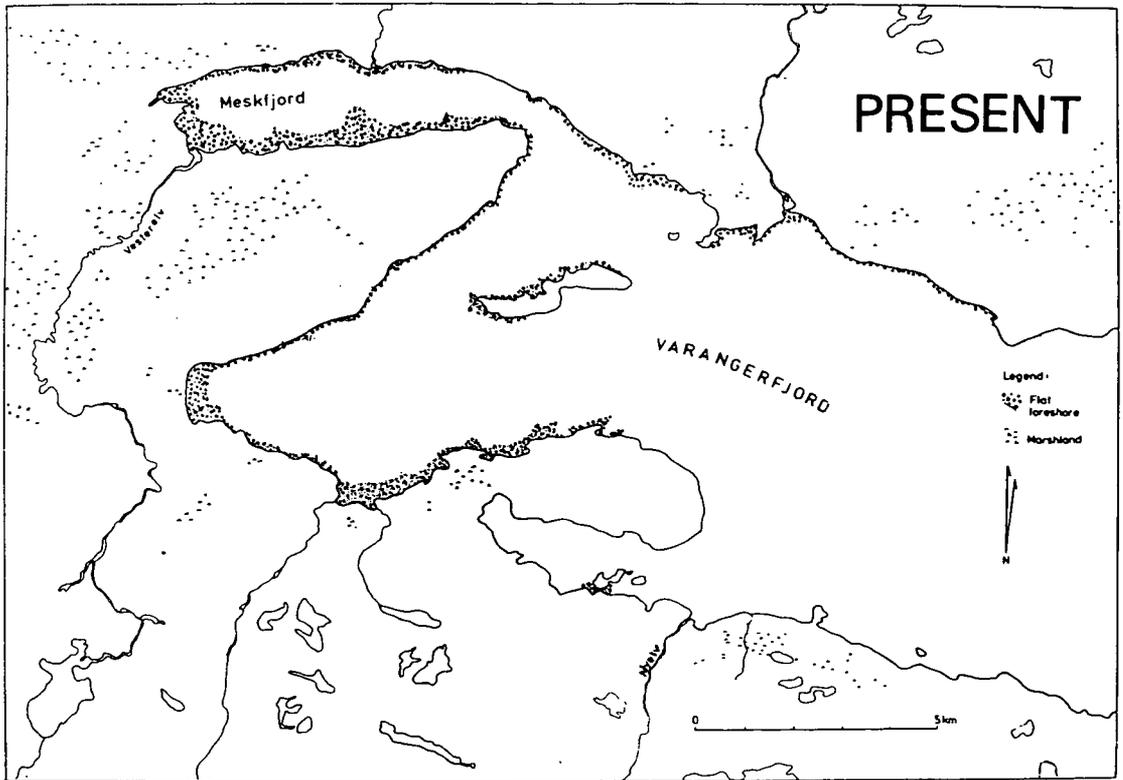
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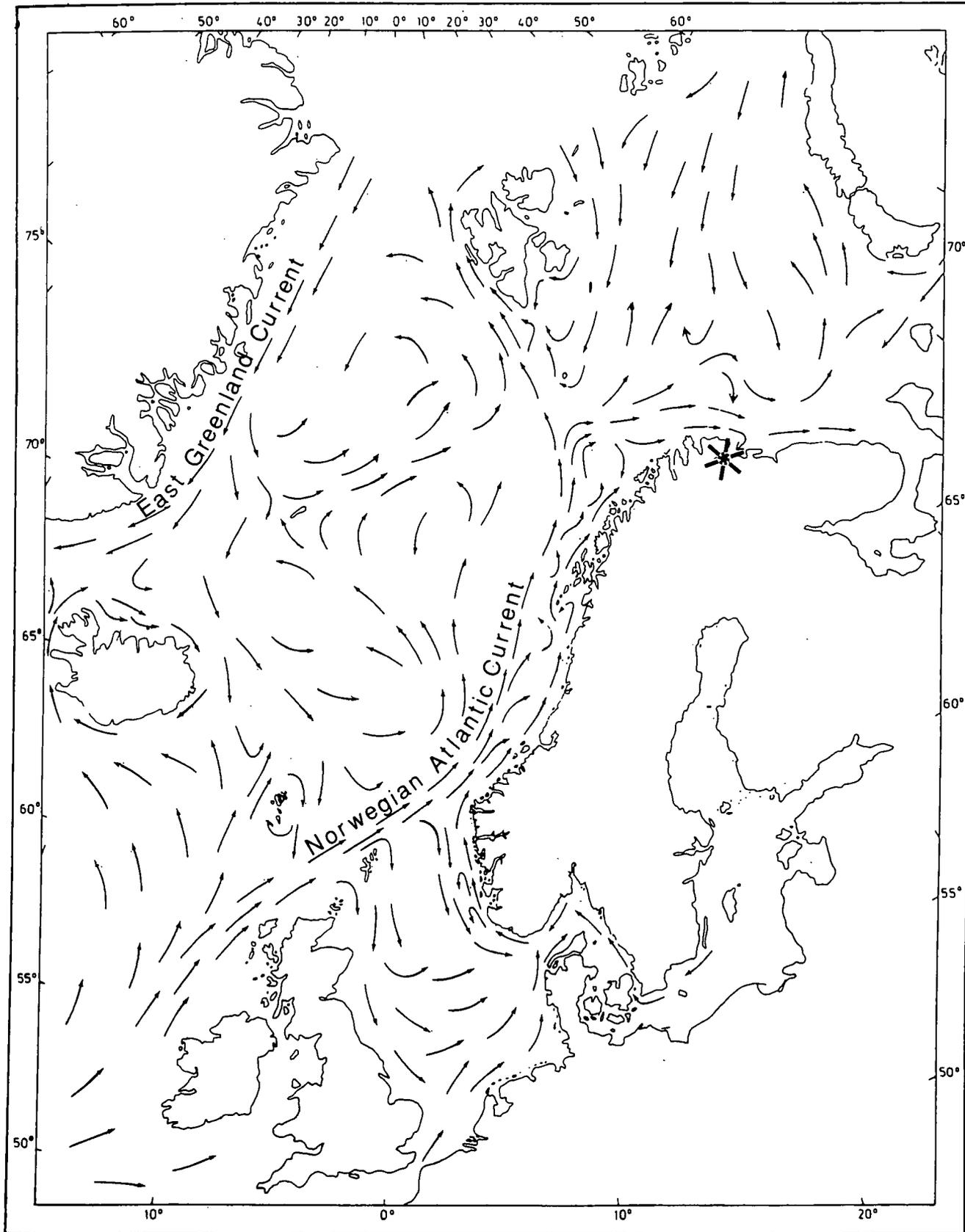
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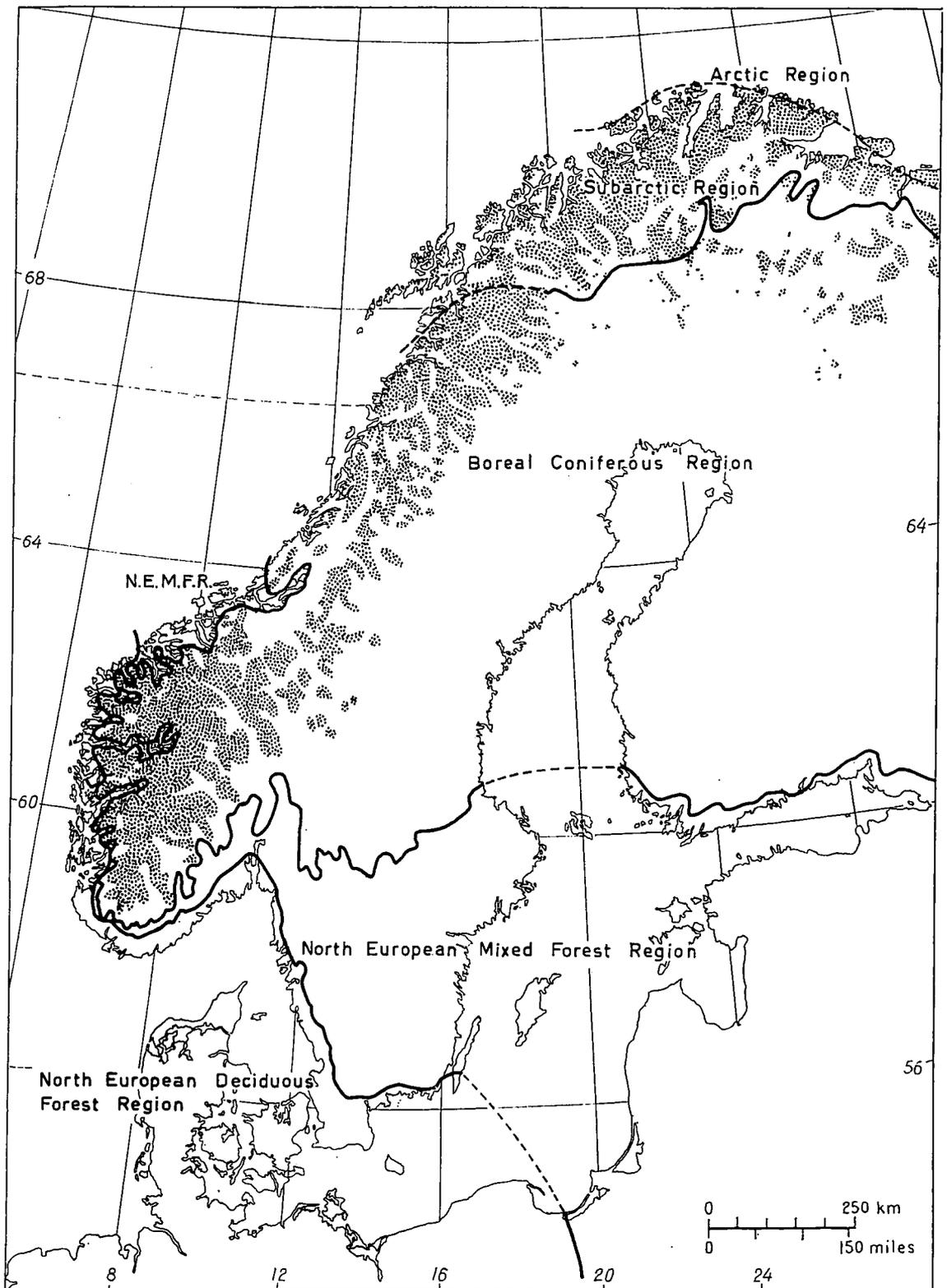
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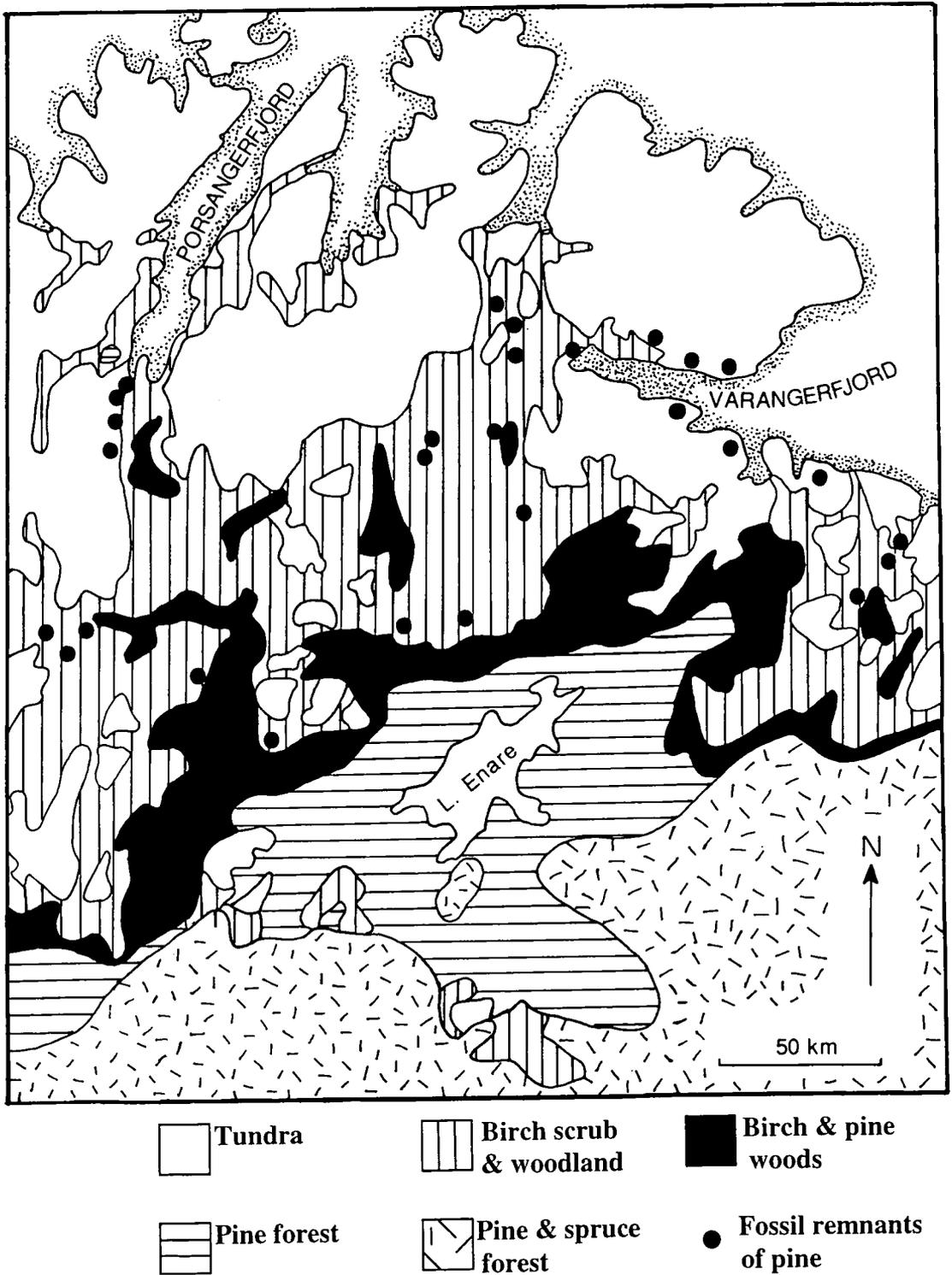
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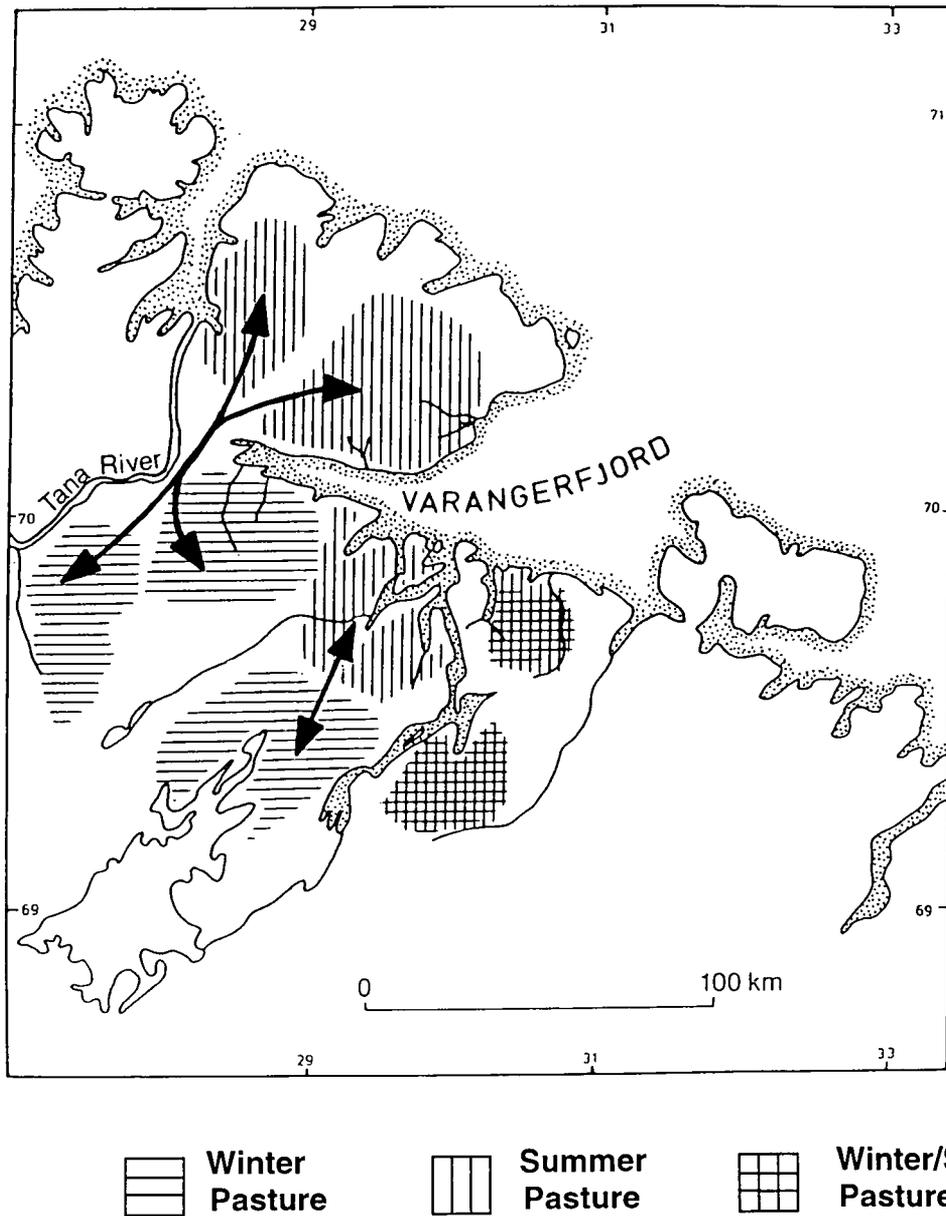


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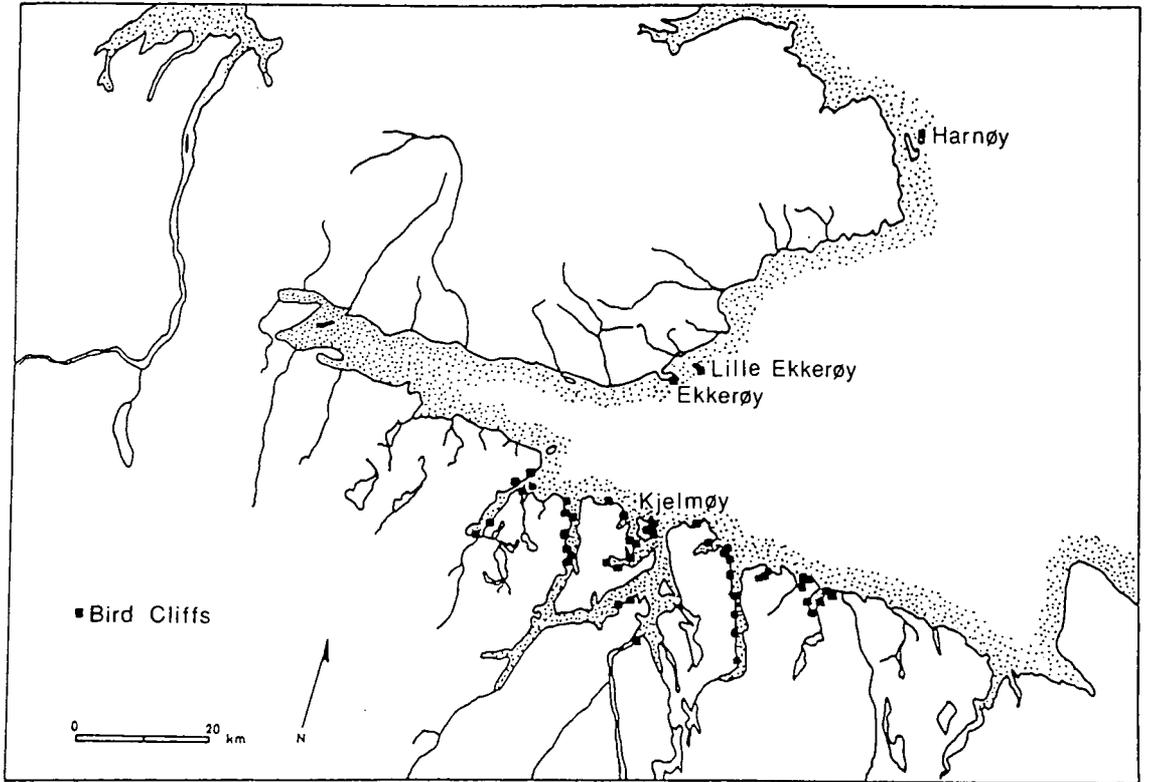


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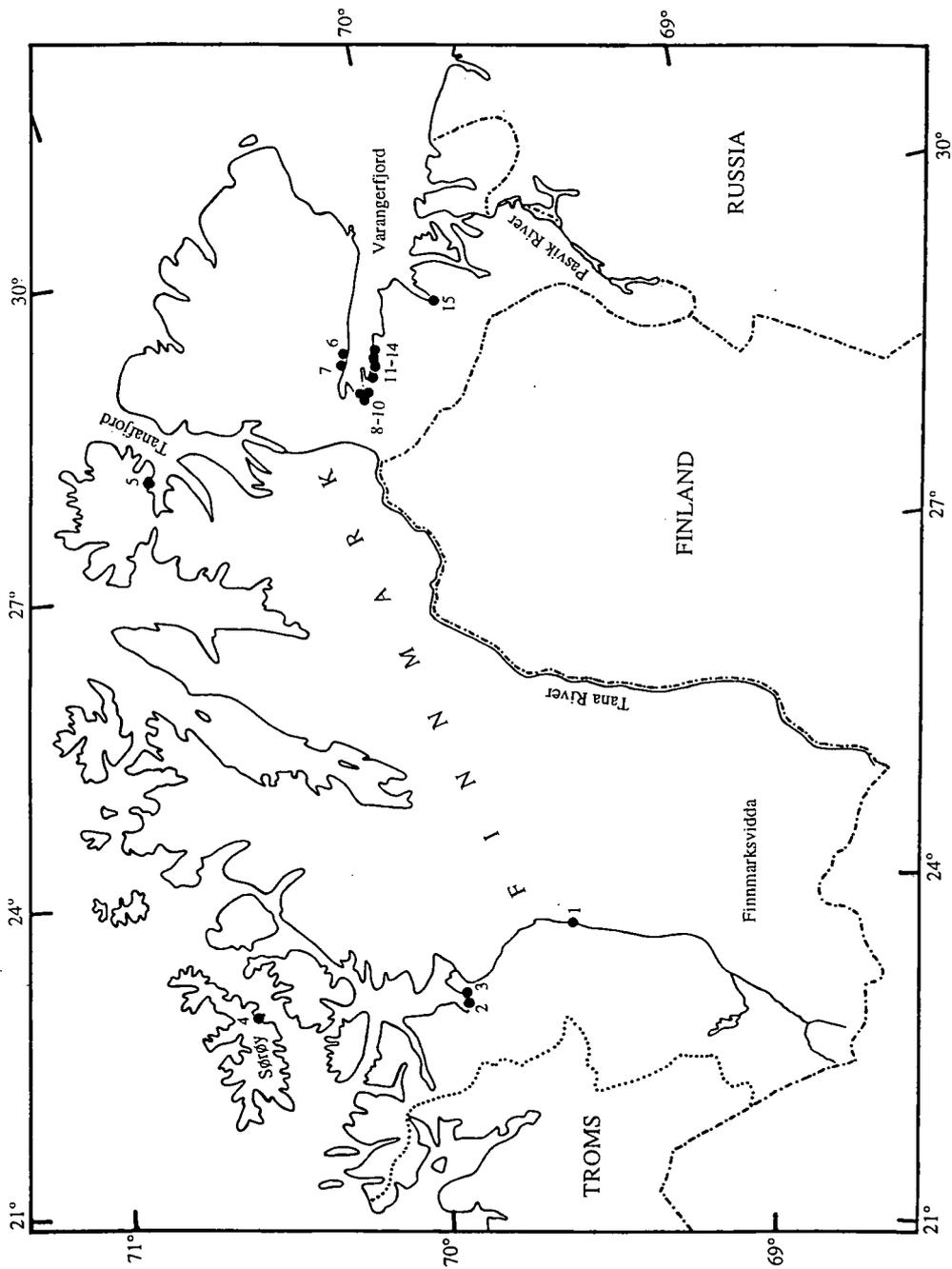
The two concentric circles at the far right of the panel represent a bear den. Tracks lead from the den to where the bears are being hunted by human figures in the centre of the panel. On the left, the clover-shaped series of lines probably represents a fenced reindeer enclosure or trap which opens to the right. The thin dotted line at the bottom of the fence indicates where a large piece of rock has broken away.



**Figure 2.8** Migration routes of domestic reindeer in the Varanger region (after Renouf 1989: figure 3.5; Vorren 1951)

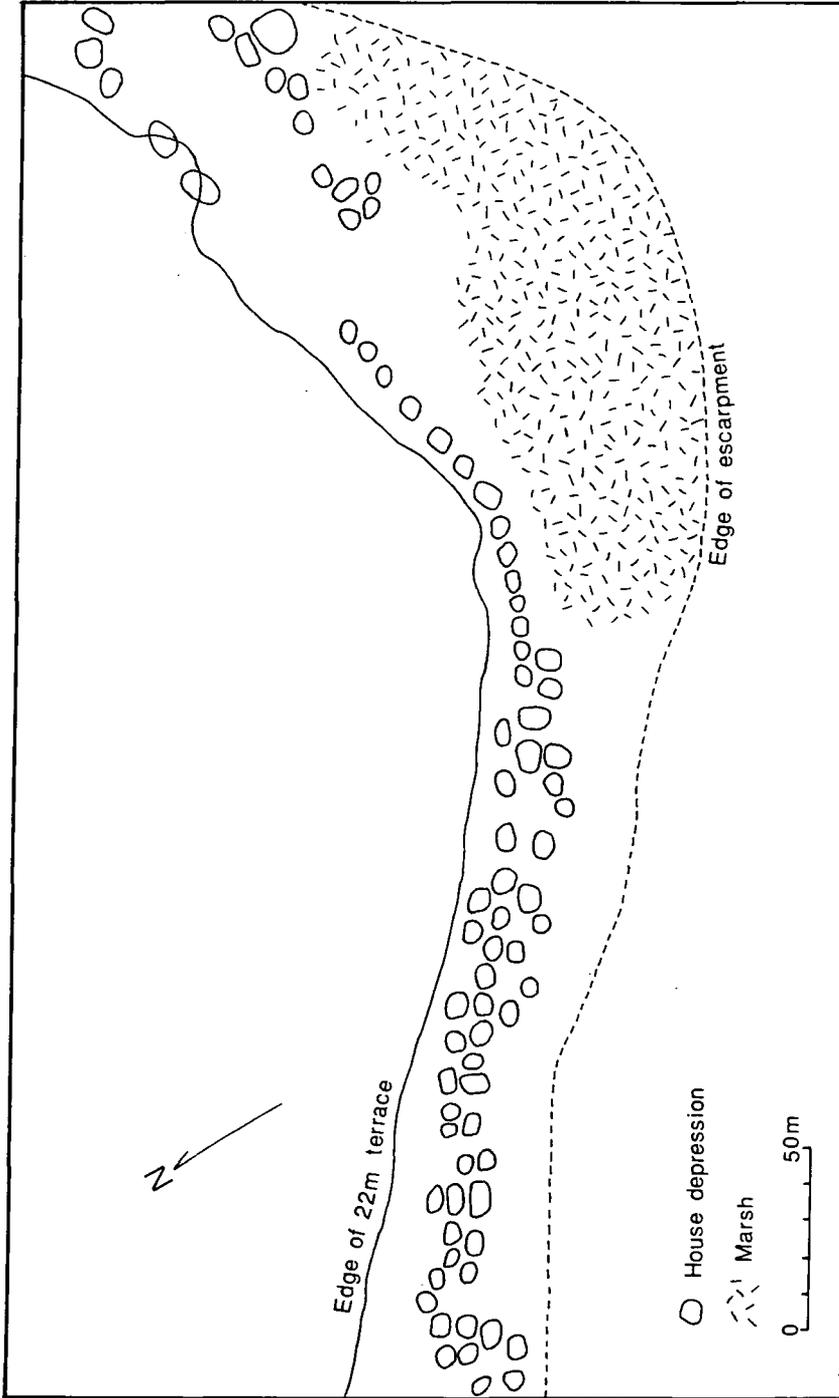


**Figure 2.9** Location of main sea bird breeding colonies around Varangerfjord (after Renouf 1989: figure 3.2)



**Figure 3.1** Map of Finnmark showing sites mentioned in the text

- |               |              |                  |                |                     |
|---------------|--------------|------------------|----------------|---------------------|
| 1 Virdnejavri | 4 Slettnes   | 7 Bergeby        | 10 Karlebotn   | 13 Nyelv Nedre Vest |
| 2 Hjemmeluft  | 5 Iversfjord | 8 Gropbakkeengen | 11 Advik       | 14 Lossoa's Hus     |
| 3 Alta        | 6 Mortensnes | 9 Nordli         | 12 Gressbakken | 15 Bugøyfjord       |



**Figure 3.2** Site plan of Gropbakkeengen, YSA period II (redrawn from Simonsen 1961: figure 35)

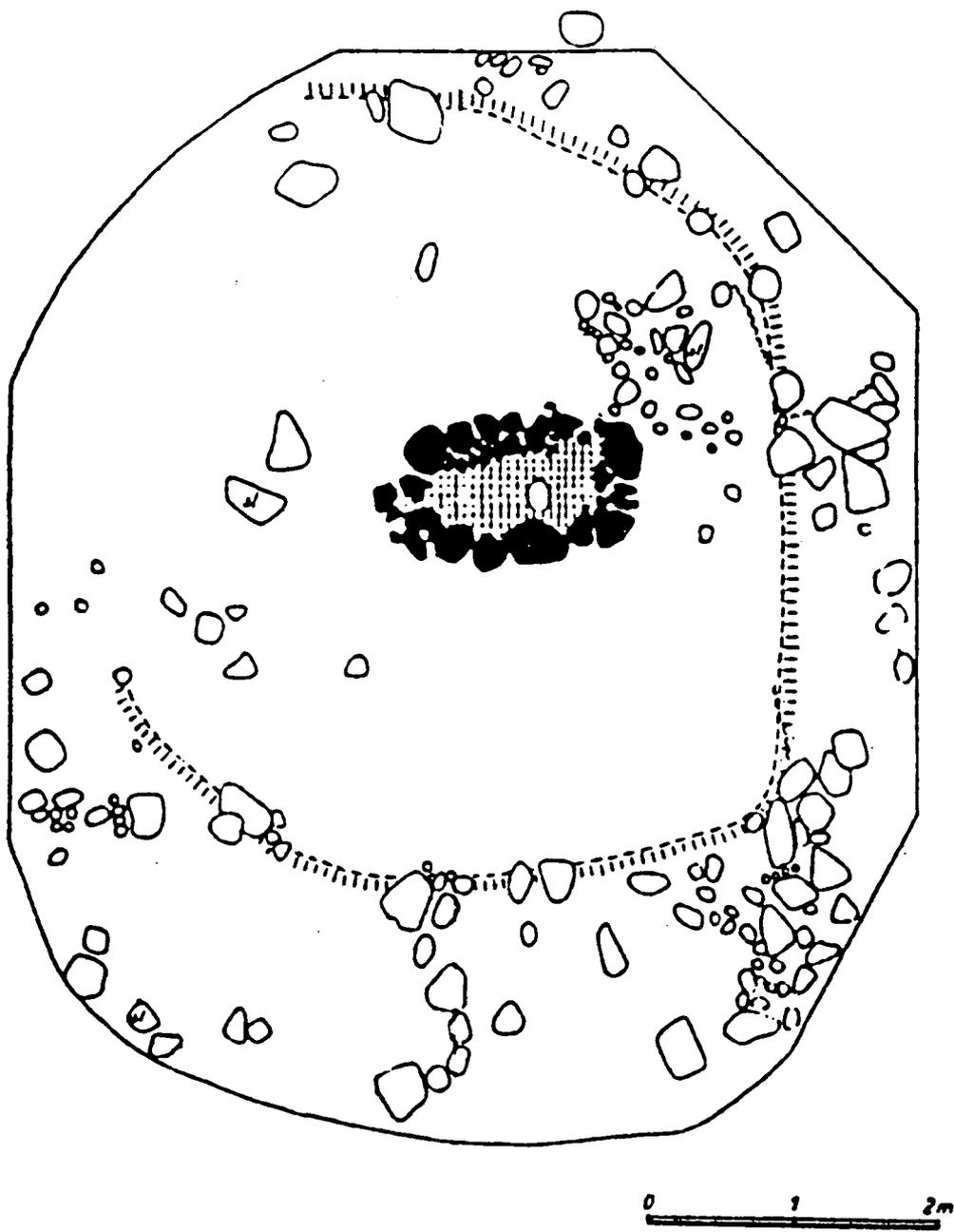


Figure 3.3 Karlebotn-type house (after Simonsen 1961: figure 55)

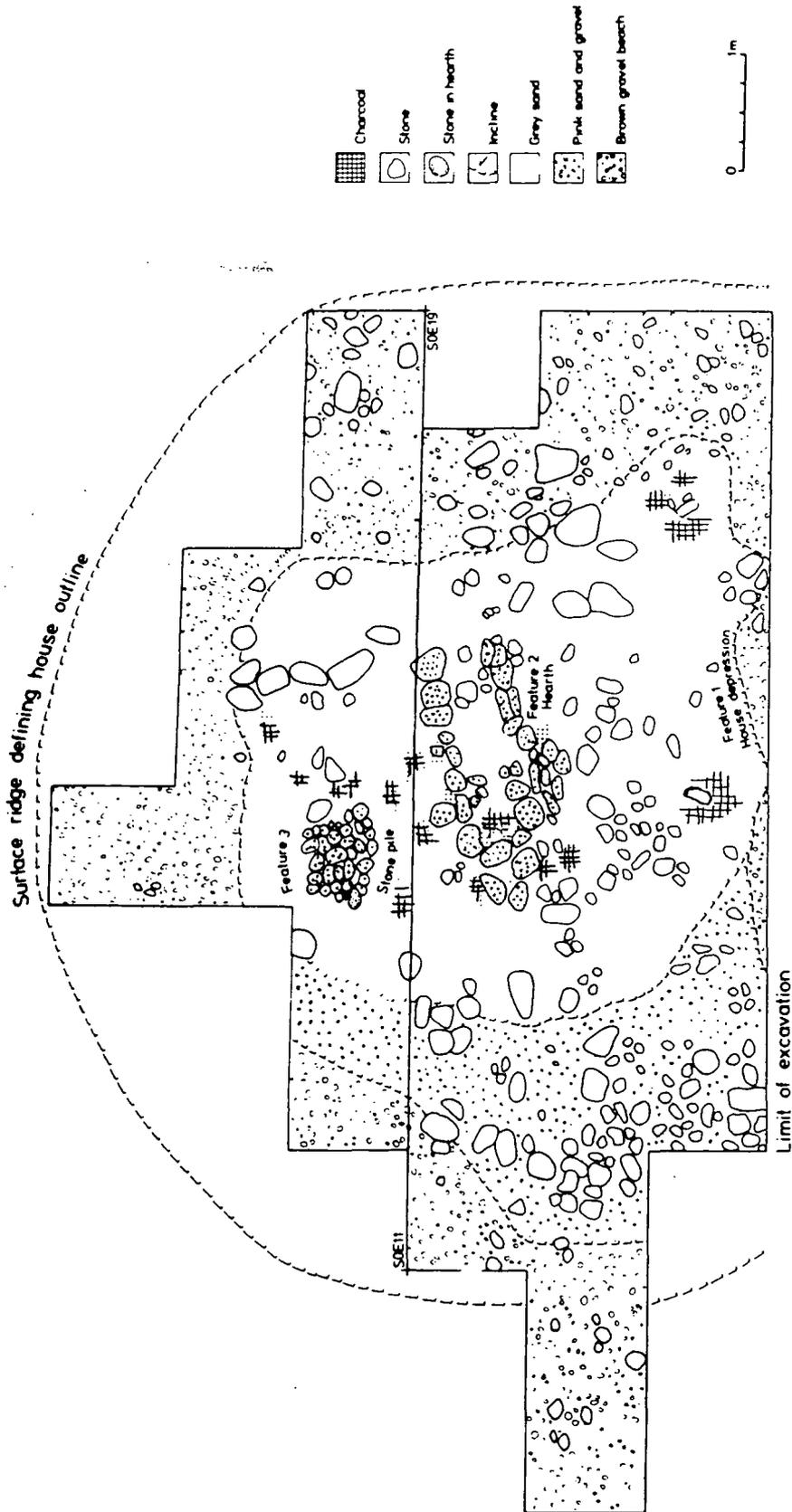


Figure 3.4 Nyelv-type house; Nyelv Nedre Vest Area 3, feature 1 is illustrated (from Renouf 1989: figure 5.5)

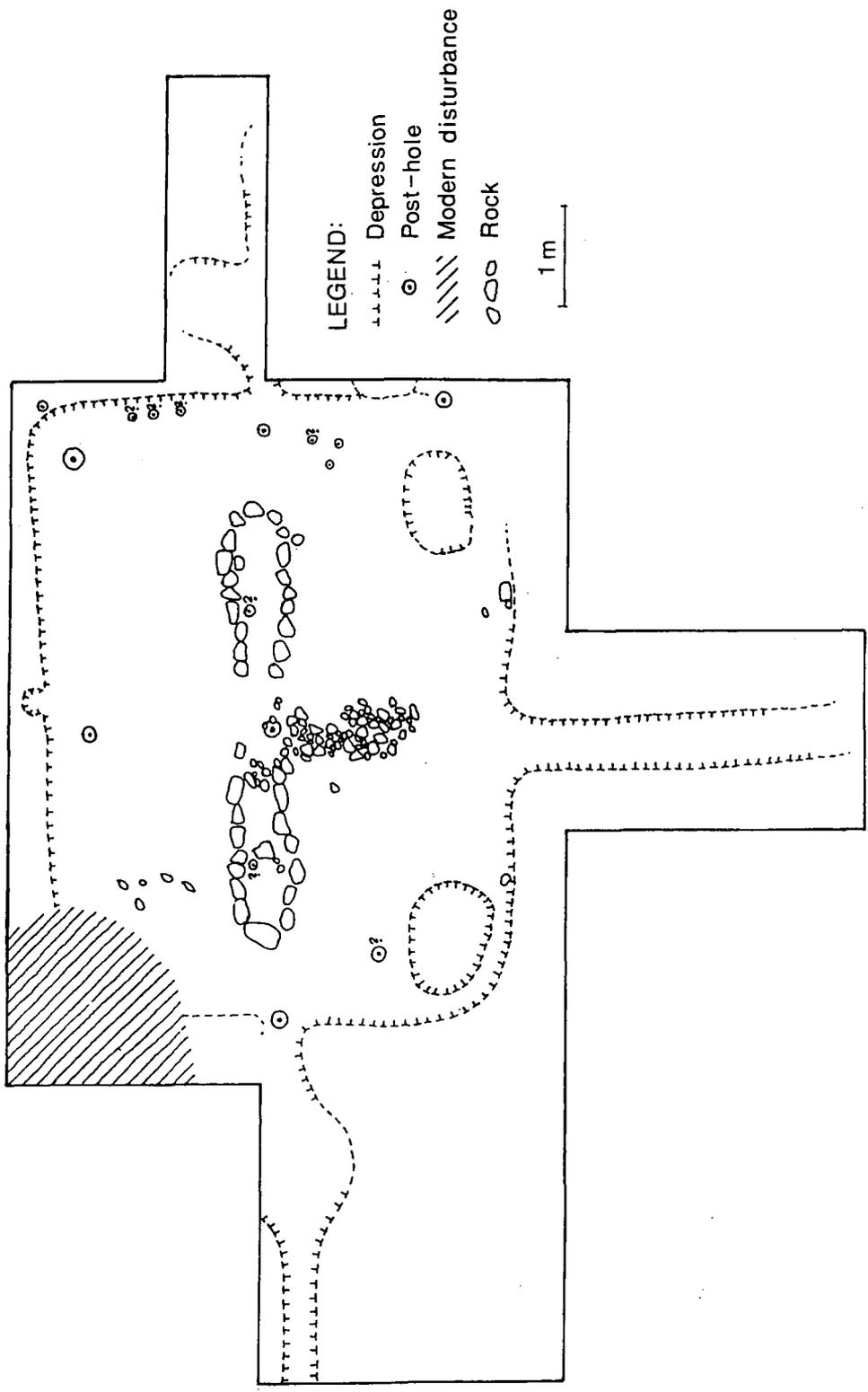
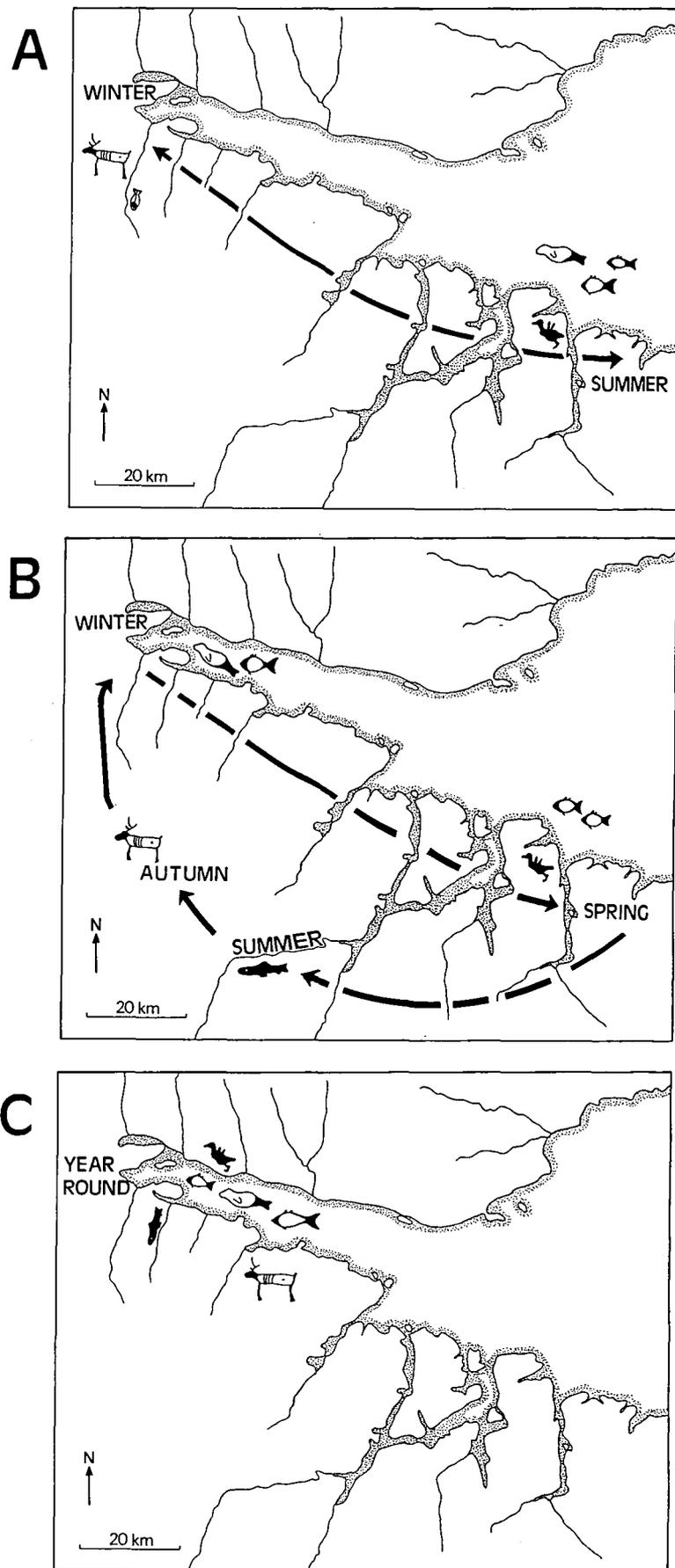
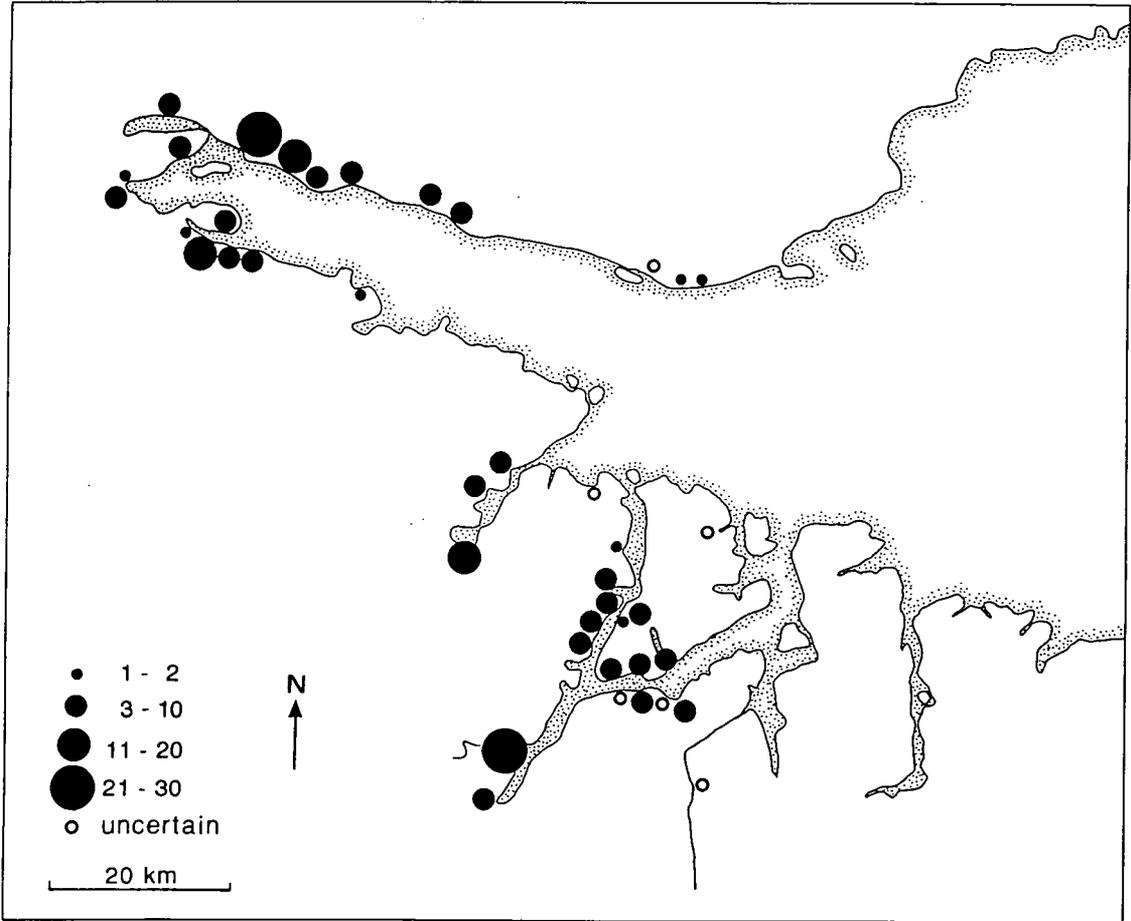


Figure 3.5 Gressbakken-type house; Kalkillebukta 7 is illustrated (after Schanche 1994: Figure 14)



**Figure 3.6** Changing models of seasonal patterns in Younger Stone Age settlement and subsistence. A: Gjessing; B: Simonsen; C: Renouf



**Figure 3.7** Distribution of Gressbakken-type houses around Varangerfjord (from Schanche 1994: figure 37)

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D
<i>P. alle</i>	Little auk	*****											*****
<i>U. lomvia</i>	Brunnich's murre	*****											*****
<i>S. spectabilis</i>	King eider	*****											*****
<i>F. glacialis</i>	Fulmar	*****											*****
<i>L. lagopus</i>	Willow grouse	*****											*****
<i>U. aalge</i>	Guillemot												*****
<i>A. torda</i>	Razorbill												*****
<i>P. impennis</i>	Great auk												*****
<i>F. arctica</i>	Puffin												*****
<i>L. canus</i>	Common gull												*****
<i>L. fuscus</i>	Lesser black gull												*****
<i>L. marinus</i>	Greater black back gull												*****
<i>C. cygnus</i>	Whooper swan												*****
<i>P. groenlandica</i>	Harp seal												*****
<i>P. hispida</i>	Ringed seal	*****											*****
<i>P. vitulina</i>	Harbour seal												*****
<i>H. grypus</i>	Grey seal												*****
<i>E. barbatus</i>	Bearded seal												*****
<i>L. albirostris</i>	White-nosed dolphin												*****
Small game		*****											*****
<i>R. tarandus</i>	Reindeer												*****
% of fish species													*****

**Figure 3.8** Seasonal availability of fauna from the northwest midden at Gressbakken House 4 (after Renouf 1989, Figure 8.11)

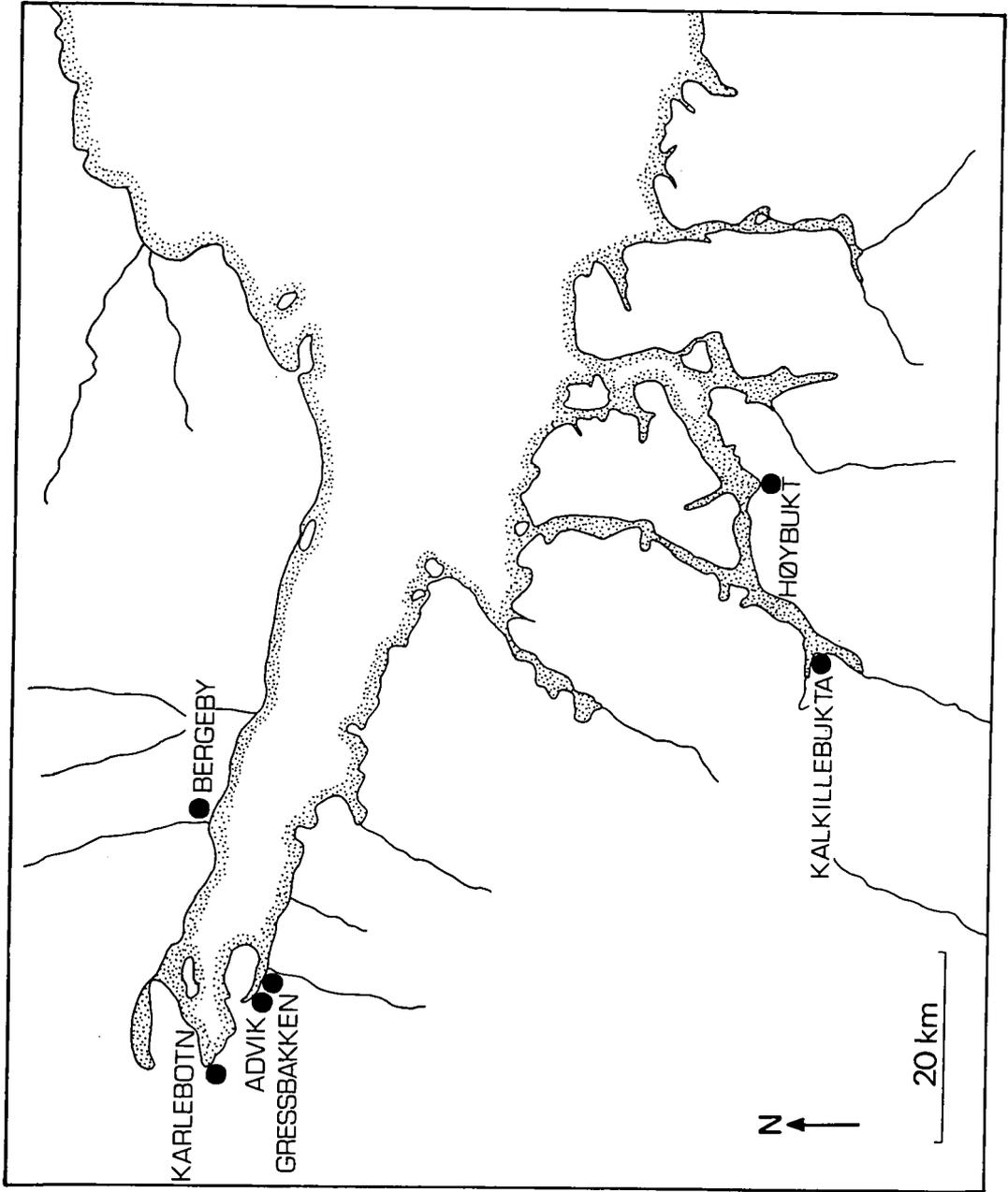
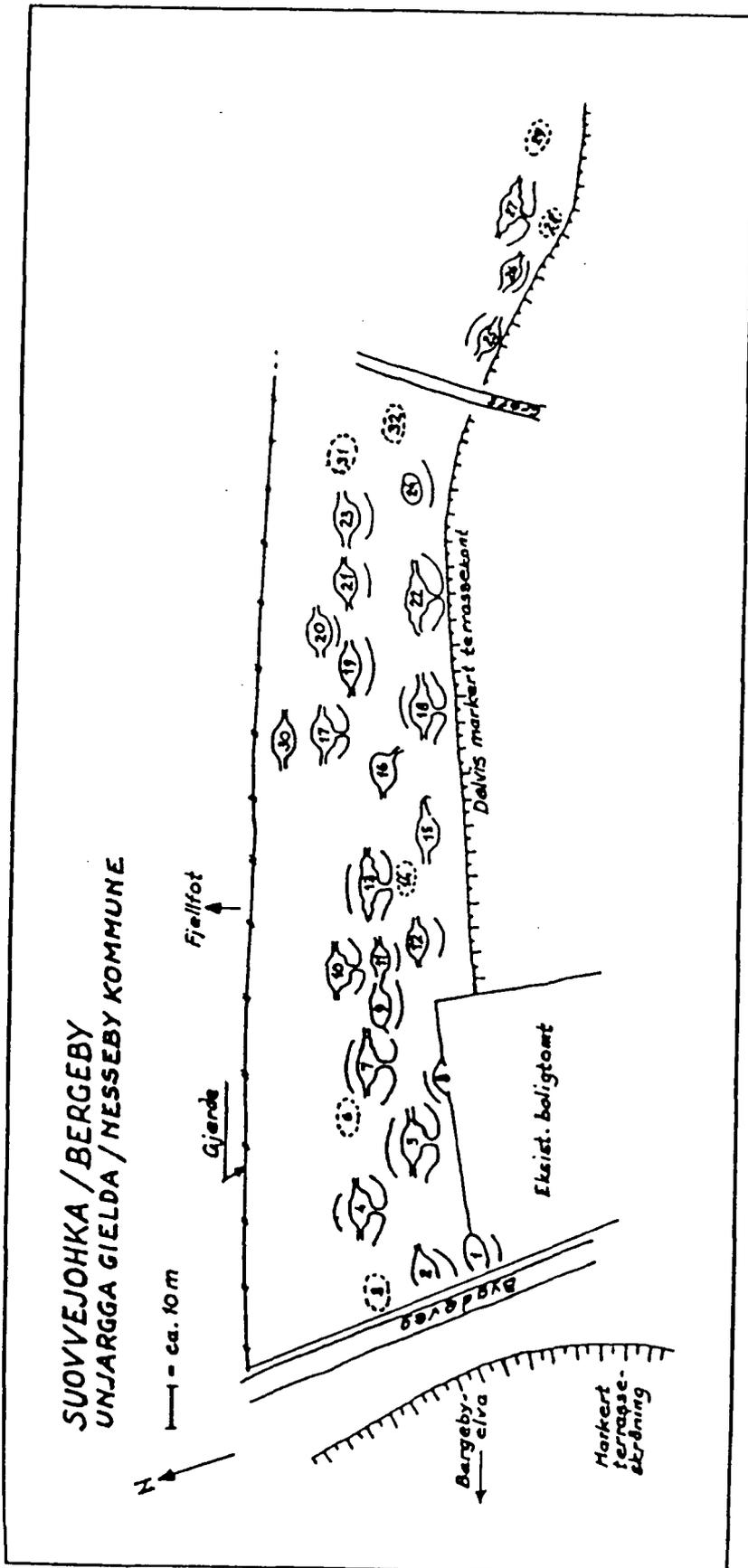
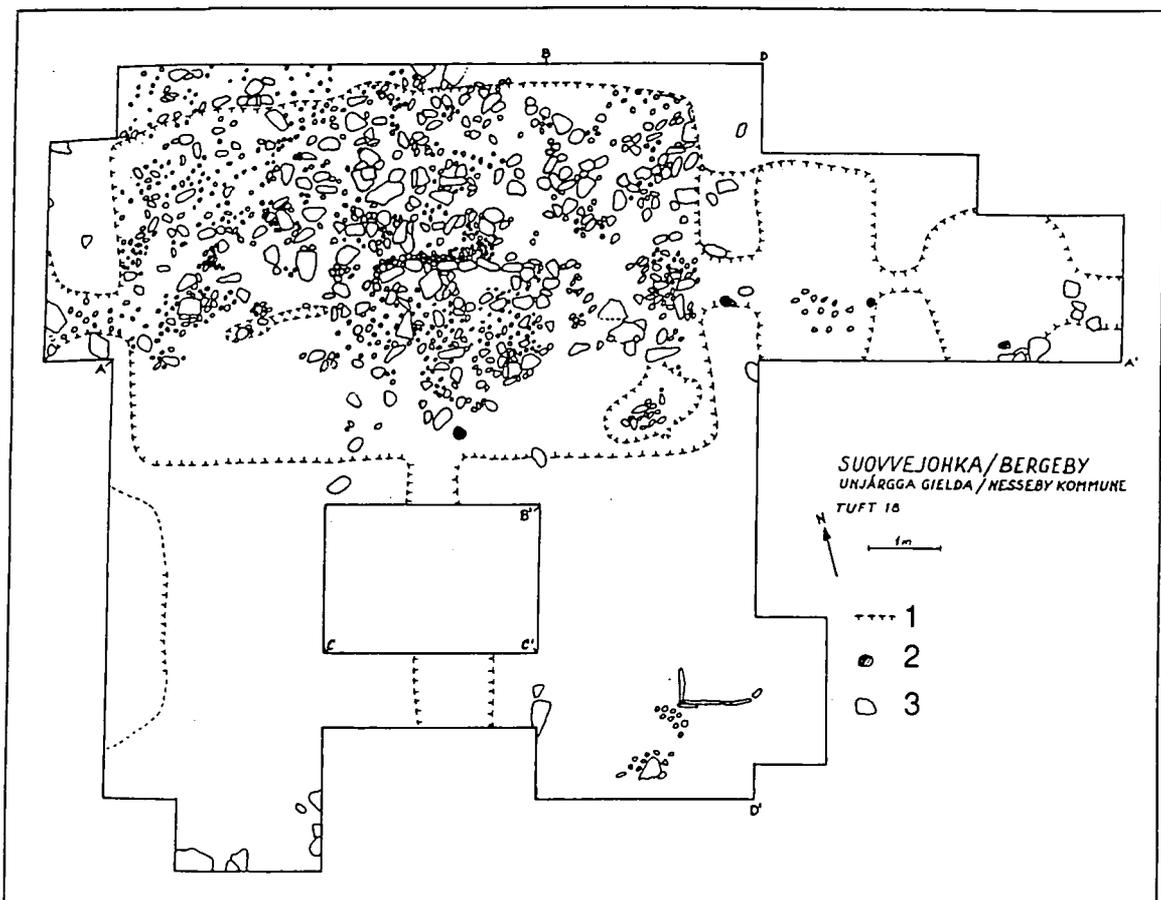


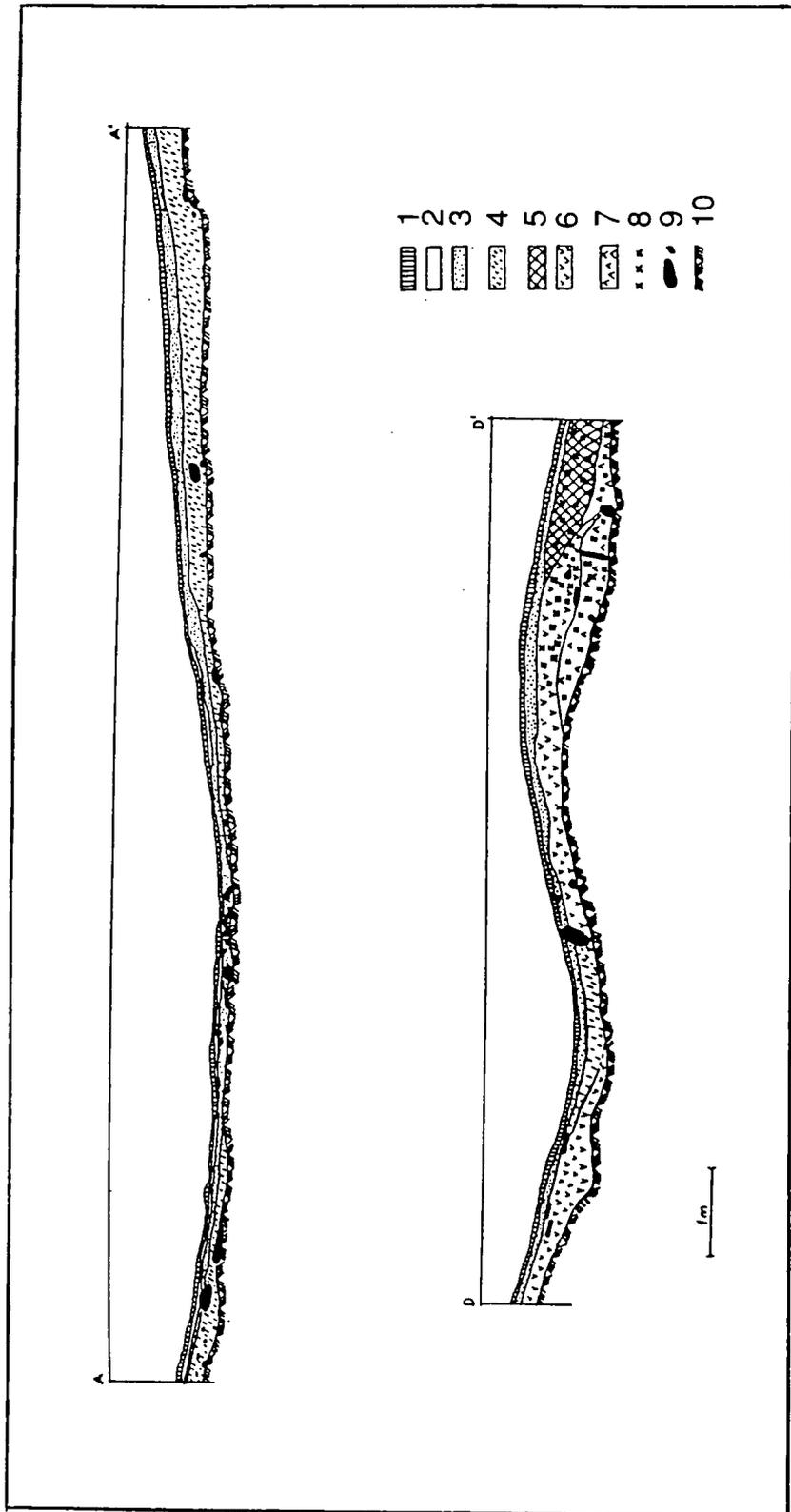
Figure 4.1 Map of Varangerfjord showing location of sites in the study sample



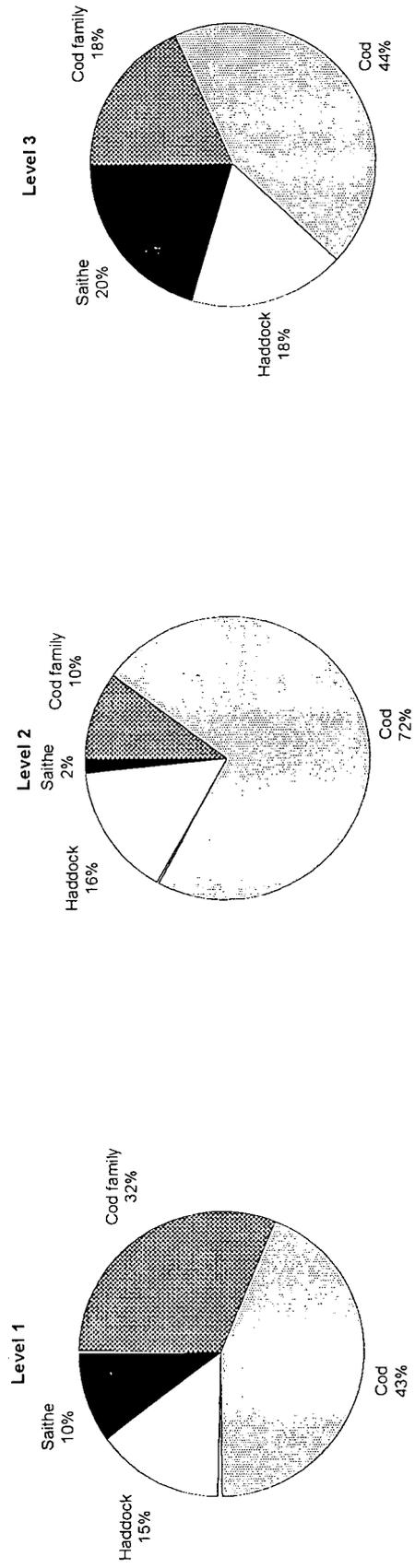
**Figure 4.2** Site map of Bergeby (from Schanche 1994: figure 5)  
 translations: *Bergebyelva*=Bergeby River; *Markert terrasse skråning*=steep slope; *Bygdeveg*=dirt road; *Eksist. Boligomt*=existing building; *Gjærde*=fence; *Fjellfot*=cliff-base; *Delvis markert terrassekant*=partly marked terrace edge; *Grøft*=ditch



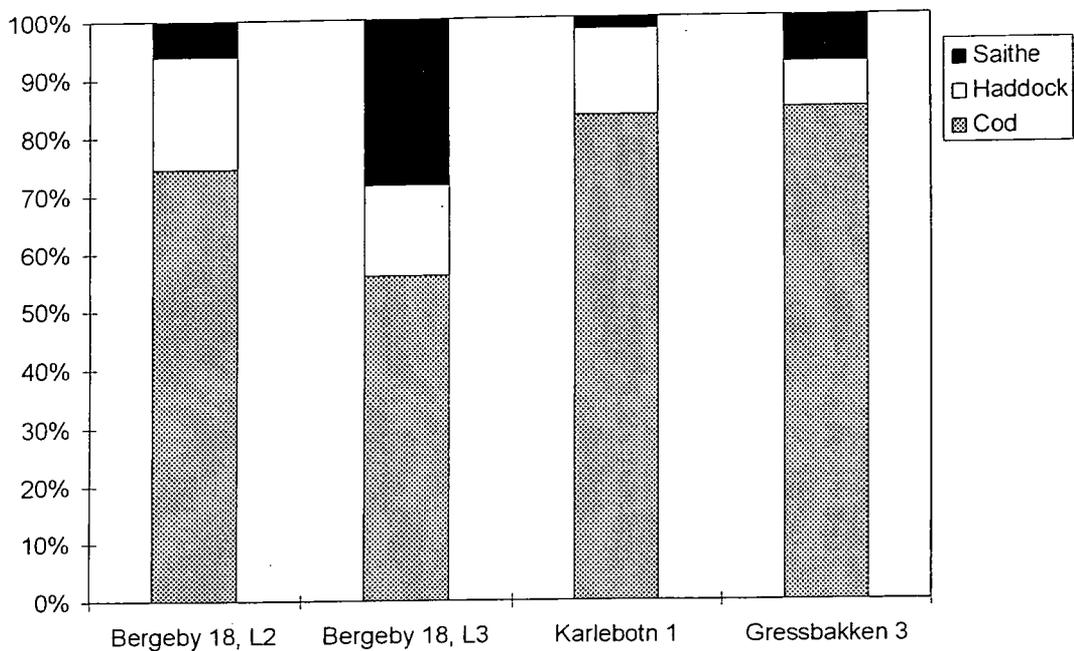
**Figure 4.3** Plan of excavations at Bergeby 18 (from Schanche 1994: figure 8)  
Legend: 1=depression; 2=possible post-hole; 3=stone



**Figure 4.4** Section drawings of Bergeby 18 (from Schanche 1994: figure 7)  
 Legend: 1=peat; 2=whitish soil; 3=reddish-brown gravel with some charcoal and fire-cracked rock; 4=brownish gravel with some charcoal and fire-cracked rock; 5=black soil with gravel; 6=dark brown gravel with soil and fire-cracked rock; 7=loose small-pebbled gravel; 8=preserved shell and bone; 9=stone; 10=undisturbed sub-soil/sterile sand and gravel



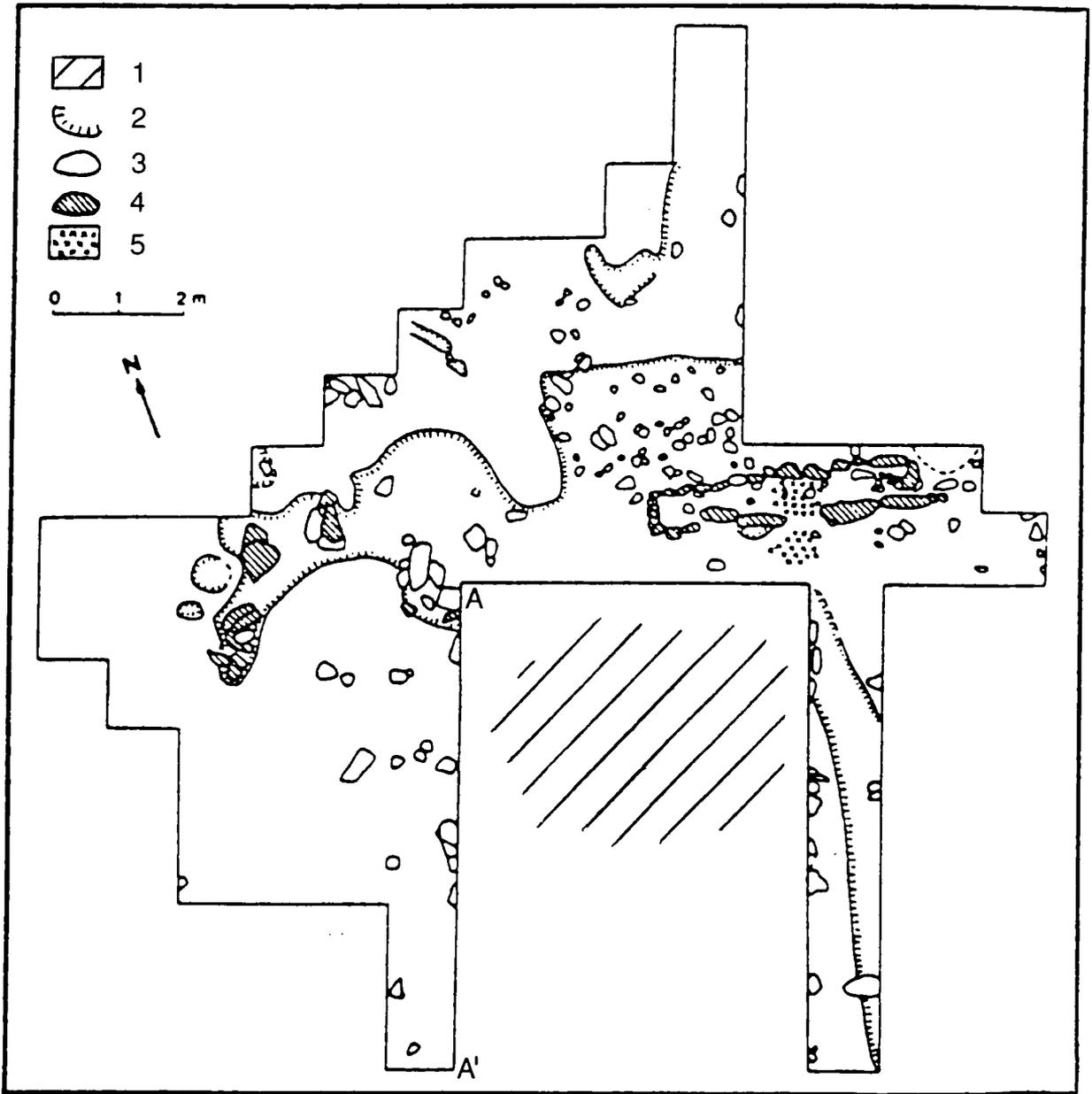
**Figure 4.5** Relative importance of the major fish taxa in levels 1, 2 and 3 of the south-east midden at Bergeby 18



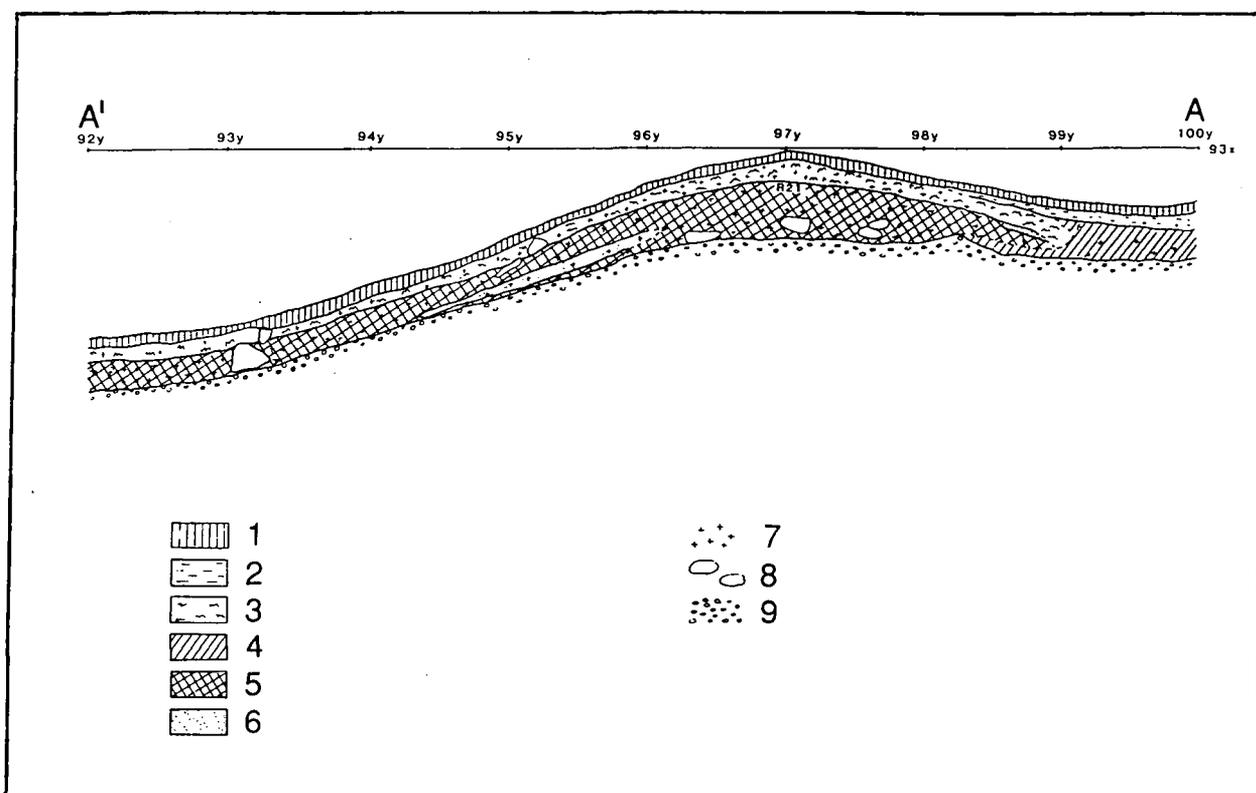
**Figure 4.6** Relative importance of cod, haddock and saithe at Bergeby, Karlebotnbakken and Gressbakken 3

notes: 1) values from Bergeby are for south-east and south-west middens combined

2) Bergeby 18 was the only site where a cod family (Gadidae) category was identified as well as the cod species *Gadus morhua*. Both taxa are here included in the "cod" category to make the values from Bergeby more comparable to those from the other sites. This may mean that the Bergeby cod are slightly over-represented in the figure.

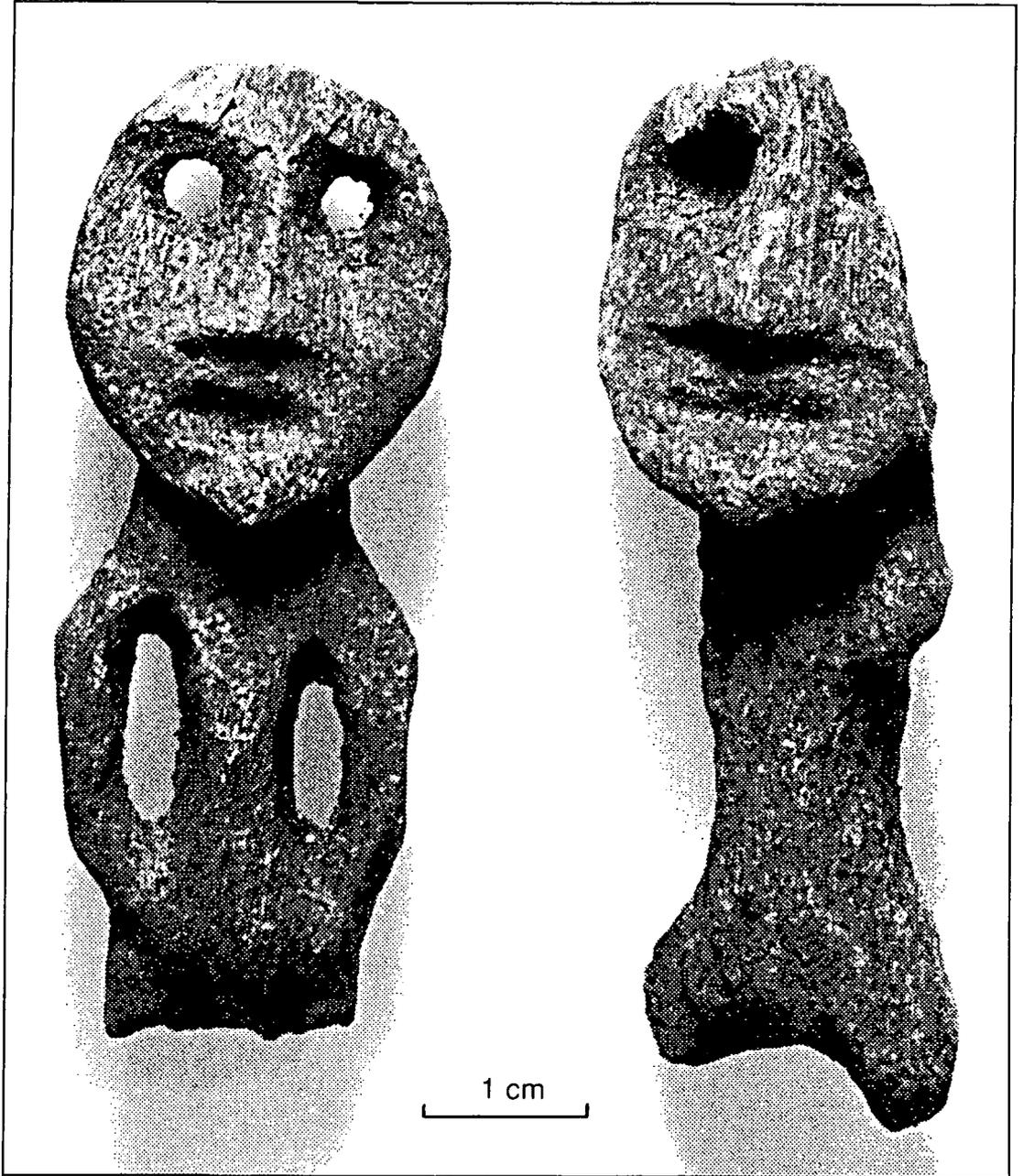


**Figure 4.7** Plan of excavations at Karlebotn 1 (from Schanche 1994: figure 22)  
 Legend: 1=modern disturbance; 2=depression; 3=stone; 4=stone set on edge;  
 5=concentration of cooking stones



**Figure 4.8** Section drawing of seaward mound at Karlebotn 1 (from Schanche 1986: figure 2)

Legend: 1=peat; 2=grey-brown sandy gravel; 3=dark brown gravelly cultural layer with some bone; 4=light brown gravelly cultural layer; 5=midden rich in bone, shell and cooking stones; 6=ash; 7=cooking stones; 8=stone; 9=sterile gravel substrate



**Figure 4.9** Antler figurines from Karlebotn 1 (from B. Olsen 1994: figure 53)

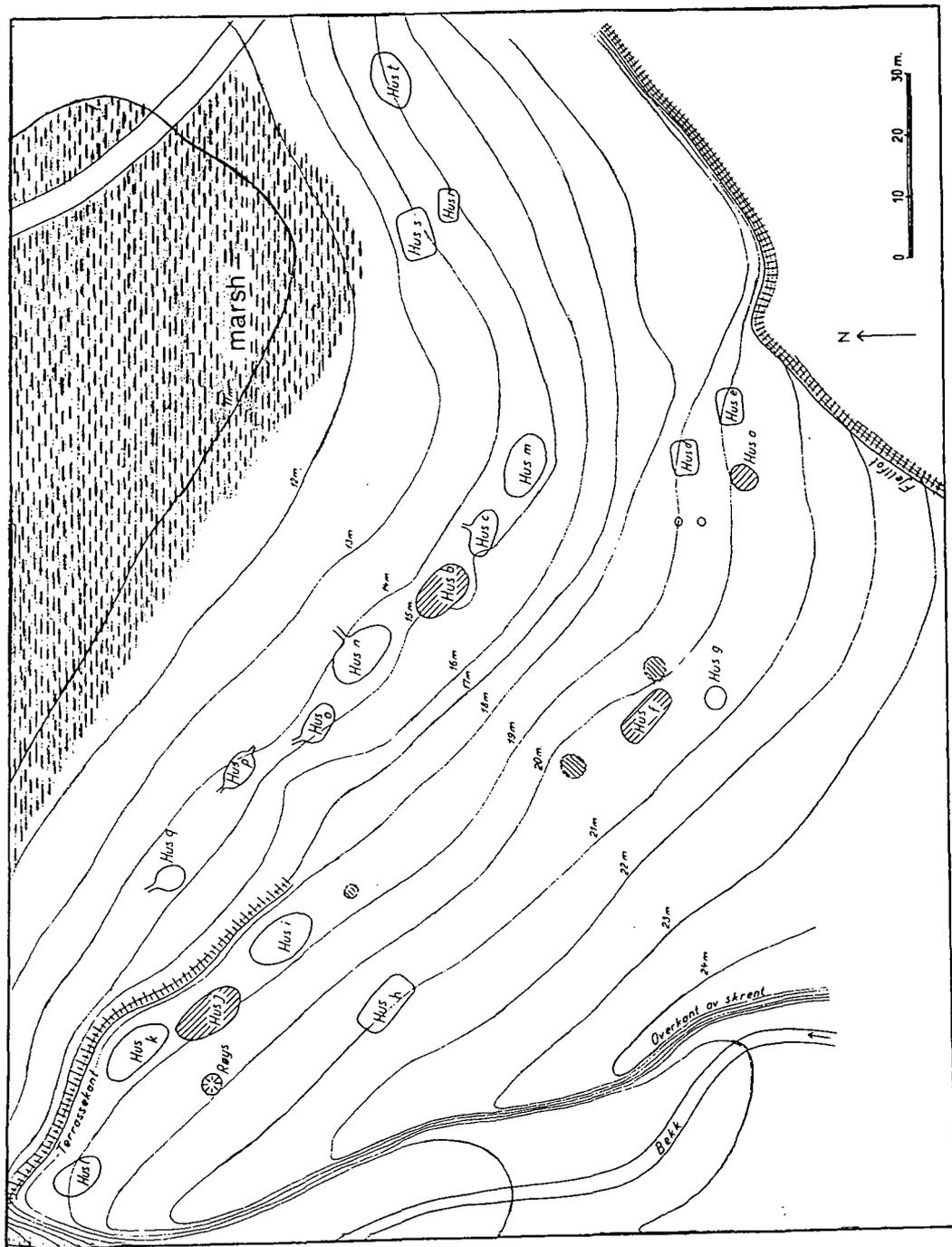
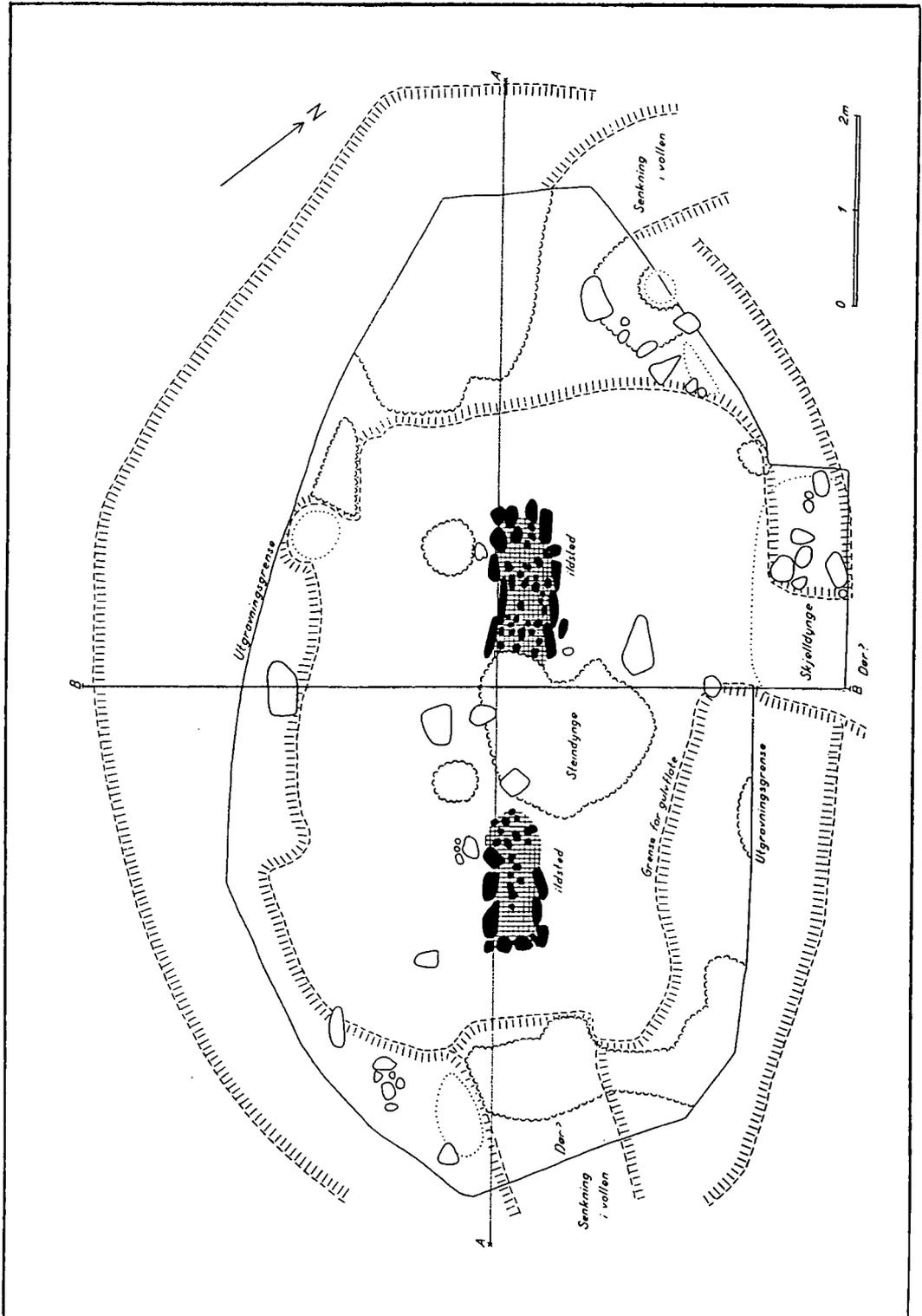
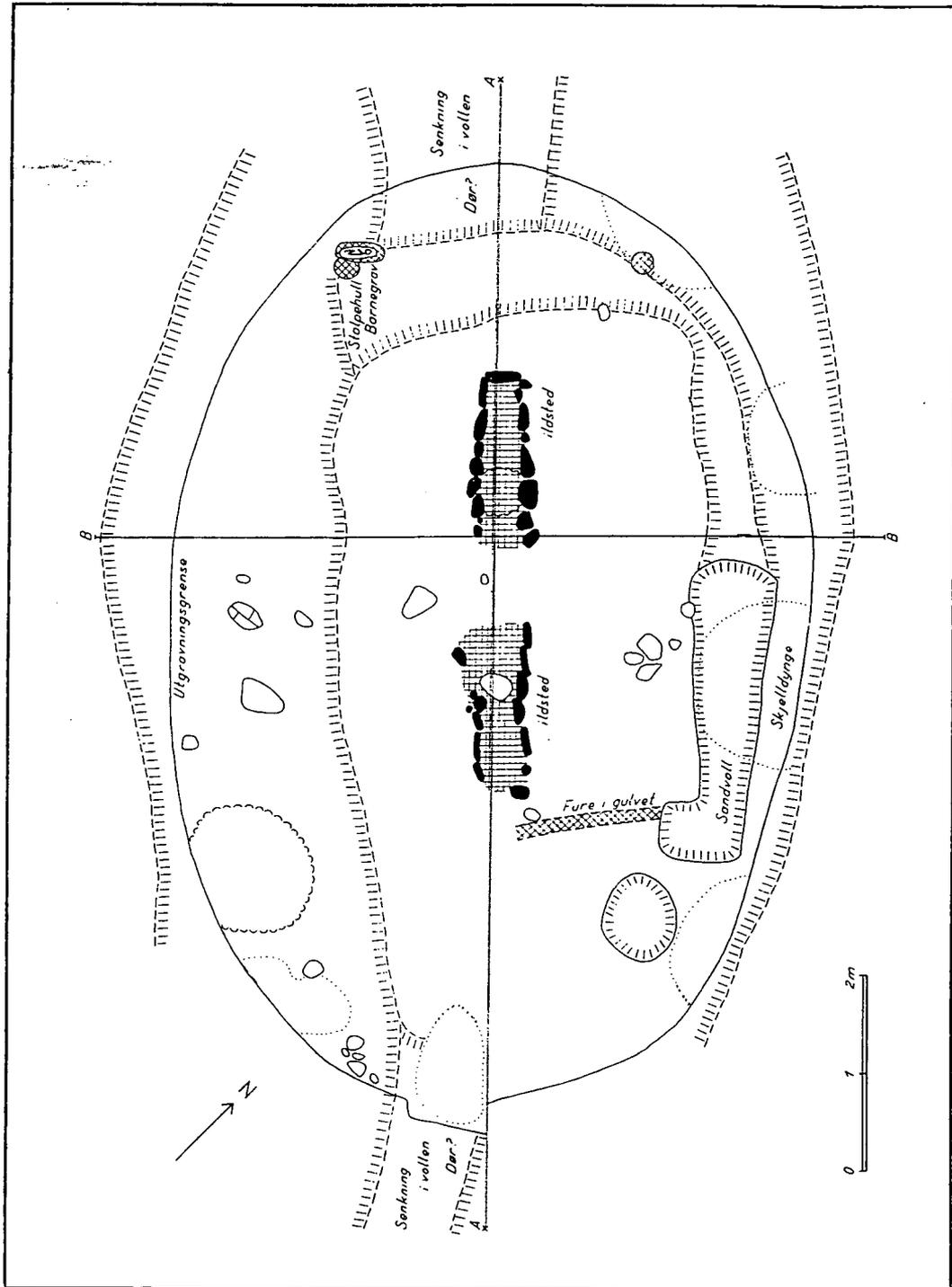


Figure 4.10 Site map of Advik (from Simonsen 1961: figure 86)

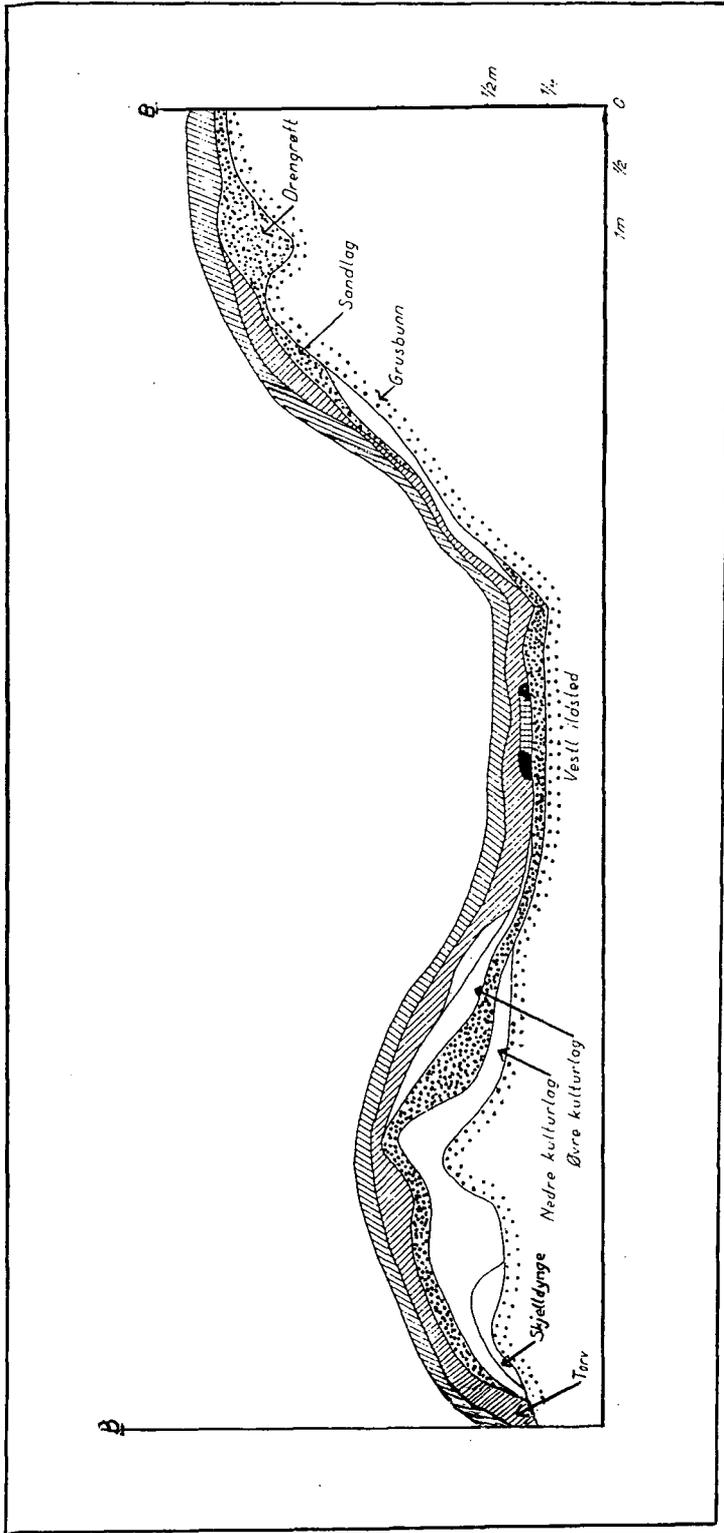


**Figure 4.11** Excavation plan of Advik B (from Simonsen 1961: figure 100)  
 Translations: *Senkning i vollen*=depression in mound; *Dør*=door; *ildsted*=hearth; *stendyngje*=stone pile; *Grense for gulyflate*=edge of house floor; *Ulgravningsgrense*=limit of excavation; *Skjeldyngje*=shell-midden

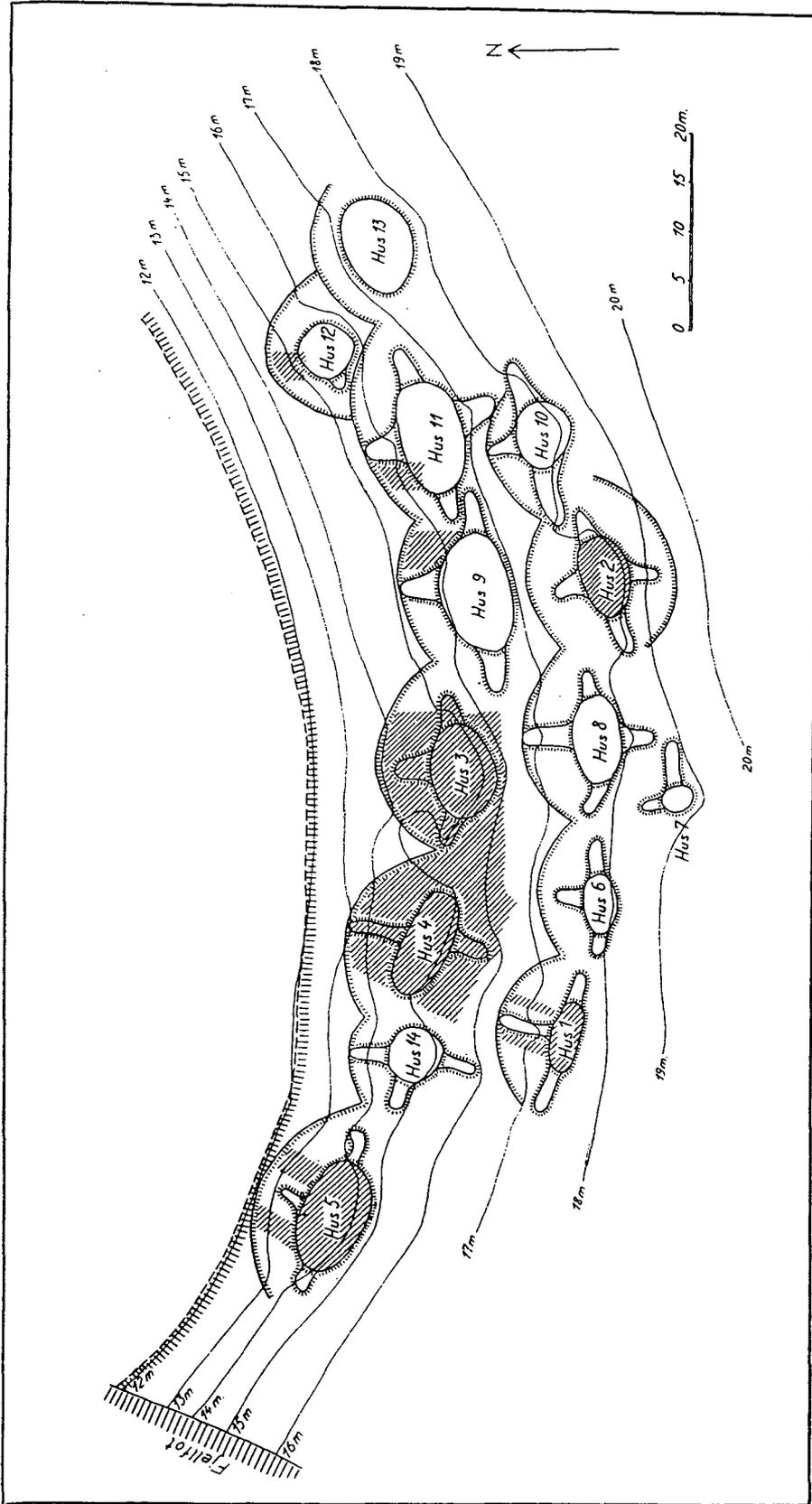


**Figure 4.12** Excavation plan of Advik J (from Simonsen 1961: figure 100)

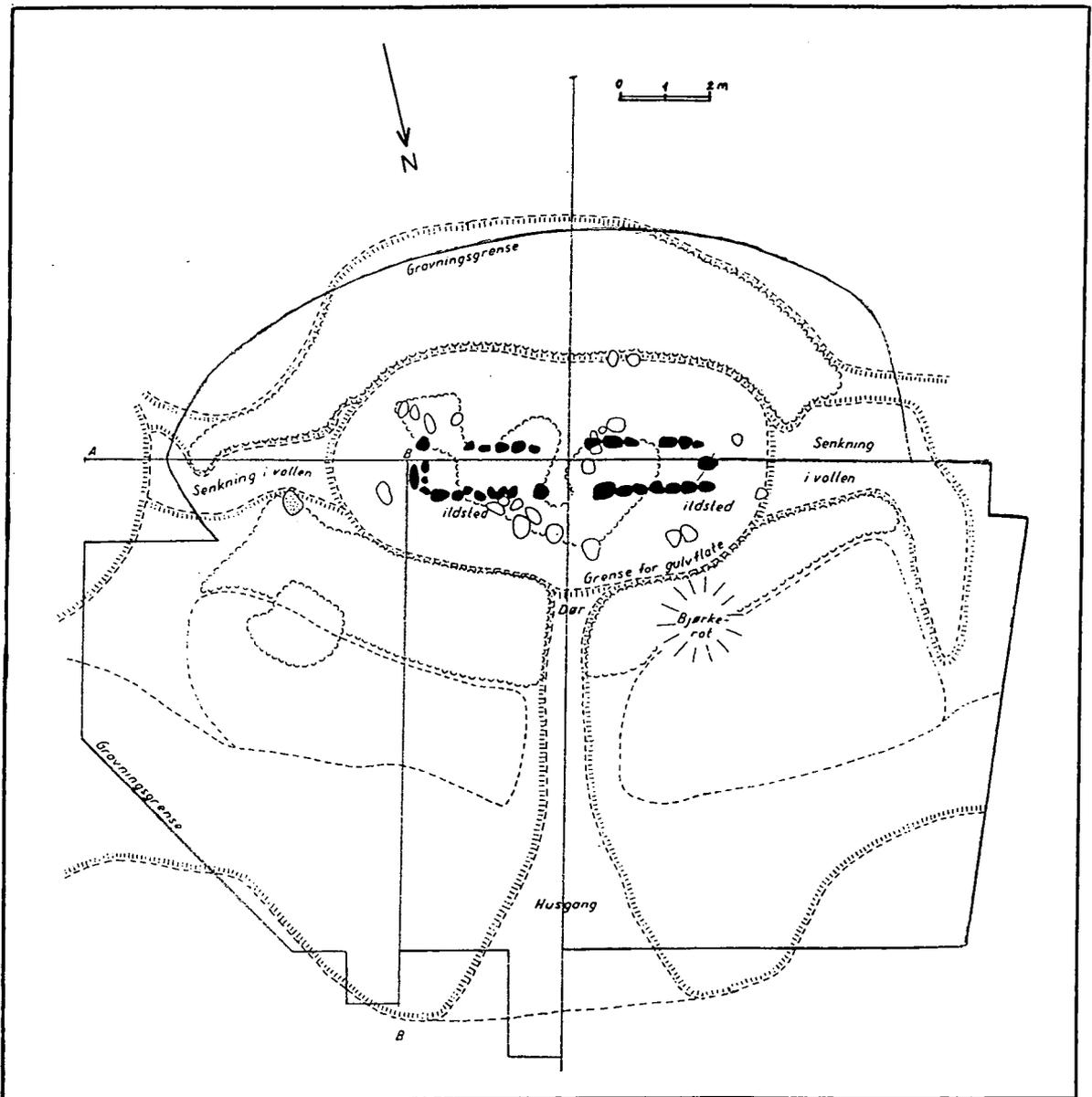
Translations: *Senkning i vollen*=depression in mound; *Dør*=door; *ildsted*=hearth; *Fure i gulvet*=channel in floor; *Sandvoll*=sand bank; *Skjelldyng*=shell-midden; *Utgravningensgrense*=limit of excavation



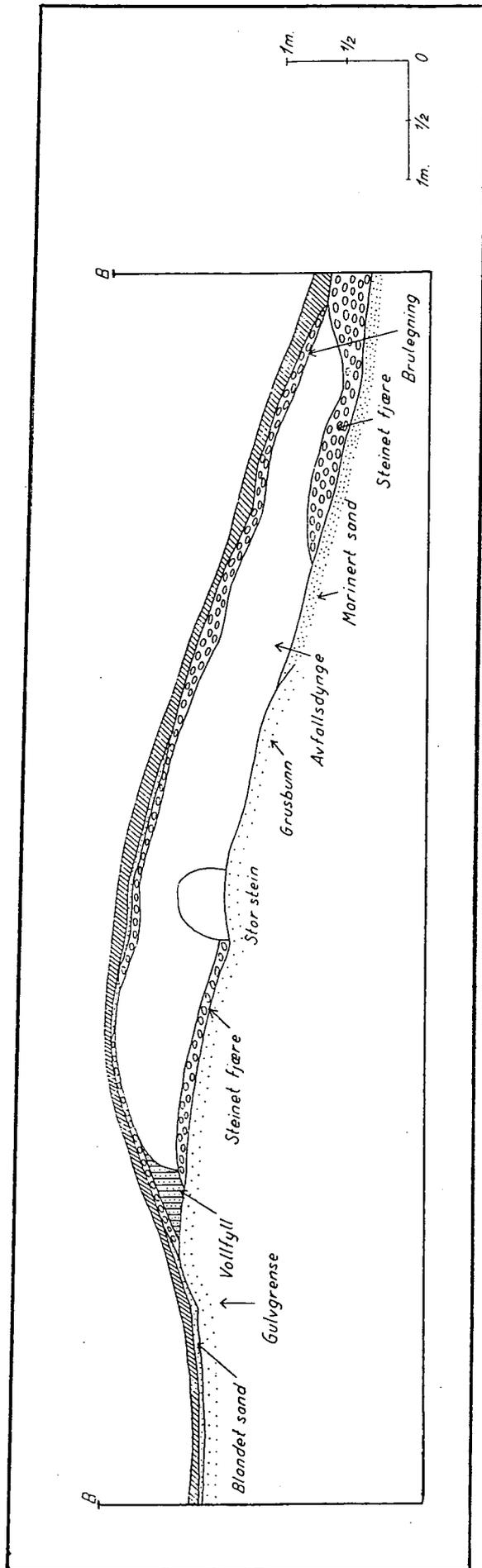
**Figure 4.13** Section drawing of Advik J (from Simonsen 1961: figure 101)  
 Translations: *Torv*=peat; *Skjelledyngje*=shell-midden; *Nedre kulturlag*=lower culture-layer; *Øvre kulturlag*=upper culture-layer;  
*Vestl. ildsted*=western hearth; *Grusbunn*=gravel substrate; *Sandlag*=sand layer; *Drenggrøft*=drainage ditch



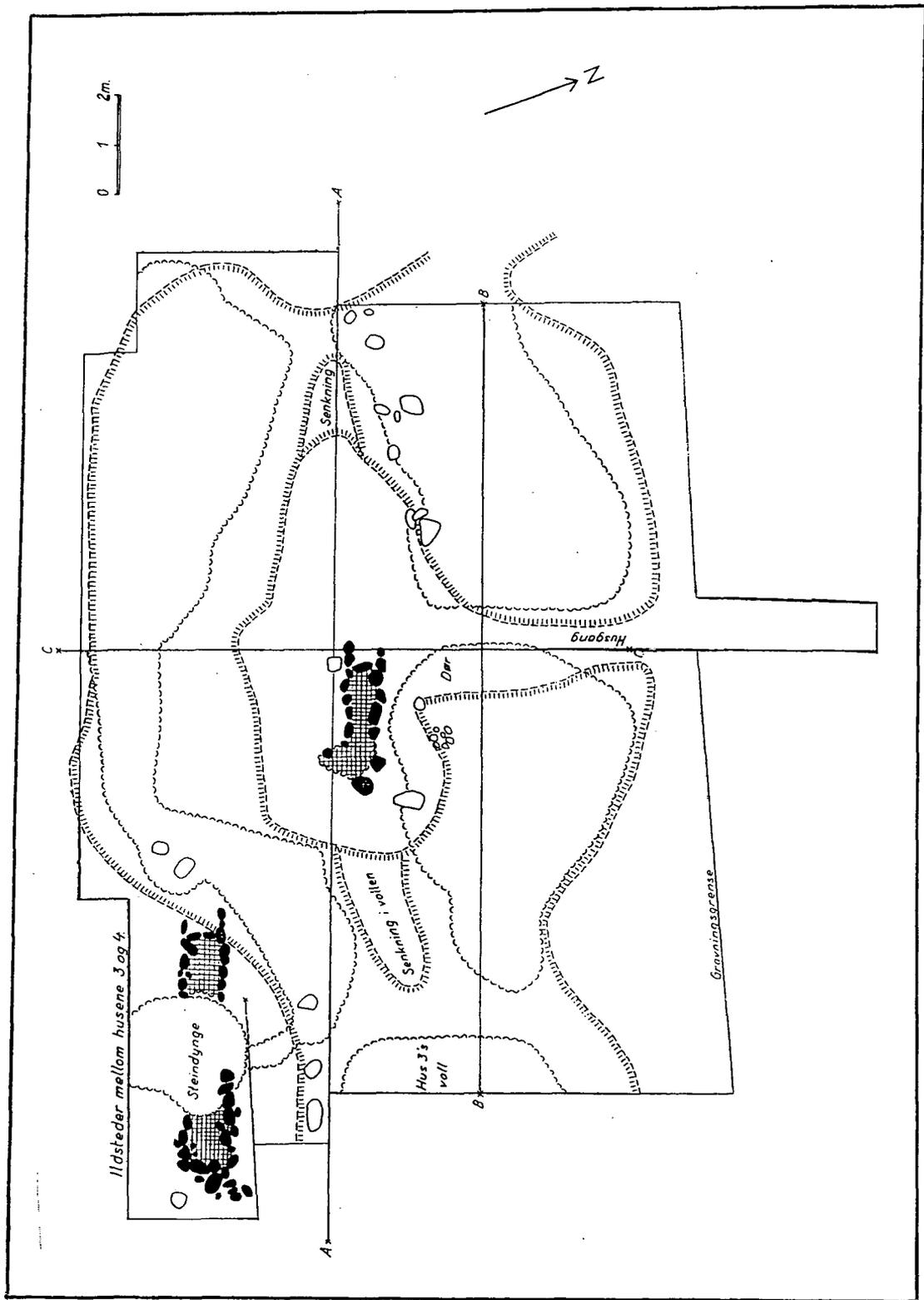
**Figure 4.14** Site map of Gressbakken Nedre Vest (from Simonsen 1961: figure 111)  
 note: Hatching indicates excavated area



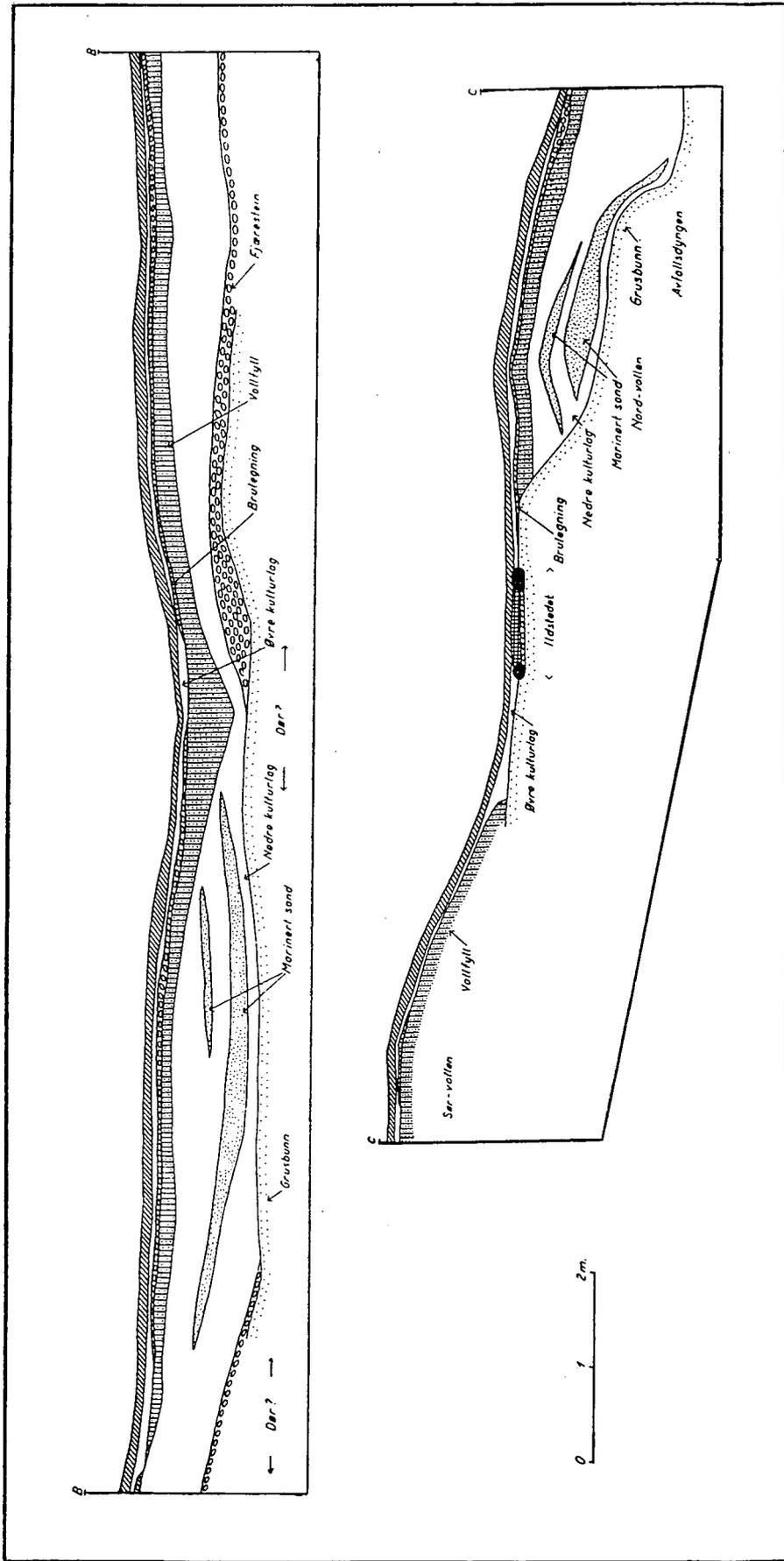
**Figure 4.15** Excavation plan of Gressbakken 3 (from Simonsen 1961: figure 124)  
 Translations: *Senkning i vollen*=depression in mound; *ildsted*=hearth; *Grense for gulvflate*=edge of house floor; *Dør*=door; *Husgang*=entrance passage; *Bjørkerot*=birch stump; *Gravningsgrense*=limit of excavation



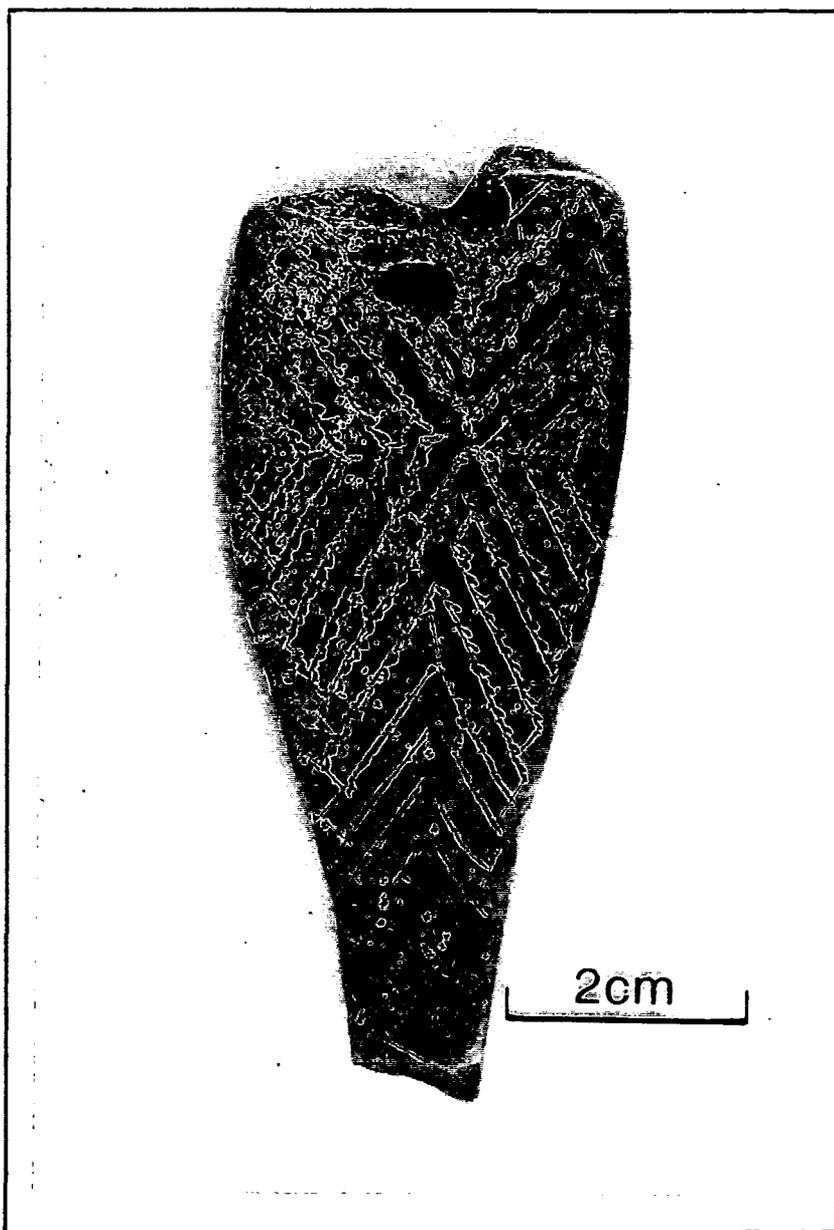
**Figure 4.16** Section drawing of north-eastern mound at Gressbakken 3 (from Simonsen 1961: figure 125)  
 Translations: *Blandet sand*=mixed sand; *Gulvgrense*=edge of house floor; *Vollfyll*=collapsed wall; *Steinet fjære*=small pebbled gravel; *Stor stein*=large stone; *Grusbunn*=gravel substrate; *Avfallsdyngje*=midden; *Marinert sand*=marine sand; *Brulegning*=pavement (compact gravel?)



**Figure 4.17** Excavation plan of Gressbakken 4 and outdoor hearth (from Simonsen 1961: figure 135)  
 Translations: *Ildsteder mellom husene 3 og 4*=hearths between houses 3 and 4; *Steindyngje*=stone pile; *Hus 3's voll*=House 3's mound; *Senkning i vollen*=depression in mound; *Dør*=door; *Husgang*=entrance passage; *Gravningsgrense*=limit of excavation



**Figure 4.18** Section drawings of Gressbakken 4 (from Simonsen 1961: figure 136)  
 Translations: *Dør*=door; *Grusbunn*=gravel substrate; *Marinert sand*=marine sand; *Nedre kultur-lag*=lower culture-layer; *Øvre kultur-lag*=upper culture-layer; *Brulegning*=pavement (compact gravel?); *Vollfyll*=wall-fill; *Fjærestein*=small-pebbled gravel; *Sør-vollen*=south mound; *Ildstedet*=hearth; *Nord-vollen*=north mound; *Avfallsdyngen*=midden



**Figure 4.19** Decorated bone artefact from Gressbakken 4

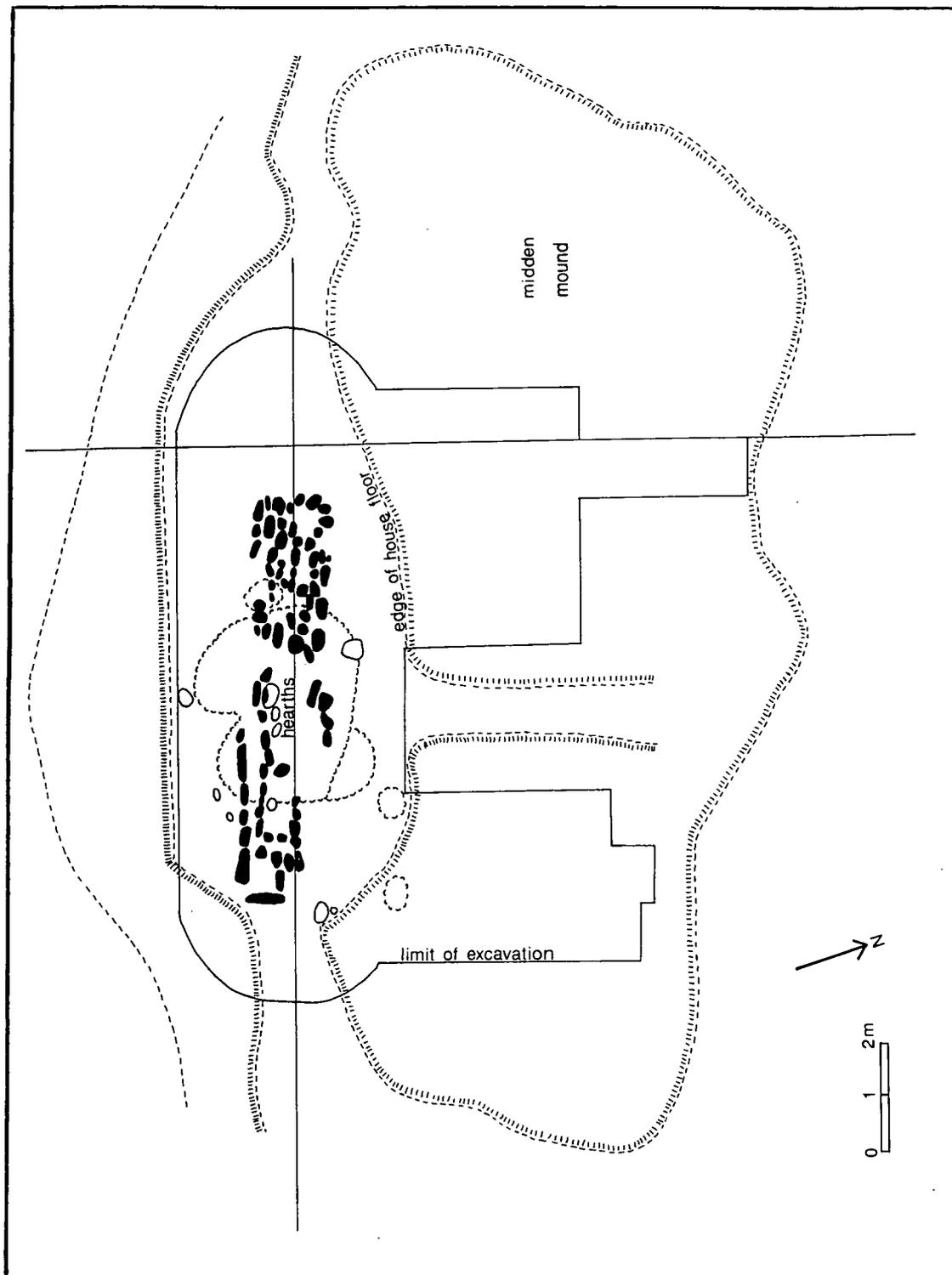


Figure 4.20 Excavation plan of Gressbakken 5 (redrawn from Simonsen 1961: figure 147)

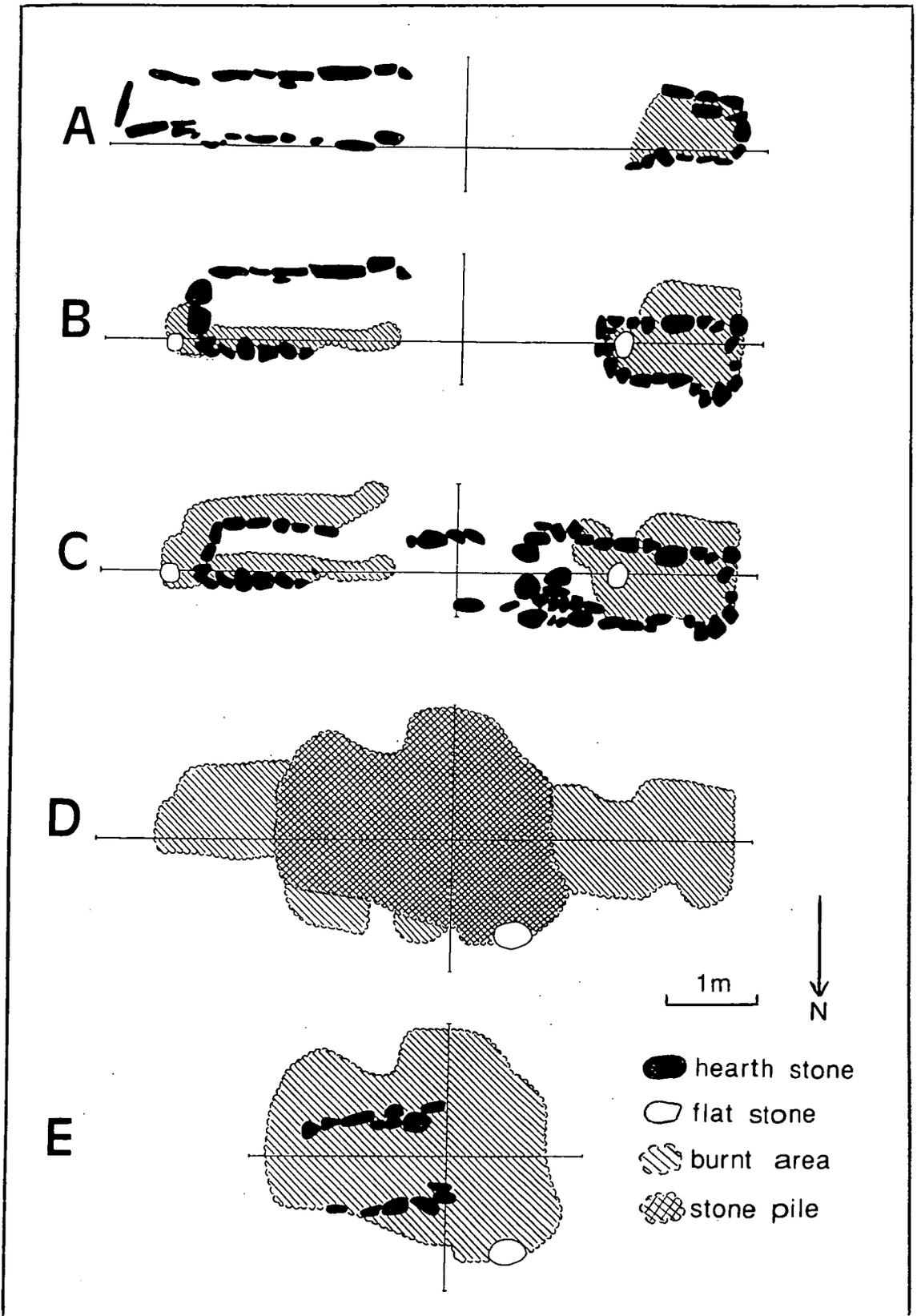
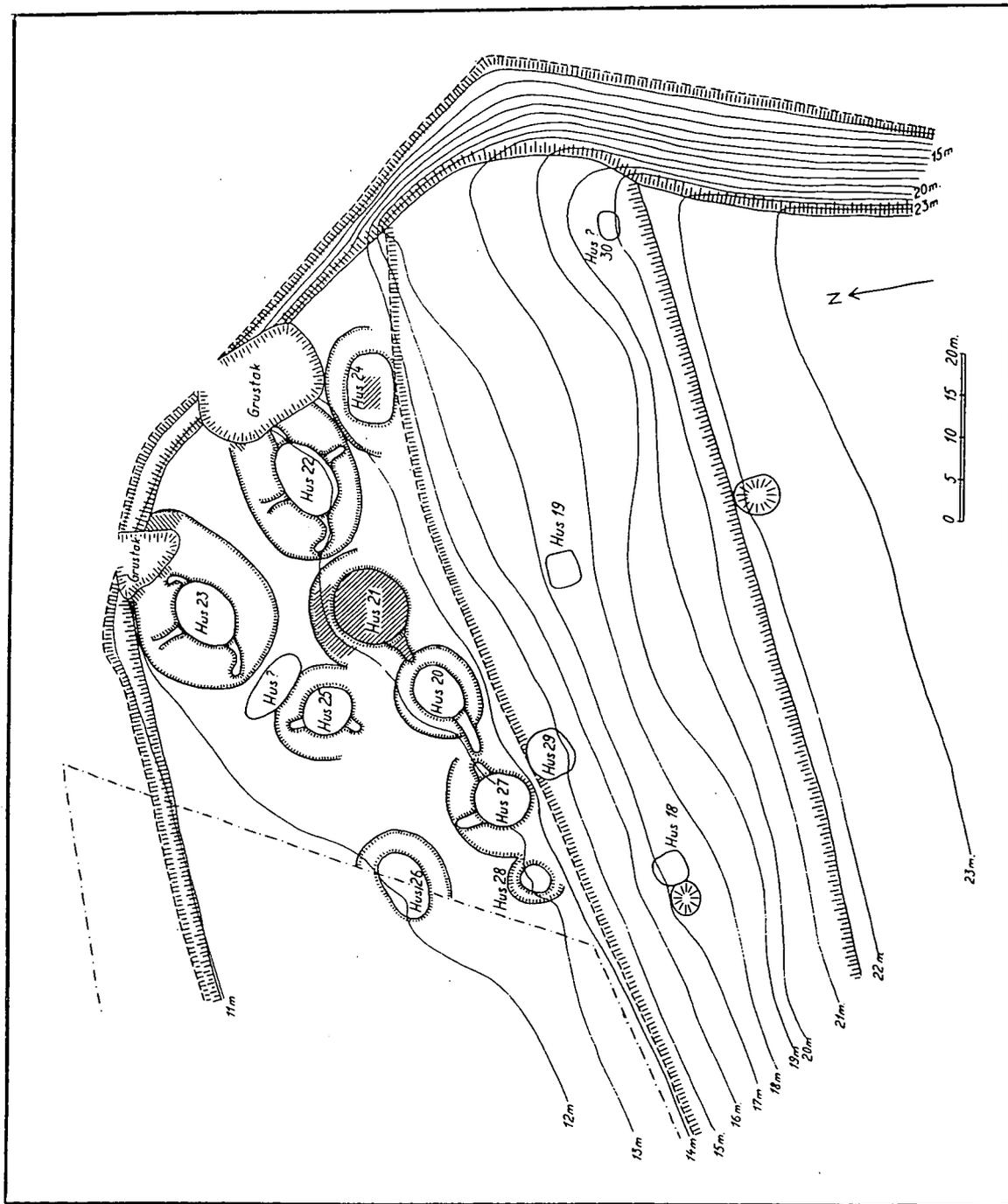
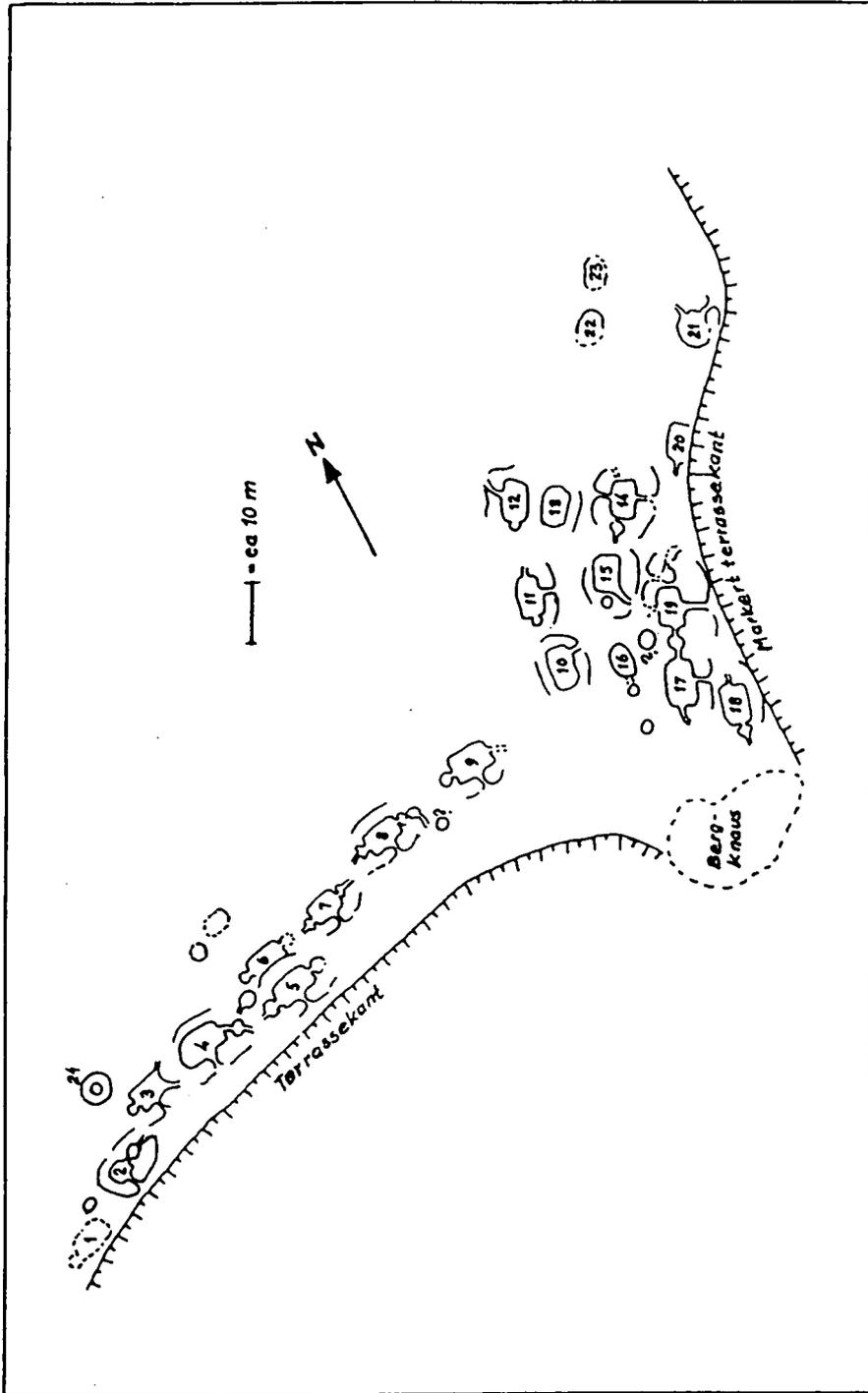


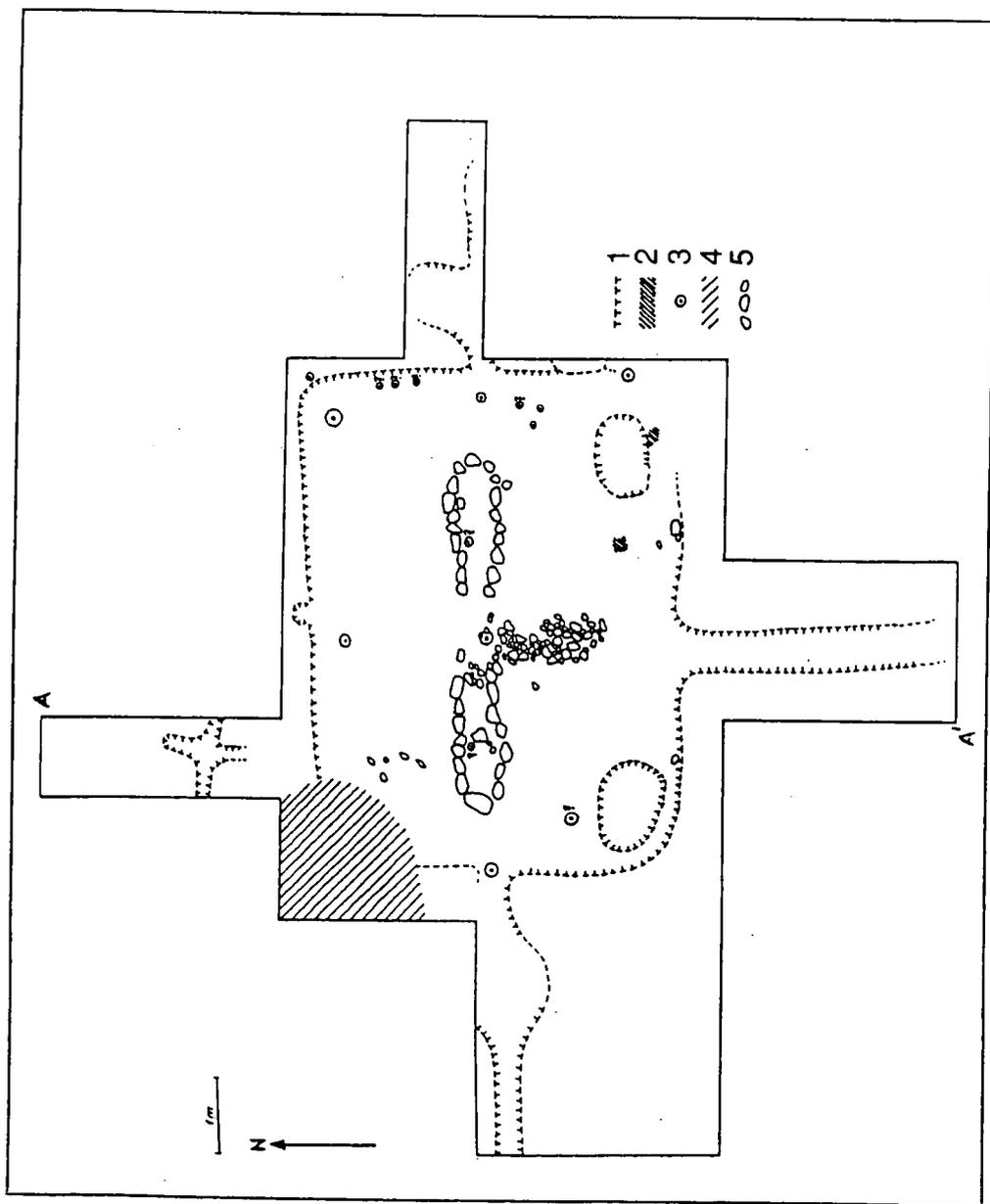
Figure 4.21 Sequence of hearths at Gressbakken 5 (after Simonsen 1961: figure 148)



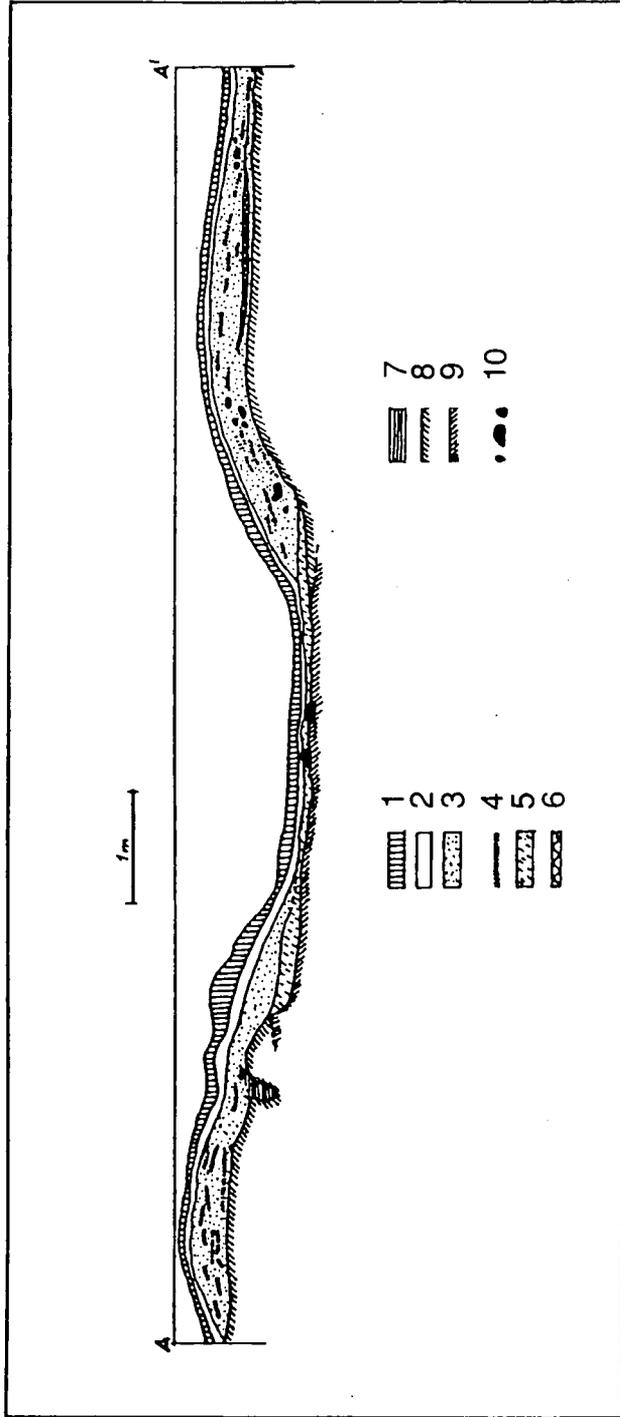
**Figure 4.22** Site map of Gressbakken Nedre Øst (from Simonsen 1961: figure 158)  
 note: hatching indicates excavated area



**Figure 4.23** Site map of Kalkillebukta (from Schanche 1994: figure 11)  
 Translations: *Terrasekant*=terrace edge; *Bergknaus*=rock outcrop; *Markert terrassekant*=sharp terrace edge

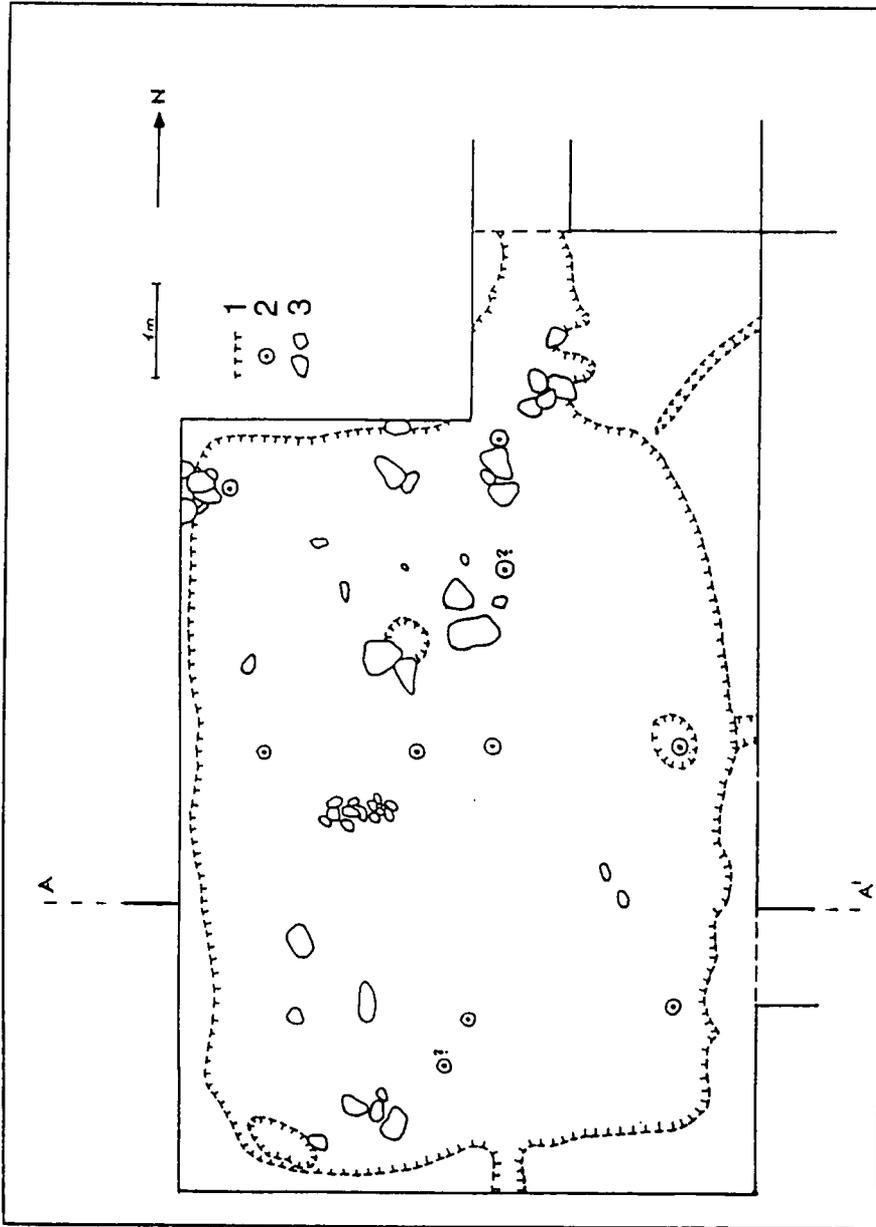


**Figure 4.24** Excavation plan of Kalkillebukta 7 (from Schanche 1994: figure 14)  
 Legend: 1=depression; 2=red ochre; 3=post-hole; 4=modern disturbance; 5=stone

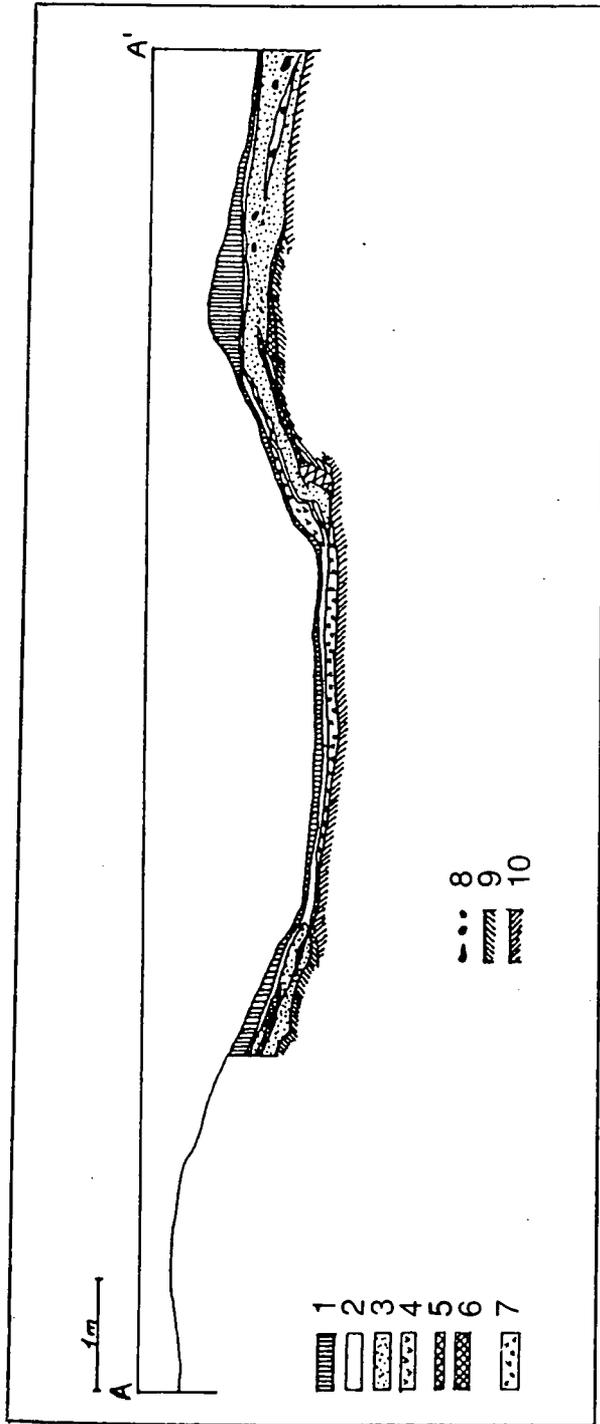


**Figure 4.25** Excavation plan of Kalkillebukta 7 (from Schanche 1994: figure 13)

Legend: 1=peat; 2=whitish soil; 3=yellowish-brown sand with some fire-cracked rock and charcoal; 4=dark brown lense (peat?); 5=grey-brown sand with charcoal; 6=rich brown sand (midden); 7=yellowish-brown sand; 8=undisturbed sterile yellow sand; 9=undisturbed sterile greyish-yellow sand; 10=stone

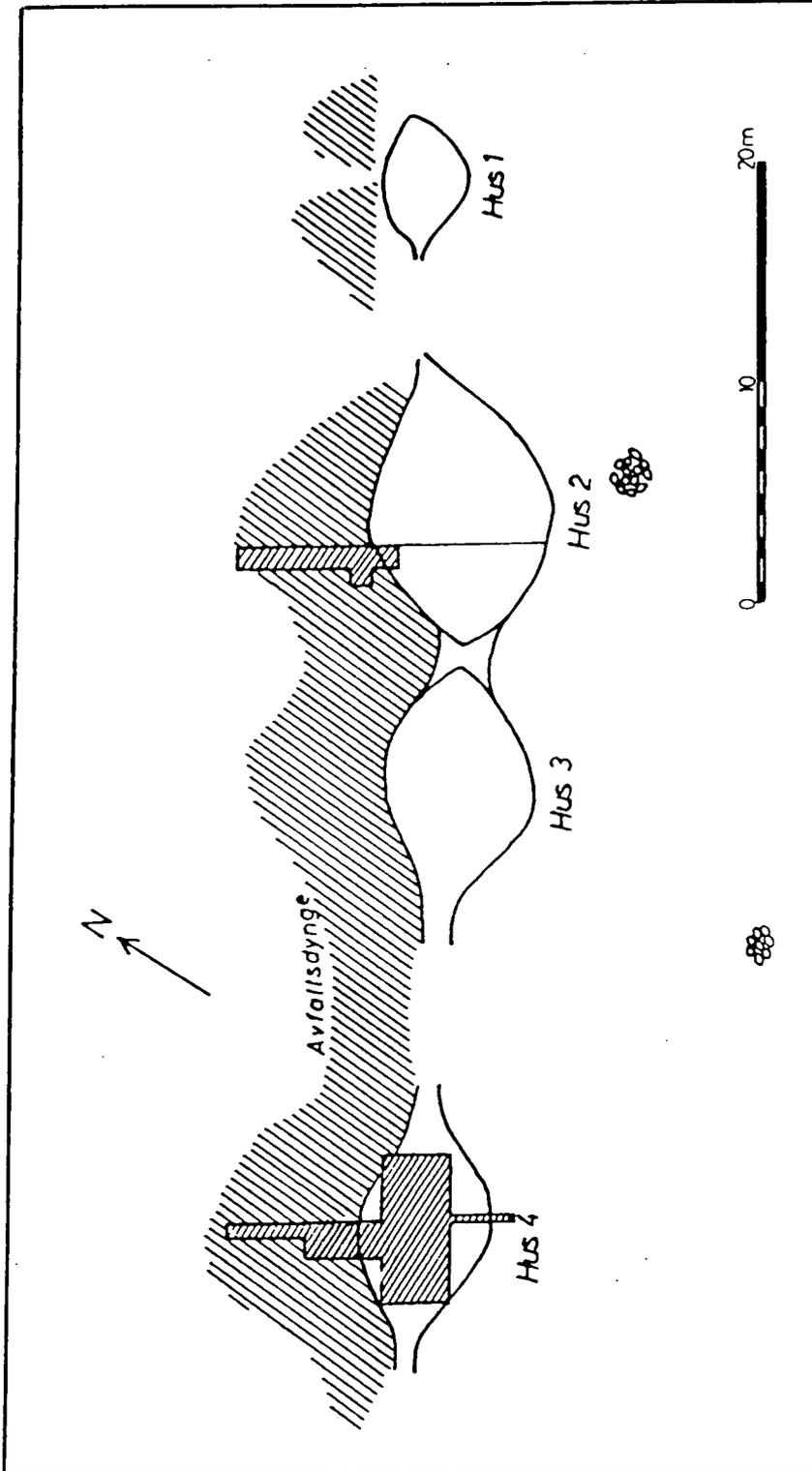


**Figure 4.26** Excavation plan of Kalkillebukta 17 (from Schanche 1994: figure 18)  
 Legend: 1=depression; 2=post-hole; 3=stone

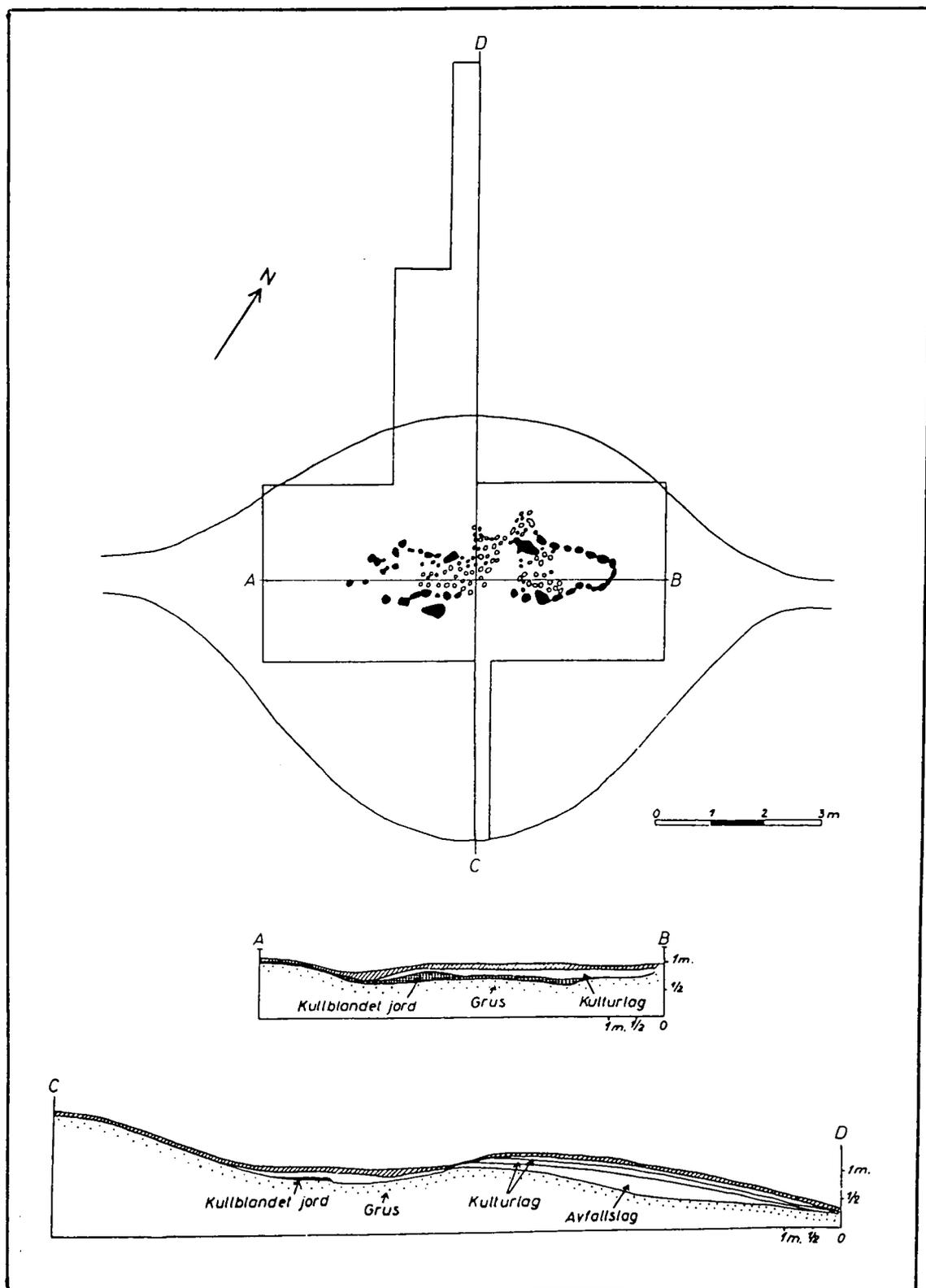


**Figure 4.27** Section drawing of Kalkillebukta 17 (from Schanche 1994: figure 17)

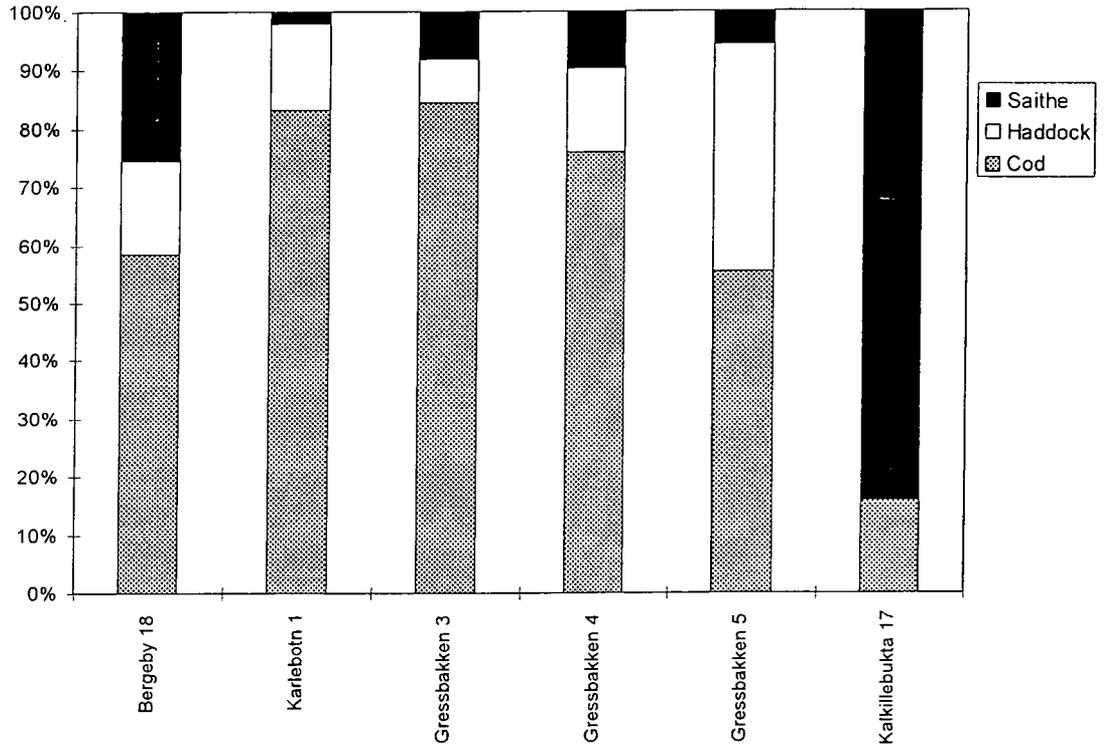
Legend: 1=peat; 2=whitish soil; 3=light brown soil with scattered charcoal; 4=grey sand; 5=rich, dark brown sand; 6=black soil with charcoal, shell and bone; 7=grey/light red sand with scattered charcoal; 8=stone; 9=undisturbed sterile yellow sand; 10=undisturbed grey/light red/ yellow mottled sand.



**Figure 4.28** Site map of Høybukt Southeast (from Simonsen 1963: figure 61)  
 Translation: *Avfallsdyng*=midden



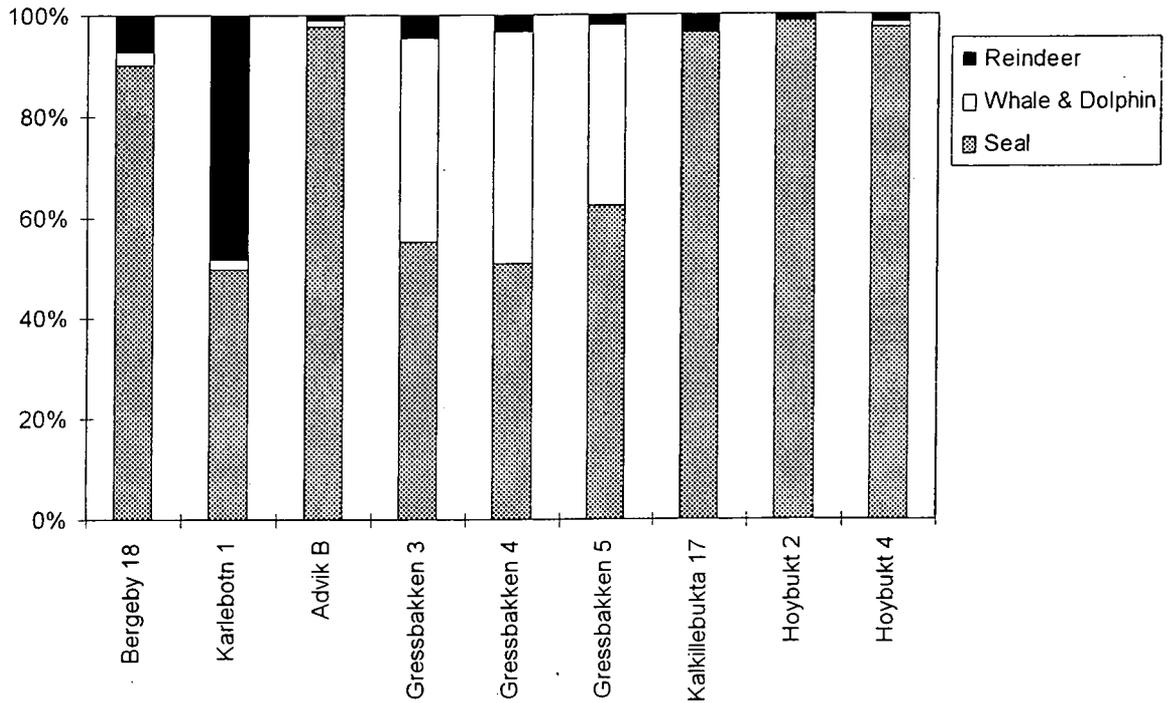
**Figure 4.29** Plan and section drawings of Høybukt 4 (after Simonsen 1963: figure 62)  
 Translations: *Kullblandet jord*=charcoal-blended soil; *Grus*=gravel; *Kulturlag*=cultural layer; *Avfallslag*=midden layer



**Figure 4.30** Relative percentages of the three most important fish species at all study sites where the total identified fish NISP is greater than 100

notes: 1) Values indicate combined totals of all middens and levels at each house

2) Bergeby 18 was the only site where a cod family (*Gadidae*) category was identified as well as the cod species *Gadus morhua*. Both taxa are here included in the "cod" category to make the values from Bergeby more comparable to those from the other sites. This may mean that the Bergeby cod are slightly over-represented in the figure.

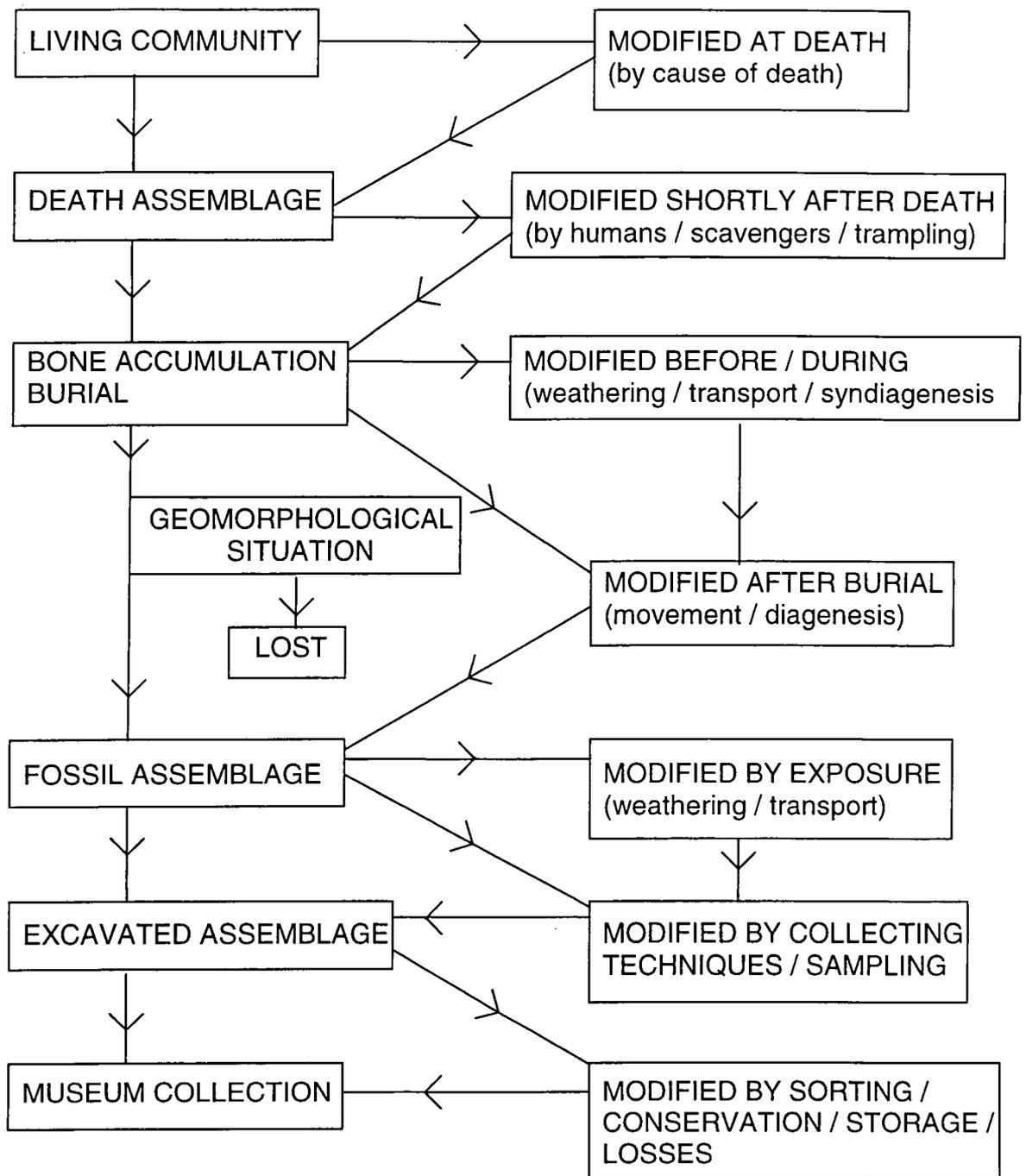


**Figure 4.31** Relative percentages of the most important mammalian taxa at all study sites where the total identified mammal NISP is greater than 100

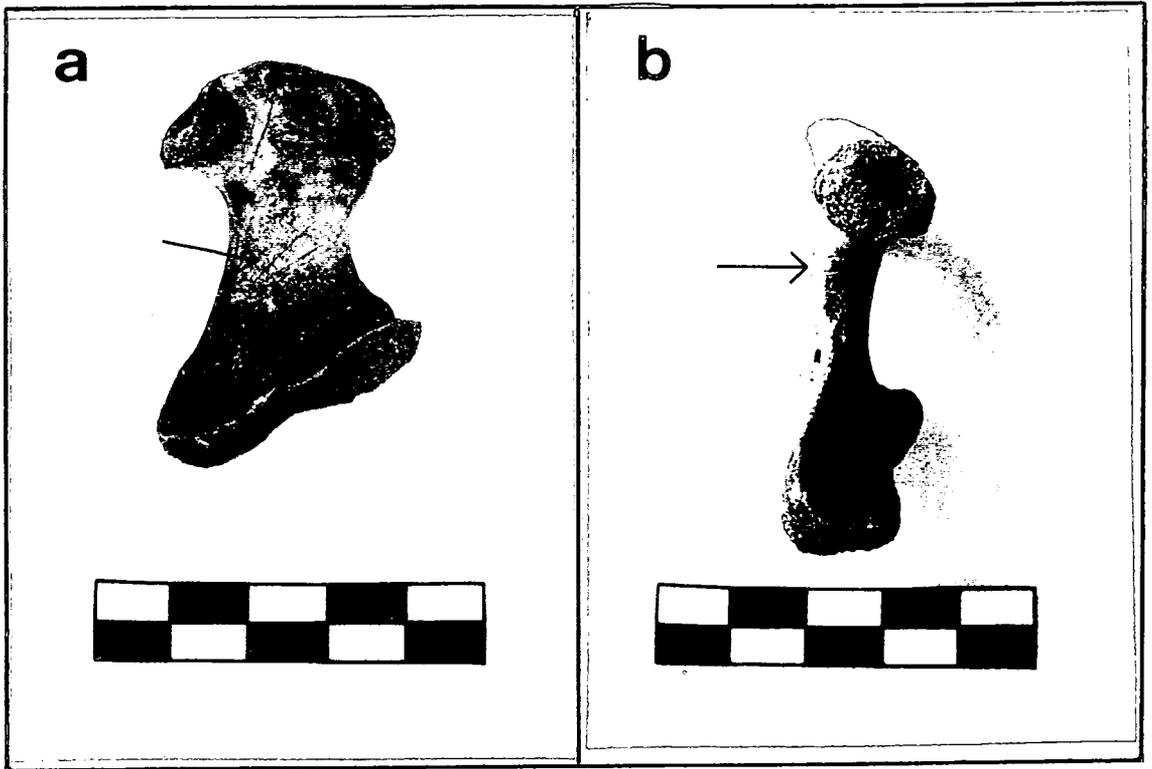
notes: 1) Values indicate combined totals of all middens and levels at each house

2) Advik J is not included because once the structural whale bones are removed from consideration, the sample size drops below 100.

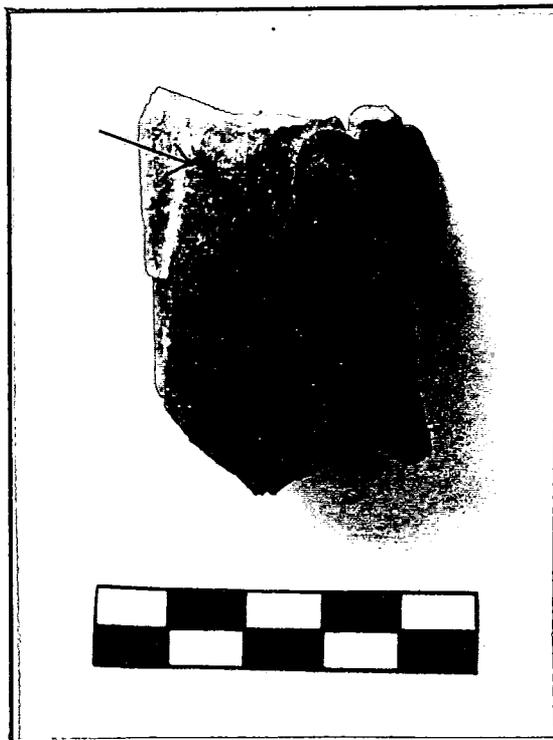
3) The majority of whale bones from Gressbakken 3 have not been identified. The NISP value used in creating figure 4.30 derives from Olsen's record of 4061 unidentified fragments of whale bone, plus the whale bone fragments identified among the other mammal bones during this analysis.



**Figure 5.1** Model of taphonomic history showing stages of modification (after Andrews and Cook 1985: 689, Figure 7)



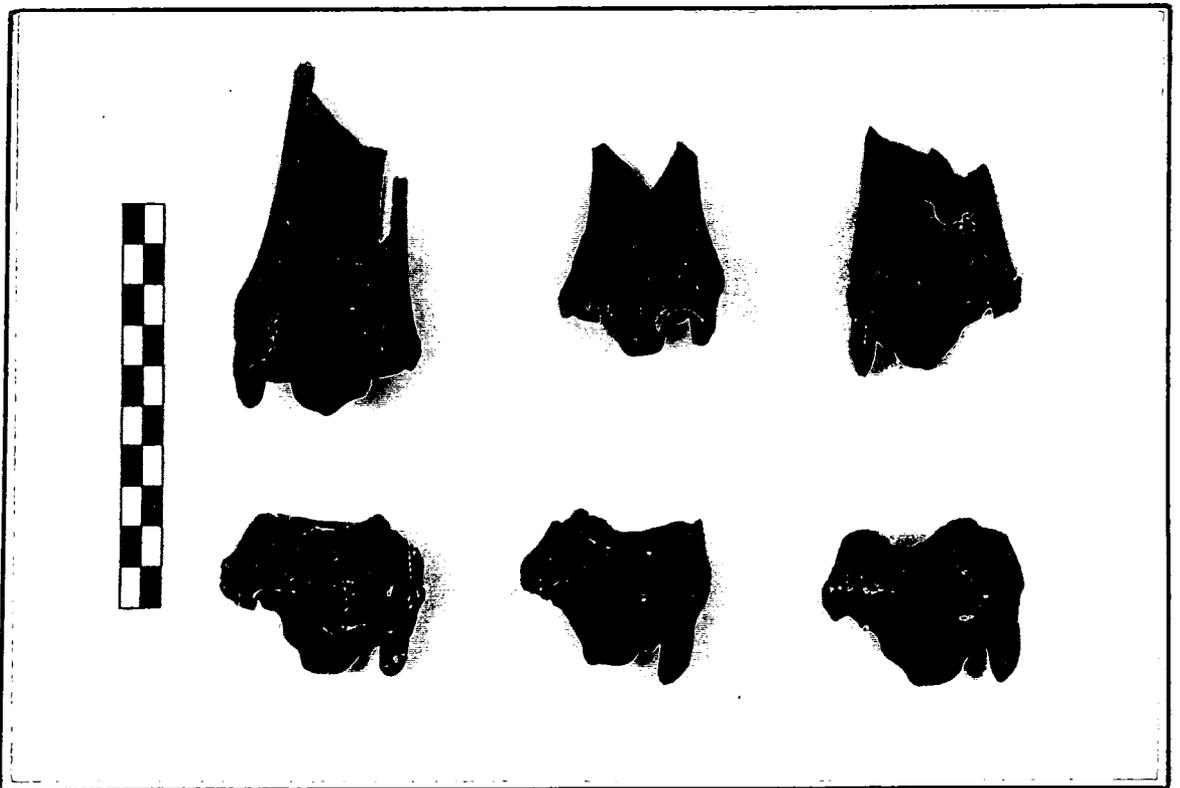
**Figure 5.2** Cutmarks on juvenile harp seal femur from Gressbakken 3.  
a) posterior view; b) medial view Scale is 5 cm long.



**Figure 5.3** Cutmarks on reindeer proximal metatarsal from Gressbakken 4.  
Scale is 5 cm long. (Bone also split length-wise for marrow extraction)



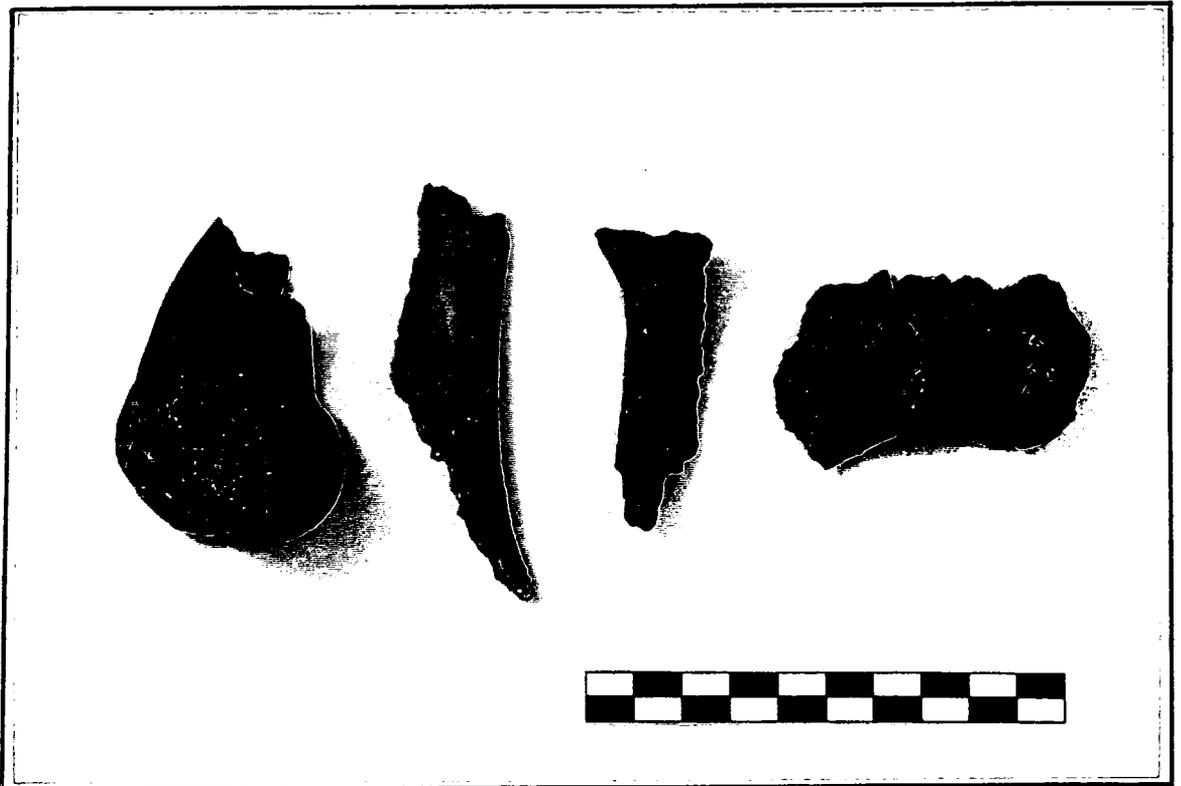
**Figure 5.4** Reindeer proximal radii broken for marrow extraction. Scale is 10 cm long. (Illustrated examples are from Gressbakken 3, 4 and 5)



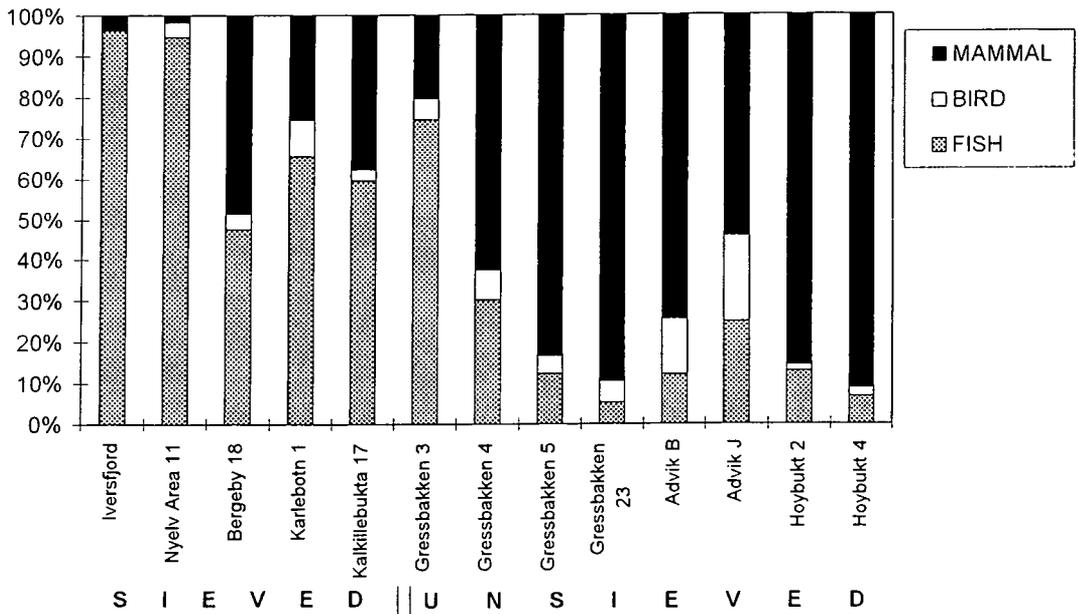
**Figure 5.5** Reindeer distal tibiae broken for marrow extraction. Scale is 10 cm long. (Illustrated examples are from Gressbakken 3, 4 and 5)



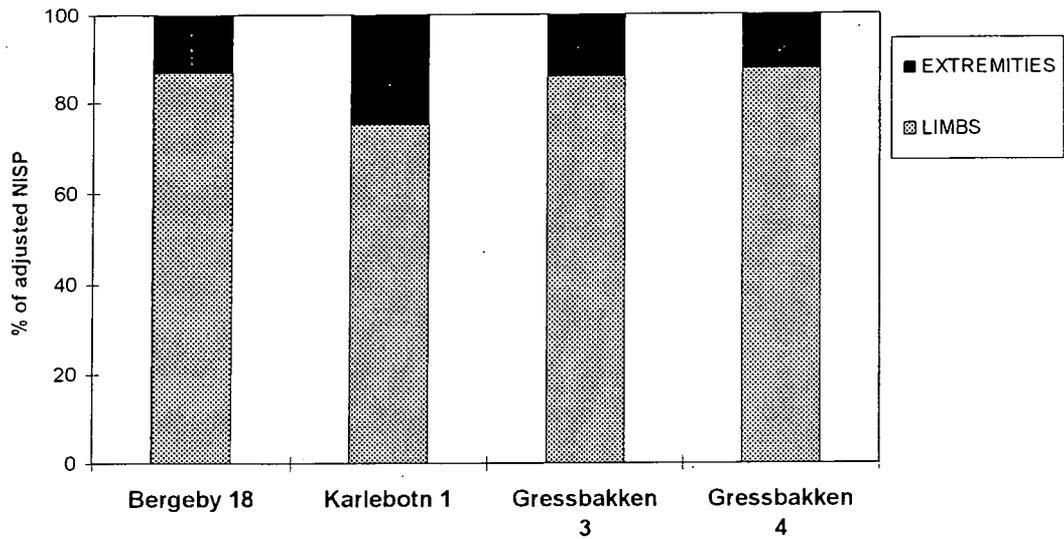
**Figure 5.6** Reindeer proximal metatarsals split length-wise for marrow extraction. Scale is 10 cm long. (Illustrated examples are from Gressbakken 3 and 4)



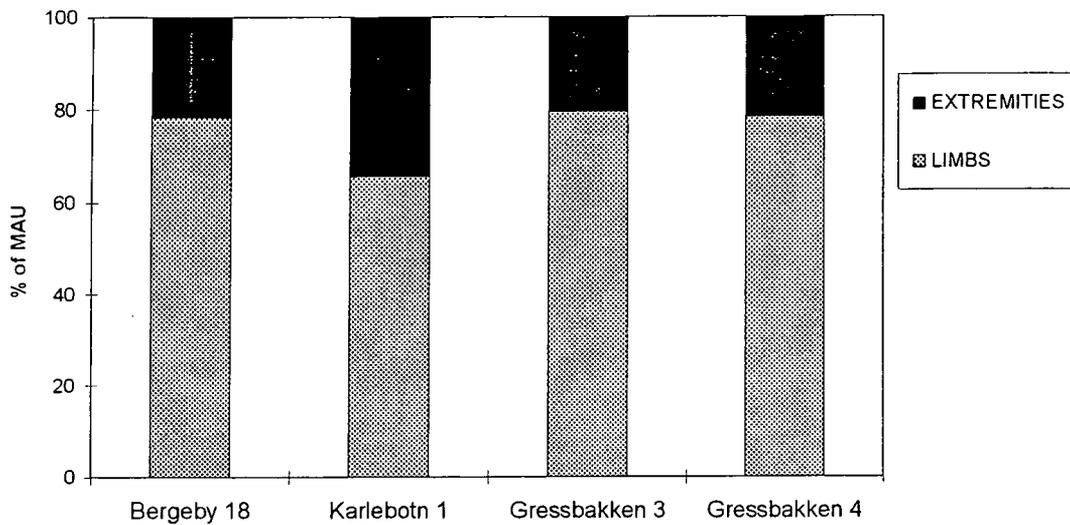
**Figure 5.7** Examples of carnivore-damaged reindeer bone from Gressbakken 4. Scale is 10 cm long. Left to right: distal humerus, scapula fragment, scapula (glenoid) fragment, proximal tibia (unfused epiphysis)



**Figure 5.8** Relative percentages of fish, bird and mammal NISP in sieved and unsieved YSA assemblages in Finnmark

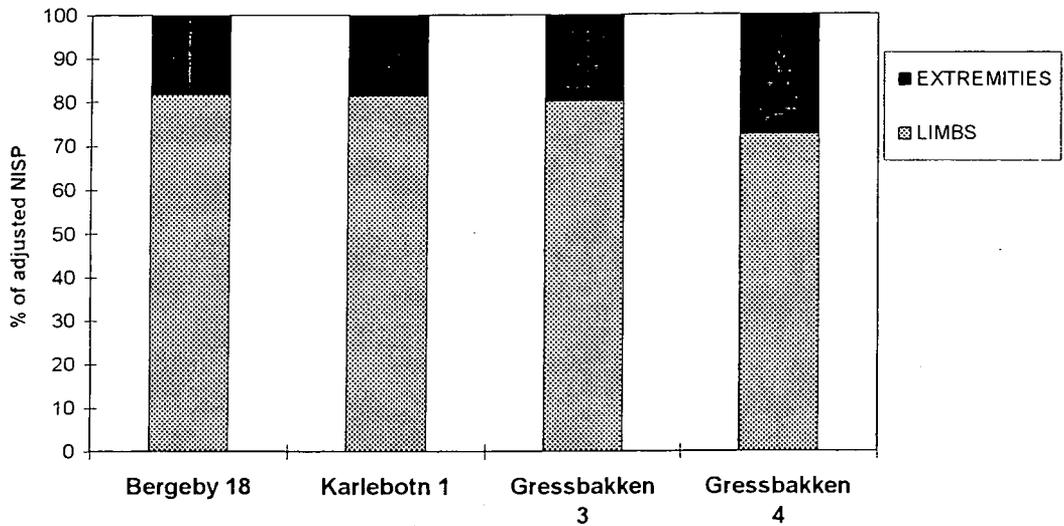


**Figure 5.9** Representation of seal extremities relative to limb bones as indicated by adjusted NISP values

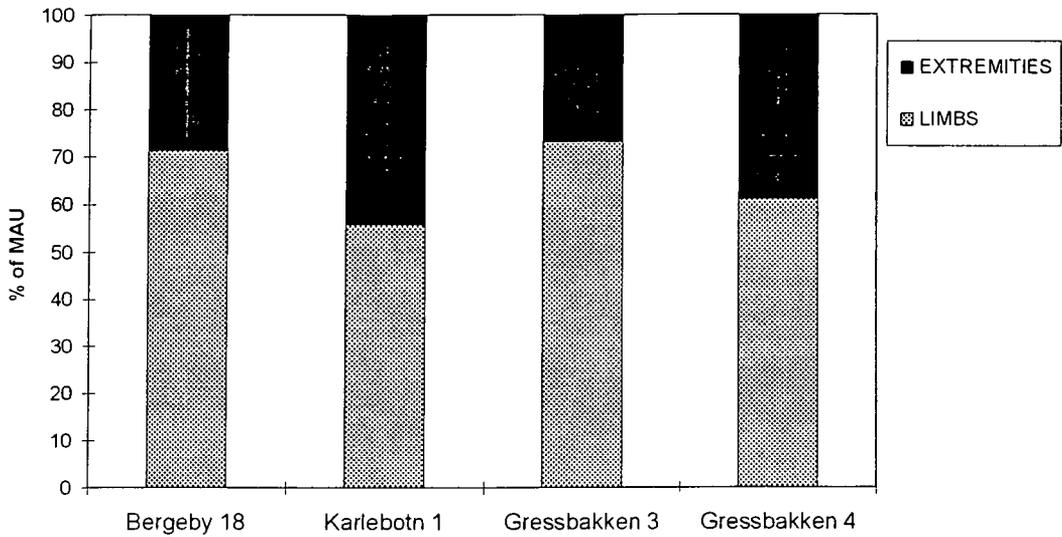


**Figure 5.10** Representation of seal extremities relative to limb bones as indicated by MAU values

EXTREMITIES=carpals, tarsals, phalanges  
 LIMBS=scapula, humerus, radius, ulna, femur, tibia

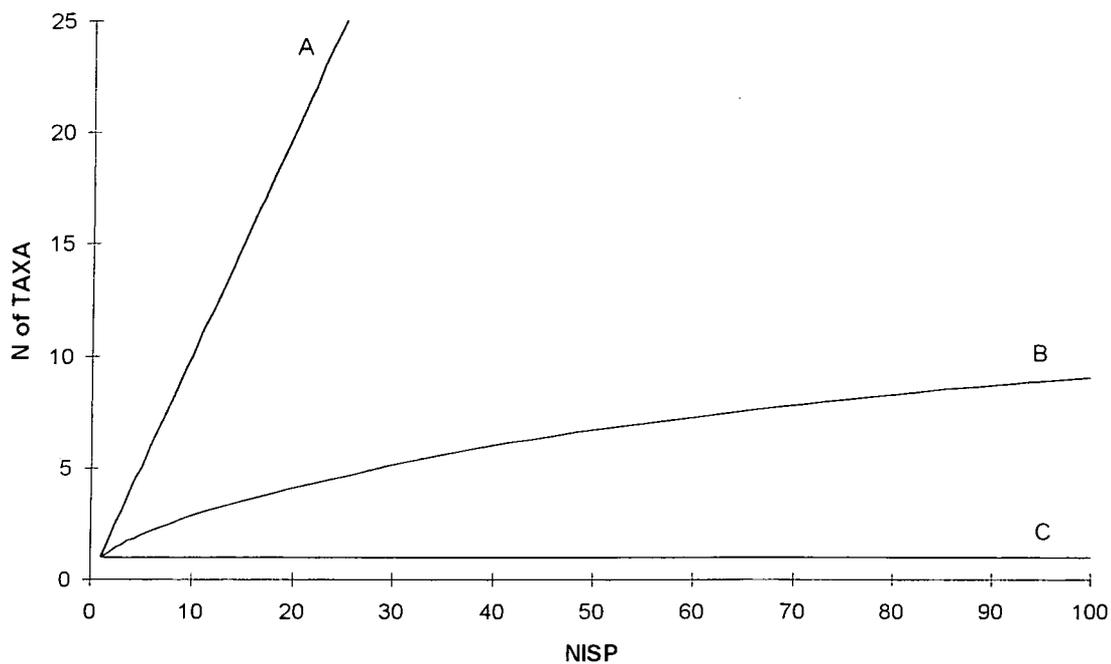


**Figure 5.11** Representation of reindeer extremities relative to limb bones as indicated by adjusted NISP values

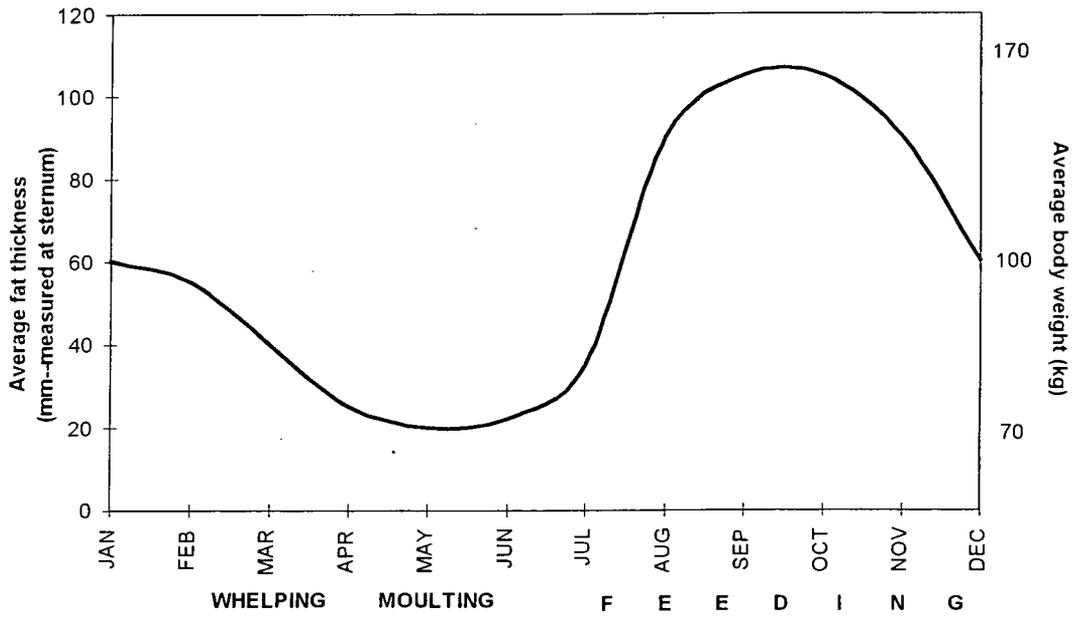


**Figure 5.12** Representation of reindeer extremities relative to limb bones as indicated by MAU values

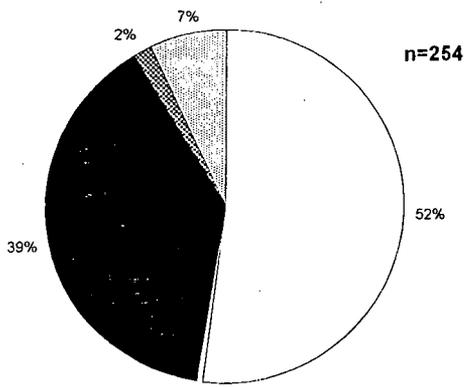
EXTREMITIES=carpals, tarsals, phalanges  
 LIMBS=scapula, humerus, radius, ulna, femur, tibia



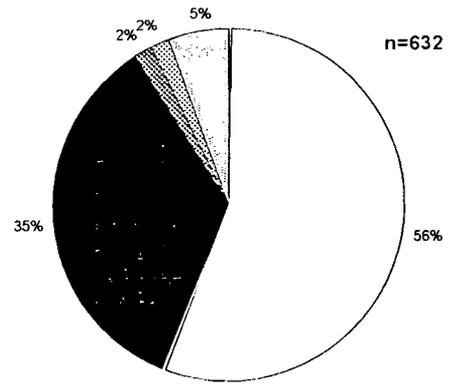
**Figure 5.13** Relationship between sample size and number of identified taxa (after Grayson 1984, Figure 5.3) Lines A and C indicate the limits between which this relationship must vary (for Line A each NISP represents a different taxon, for Line C all NISP represent the same taxon). Line B indicates the general form of the relationship for most archaeological assemblages.



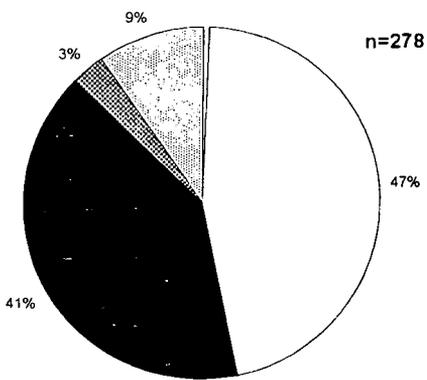
**Figure 6.1** Changing annual condition of adult harp seals in the Barents Sea



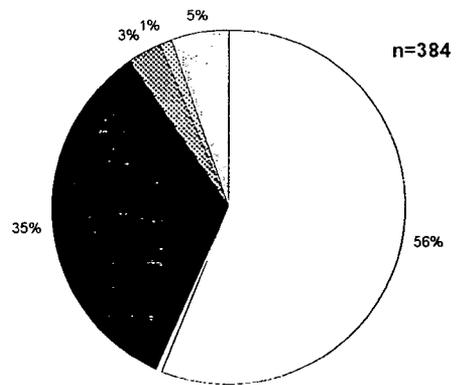
a) Gressbakken 3 NE



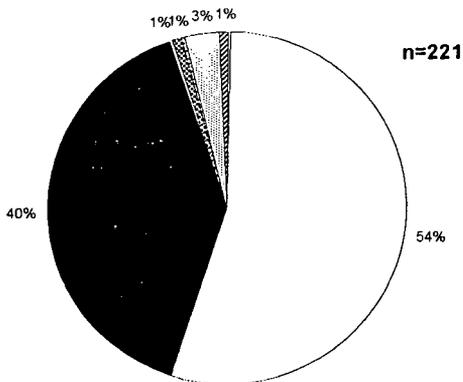
b) Gressbakken 3 NW



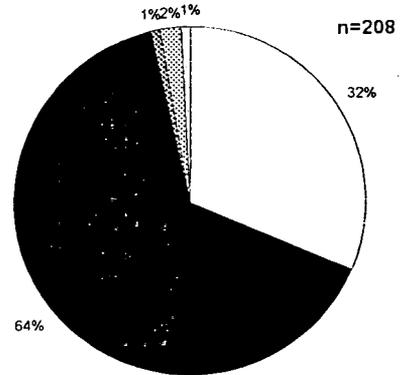
c) Gressbakken 4 NE



d) Gressbakken 4 NW



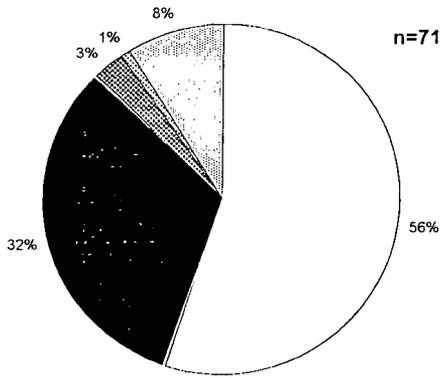
e) Gressbakken 5 NE



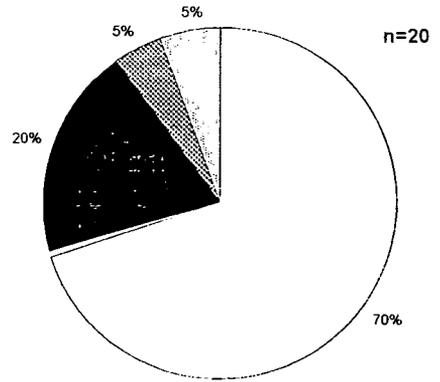
f) Gressbakken 5 NW



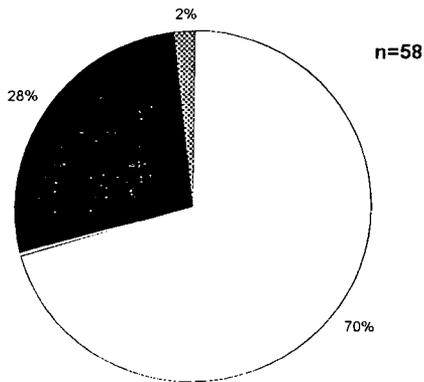
**Figure 6.2** Relative percentages of seal species (Percent values rounded to nearest whole number. Harp seal percentages include “large phocid” bones, ringed seal percentages include “small phocid” bones.)



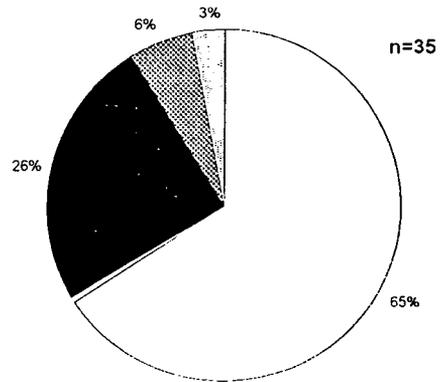
g) Gressbakken 23



h) Kalkillebukta 17



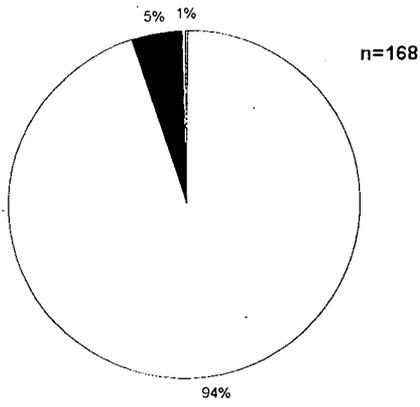
i) Høybukt 2



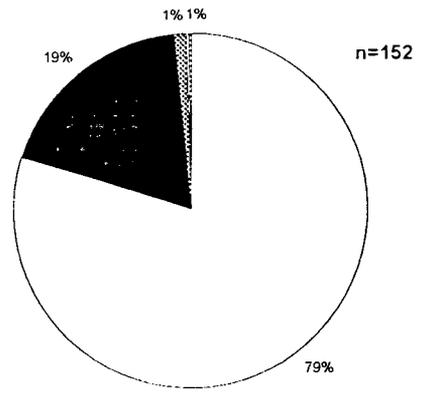
j) Høybukt 4



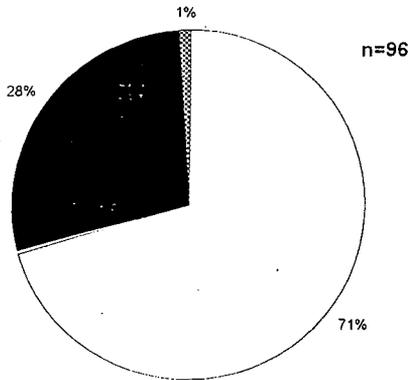
Figure 6.2 continued



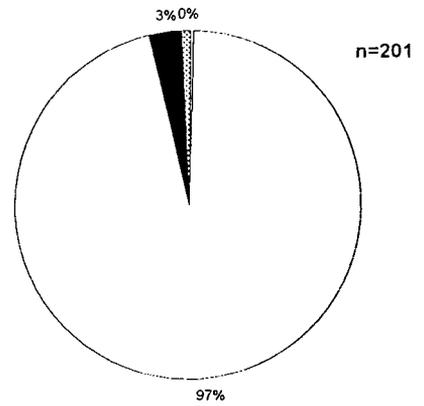
k) Bergeby 18 SE



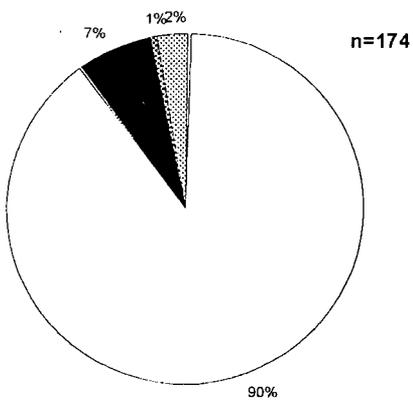
l) Bergeby 18 SW



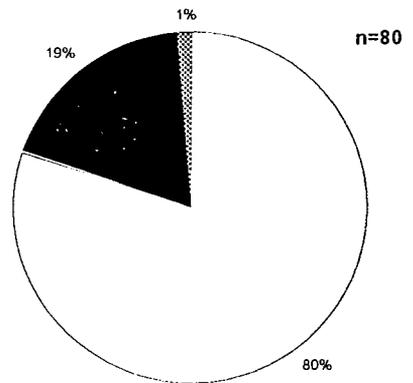
m) Bergeby 18 Level 2



n) Bergeby 18 Level 3



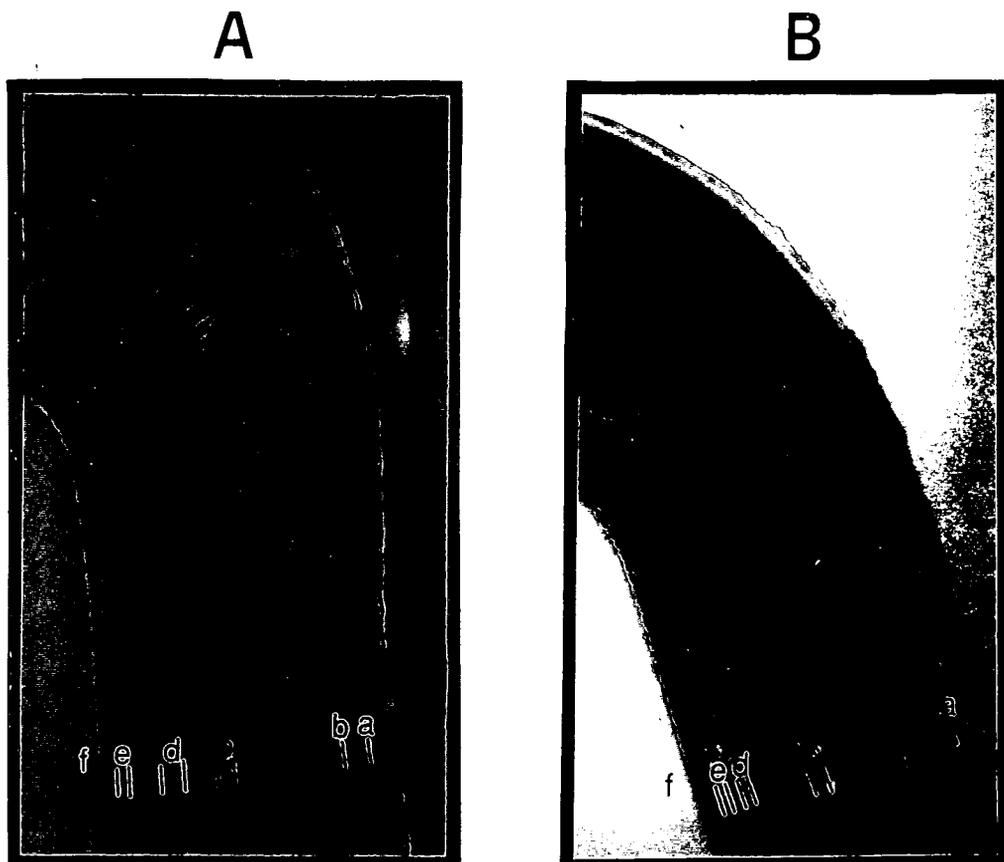
o) Karlebotnbakken



p) Advik B



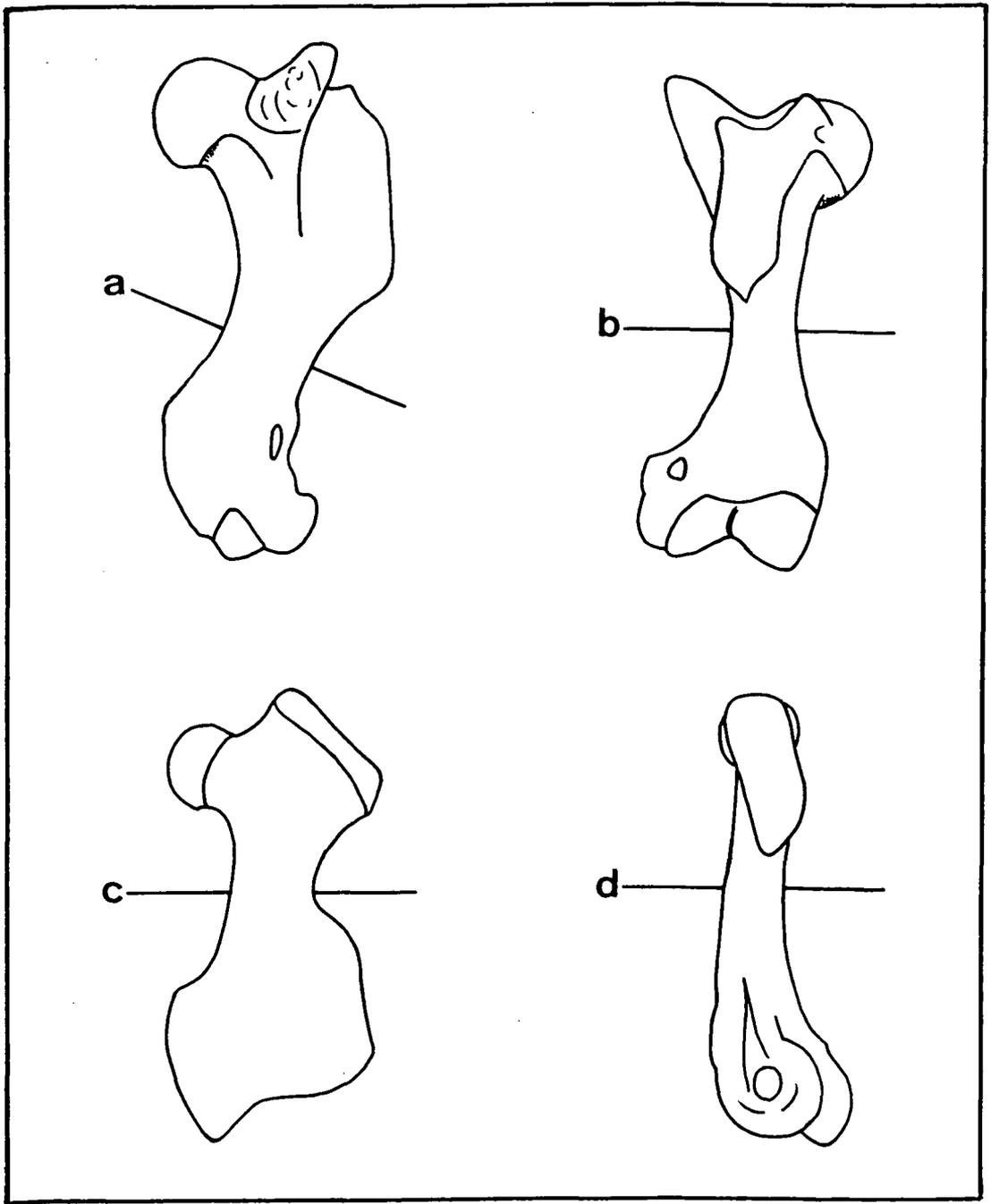
Figure 6.2 continued



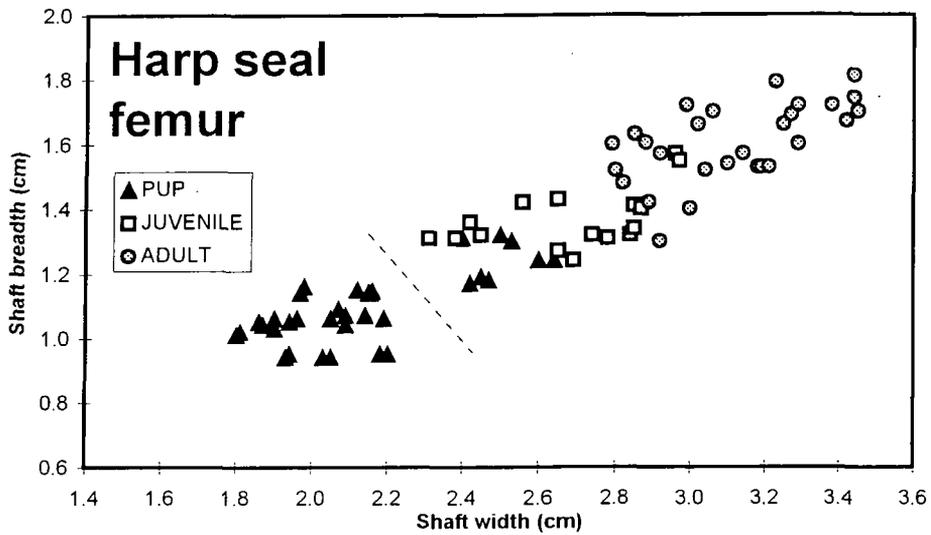
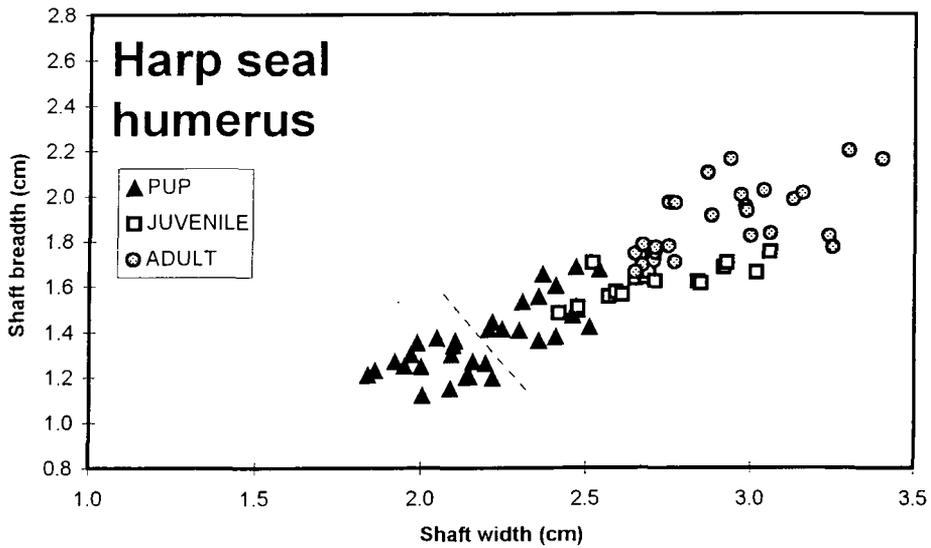
**Figure 6.3** Dentinal development indicating a spring kill (shortly before moult) in thin sections of three-year-old harp seal canines: A) section from Gressbakken 3; B) section from modern harp seal killed 12<sup>th</sup> May in Greenland Sea

Key: a) division between cementum and dentine; b) neo-natal line (weaning); c) first moult; d) second moult; e) third moult; f) pulp cavity in centre of tooth

\*\*note: The Greenland Sea population of harp seals whelp and moult one month later than the White Sea population, so this stage of development would be found during the first half of April in Varangerfjord.

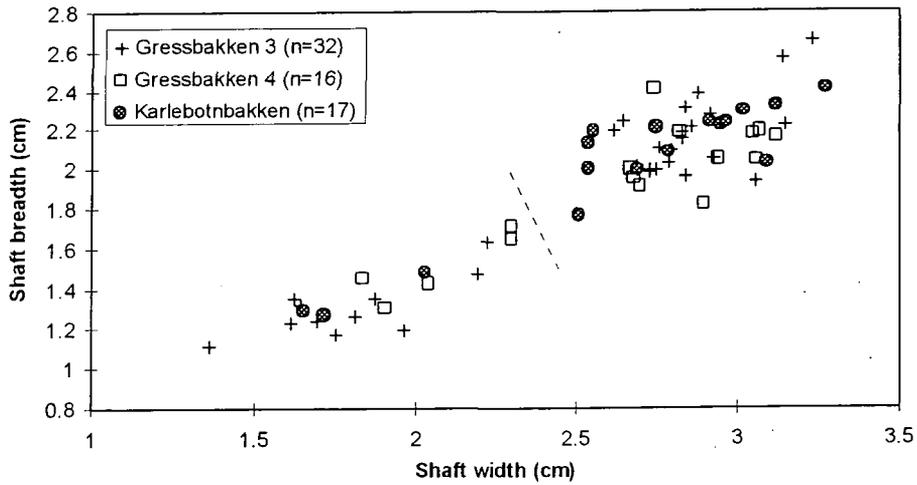


**Figure 6.4** Seal longbone shaft measurements: a) humerus shaft width; b) humerus shaft breadth; c) femur shaft width; d) femur shaft breadth

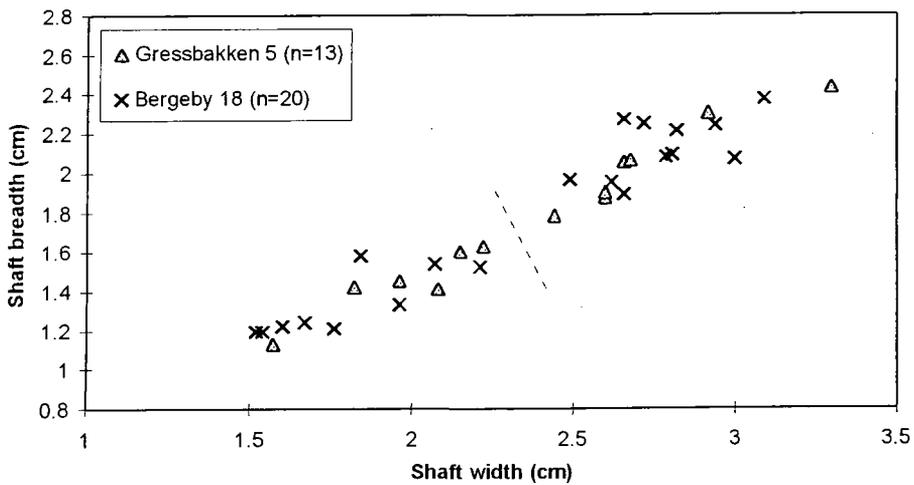


**Figure 6.5** Harp seal longbone shaft measurements from the reference collection at the Natural History Museum (NRM), Stockholm. All individuals killed January 1987. Top: Humerus shaft width vs. breadth; Bottom: Femur shaft width vs. breadth.

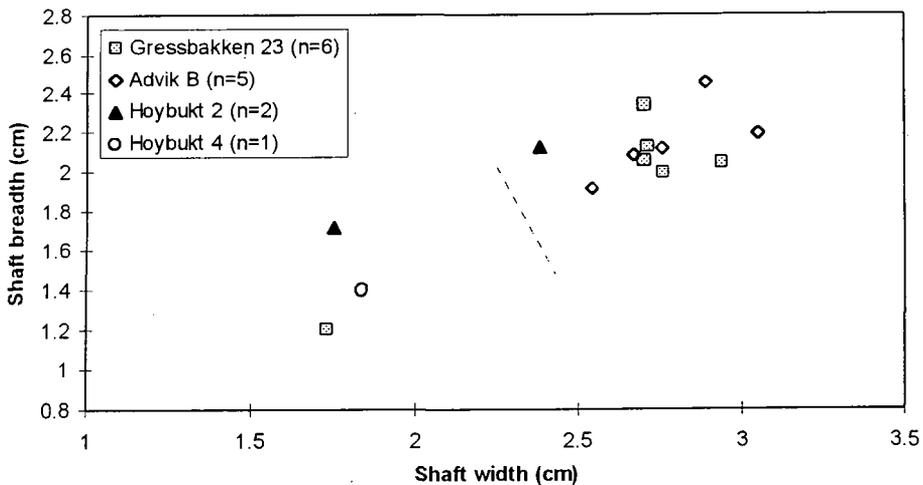
\*\*note: The “pups” which appear above the gap in both of these measurement distributions were probably animals in their second year, which were incorrectly identified by the NRM staff when they were collected (Jan Storå, pers. comm.)



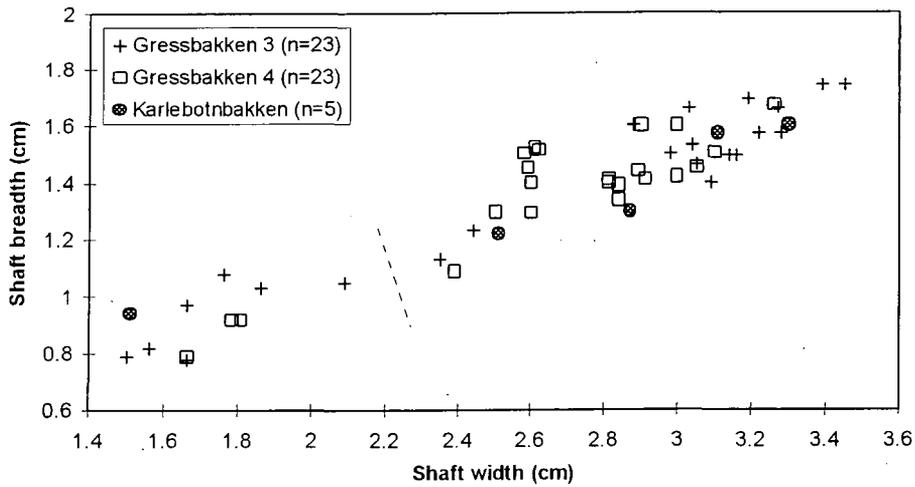
**Figure 6.6** Harp seal humerus shaft width vs. breadth at Gressbakken 3, Gressbakken 4 and Karlebotnbakken



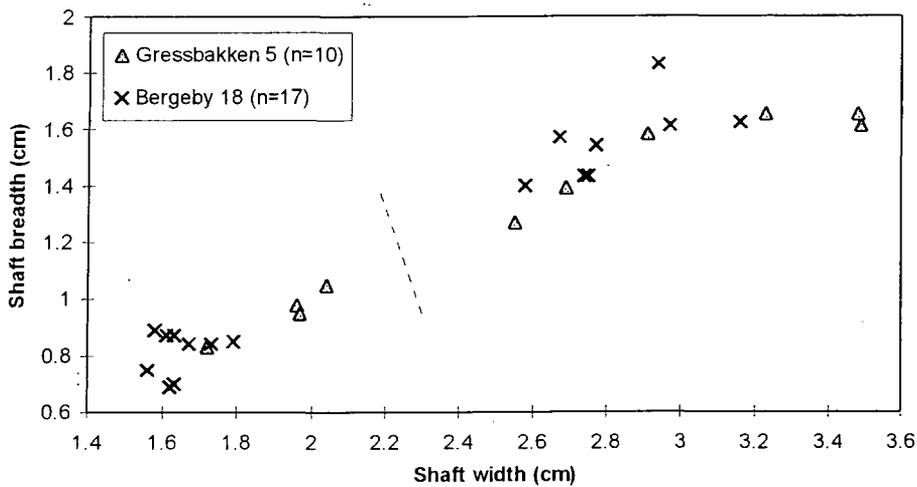
**Figure 6.7** Harp seal humerus shaft width vs. breadth at Gressbakken 5 and Bergeby 18



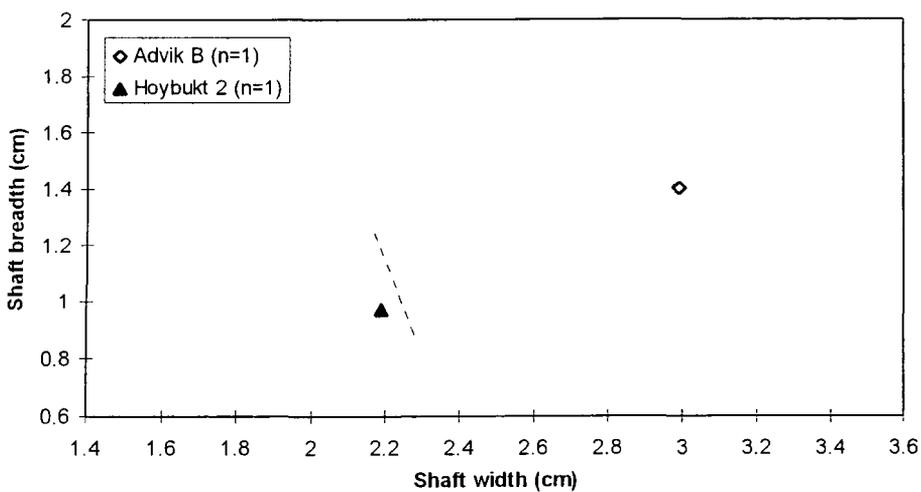
**Figure 6.8** Harp seal humerus shaft width vs. breadth at Gressbakken 23, Advik B, Høybukt 2, and Høybukt 4



**Figure 6.9** Harp seal femur shaft width vs. breadth at Gressbakken 3, Gressbakken 4 and Karlebotnbakken



**Figure 6.10** Harp seal femur shaft width vs. breadth at Gressbakken 5 and Bergeby 18



**Figure 6.11** Harp seal femur shaft width vs. breadth at Advik B, Høybukt 2 and Bugøyfjord 5

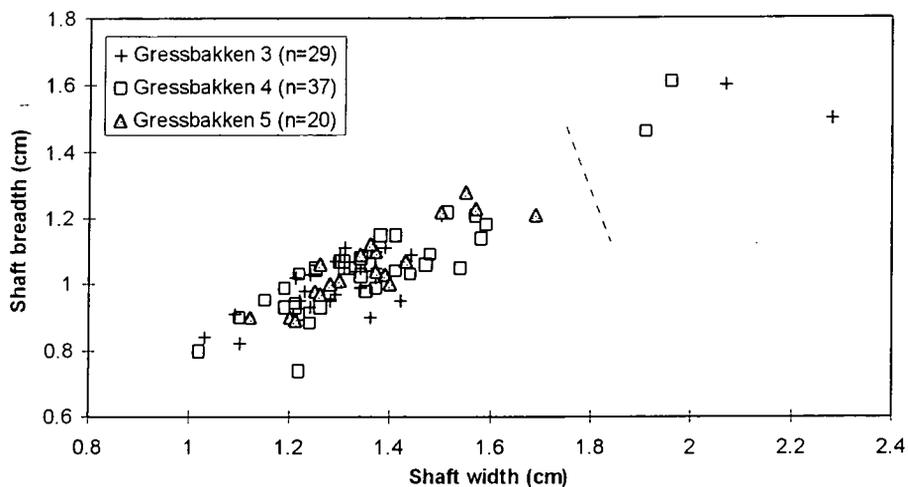


Figure 6.12 Ringed seal humerus shaft width vs. breadth at Gressbakken 3, 4 and 5

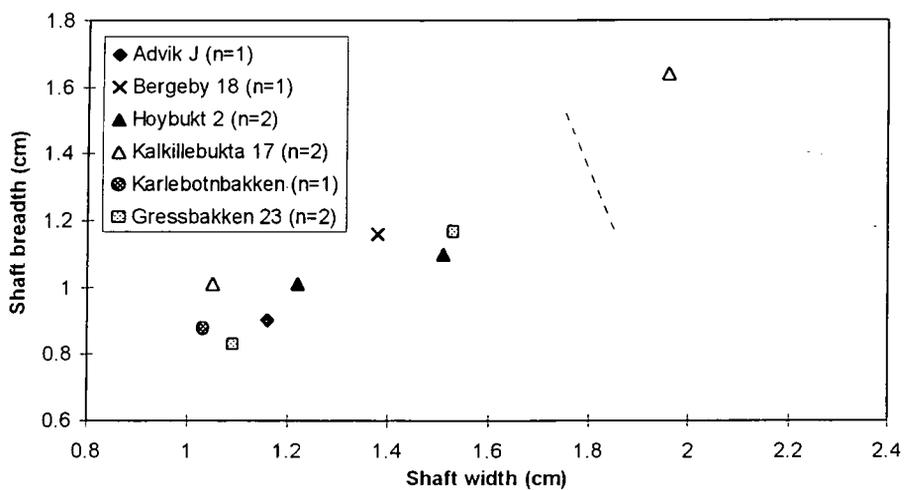


Figure 6.13 Ringed seal humerus shaft width vs. breadth at Advik J, Bergeby 18, Høybukt 2, Kalkillebukta 17, Karlebotnbakken and Gressbakken 23

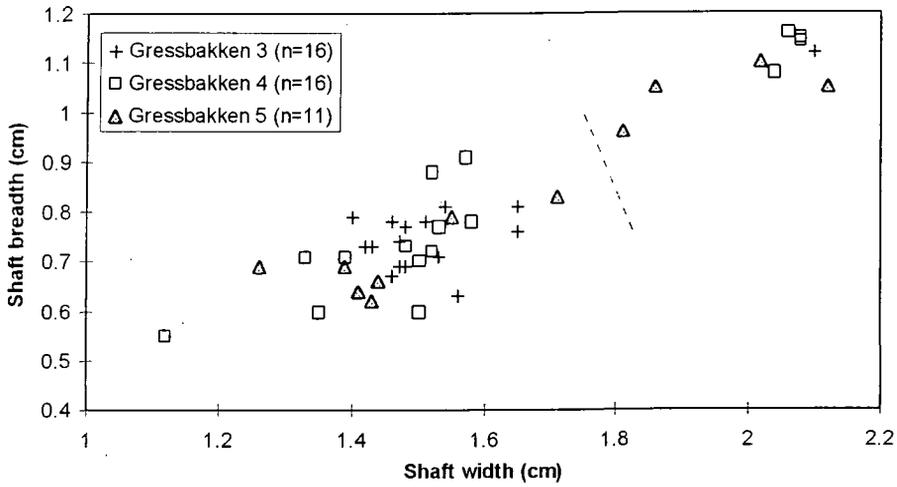


Figure 6.14 Ringed seal femur shaft width vs. breadth at Gressbakken 3, 4 and 5

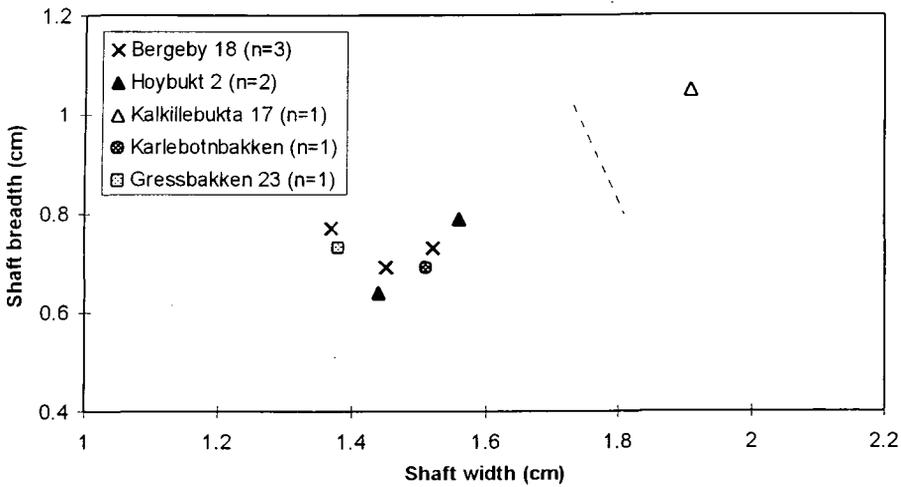
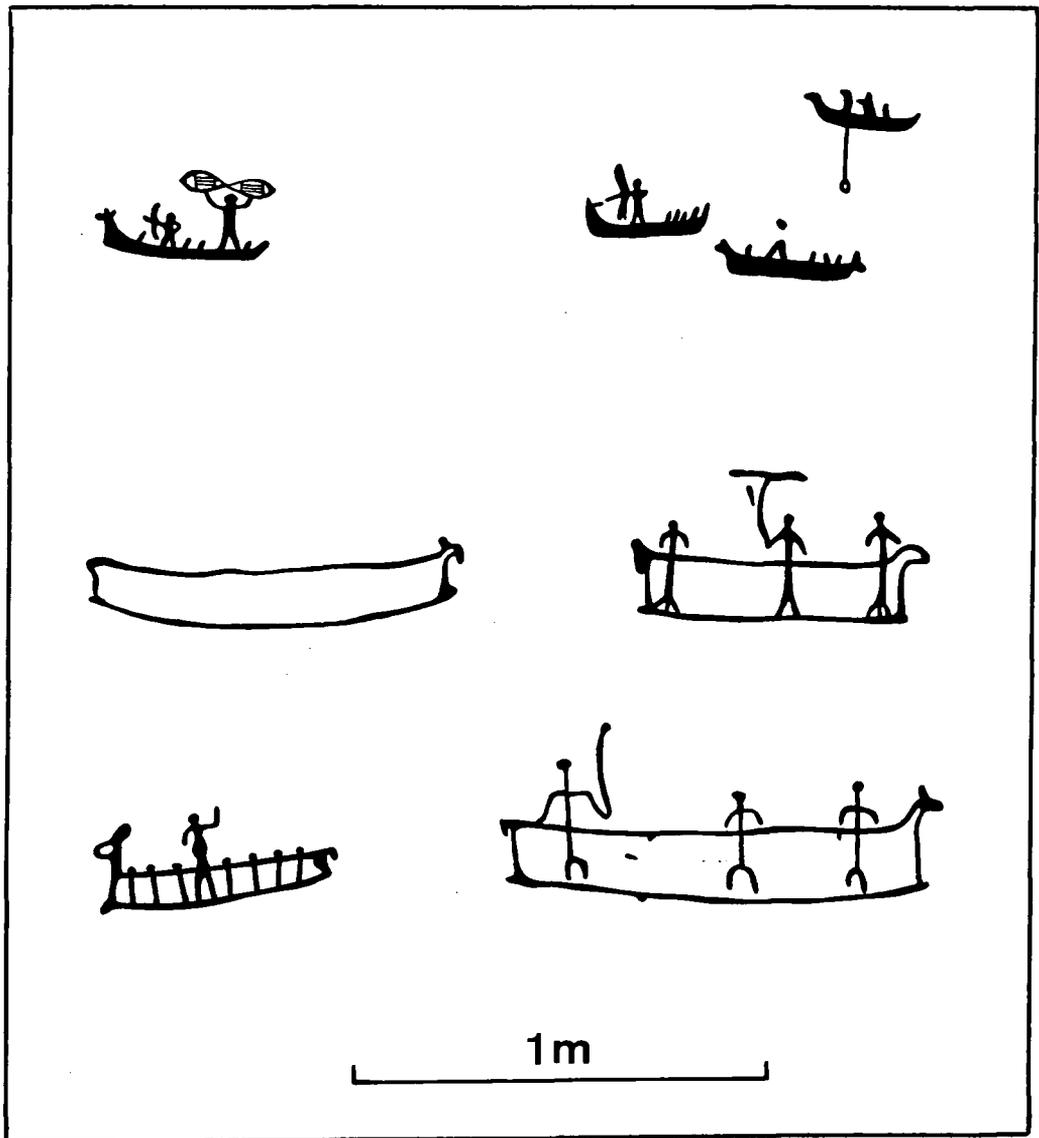
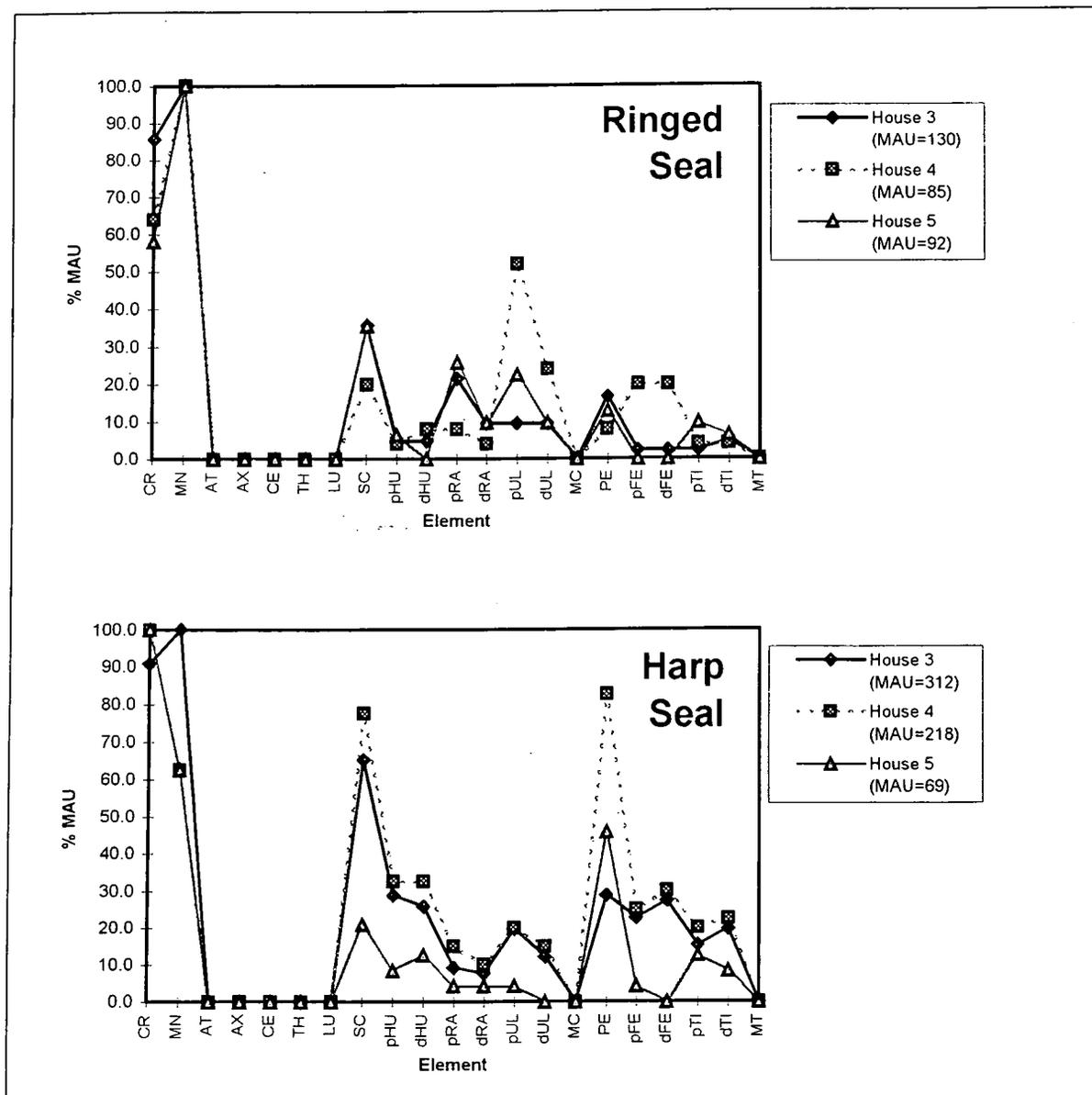


Figure 6.15 Ringed seal femur shaft width vs. shaft breadth at Bergeby 18, Høybukt 2, Kalkillebukta 17, Karlebotnbakken and Gressbakken 23



**Figure 6.16** Younger Stone Age boat petroglyphs from Alta, Finnmark (after Helskog 1988: 90) First row: 4200-3600 BC; Second and third rows: 3600-2700 BC



**Figure 7.1** Representation of positively identified ringed seal and harp seal elements at Gressbakken Nedre Vest

**Element codes for these and all subsequent figures are:**

p=proximal

d=distal

CR=cranium

CE=cervical

HU=humerus

PE=pelvis

MN=mandible

TH=thoracic

RA=radius

FE=femur

AT=atlas

LU=lumbar

UL=ulna

TI=tibia

AX=axis

SC=scapula

MC=metacarpal

MT=metatarsal

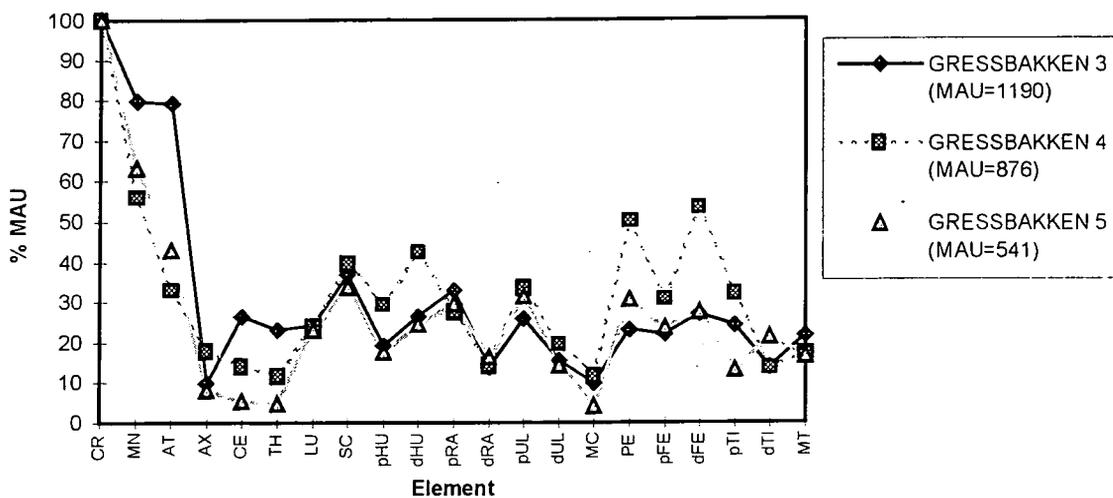


Figure 7.2 Seal element frequency at Gressbakken 3, 4 and 5

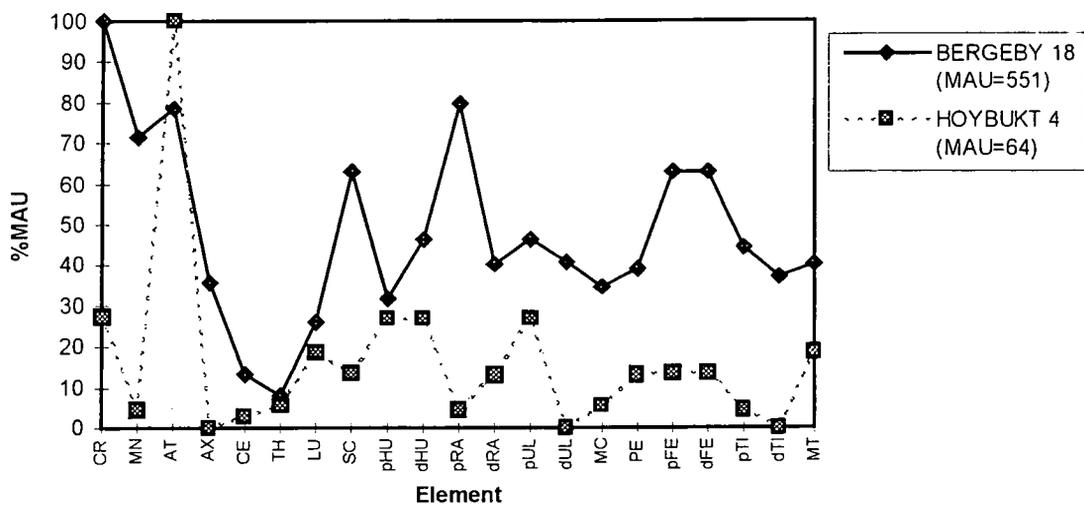


Figure 7.3 Seal element frequency at Bergeby 18 and Høybuk 4

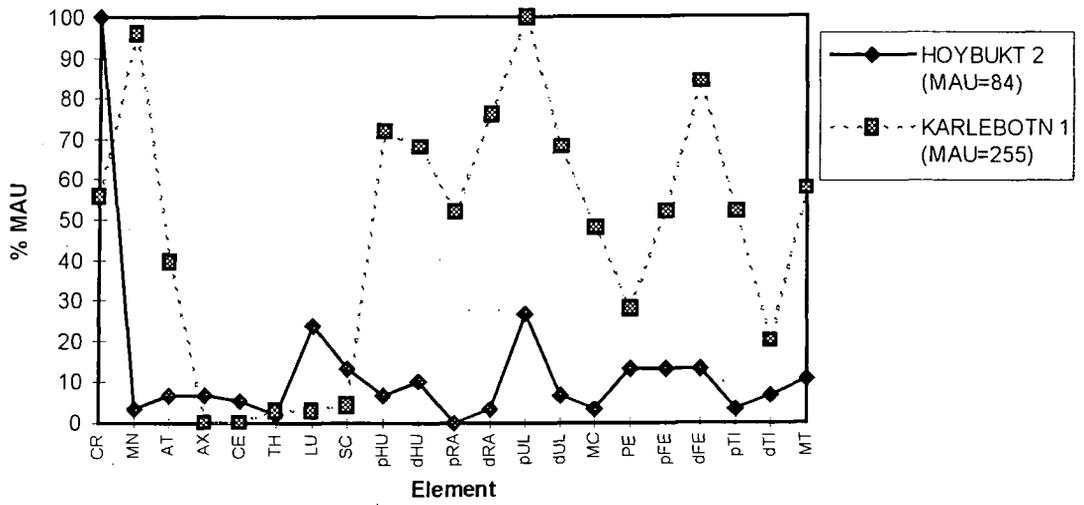


Figure 7.4 Seal element frequency at Høybukt 2 and Karlebotn 1

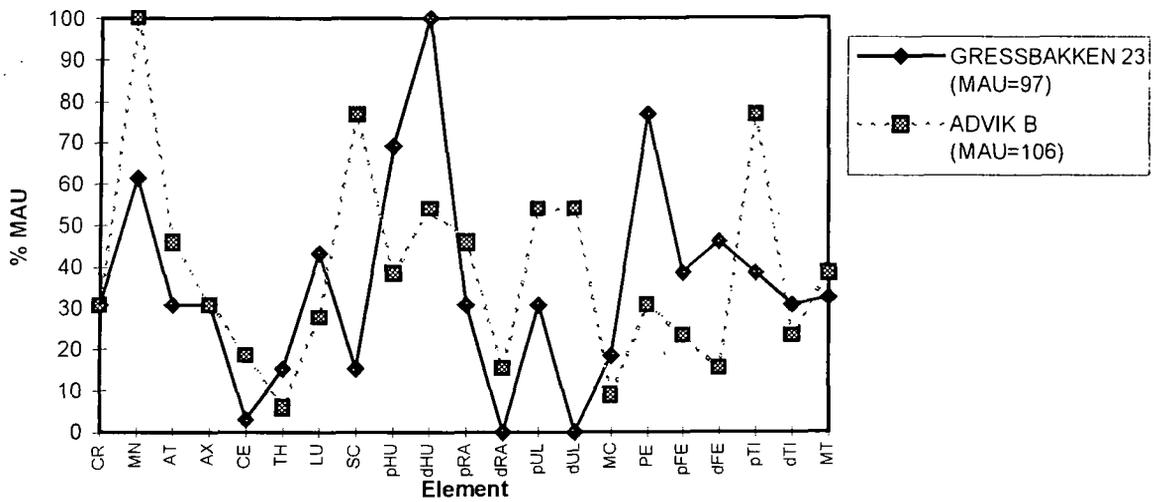
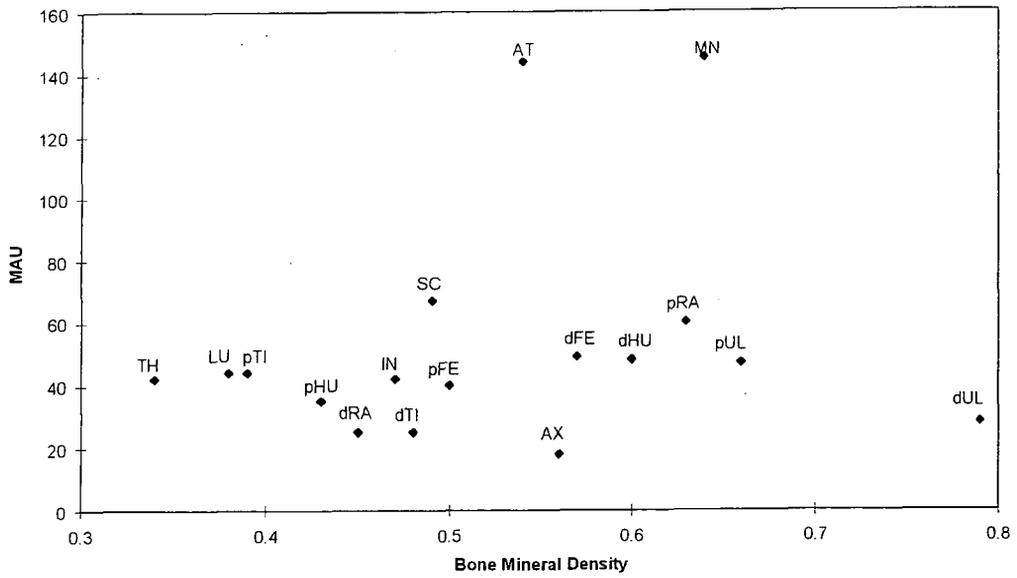
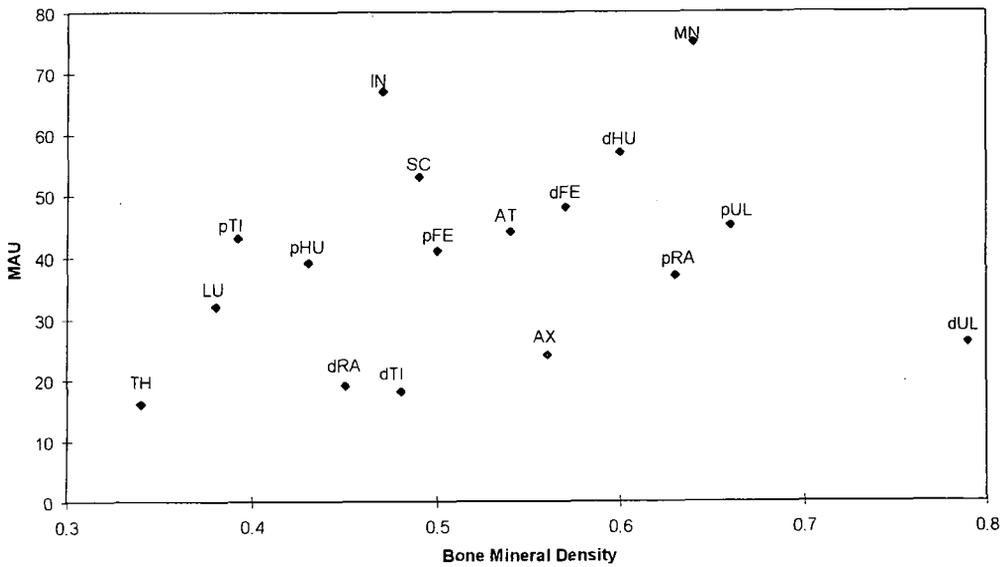


Figure 7.5 Seal element frequency at Gressbakken 23 and Advik B



**Figure 7.6** Seal bone mineral density vs. MAU at Gressbakken 3 (MAU=1190)



**Figure 7.7** Seal bone mineral density vs. MAU at Gressbakken 4 (MAU=867)

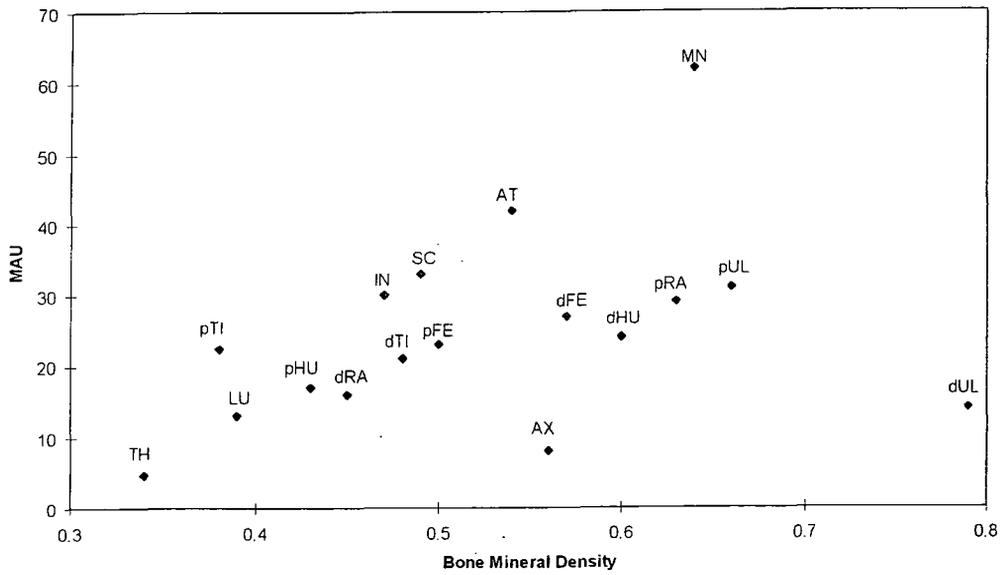


Figure 7.8 Seal bone mineral density vs. MAU at Gressbakken 5 (MAU=541)

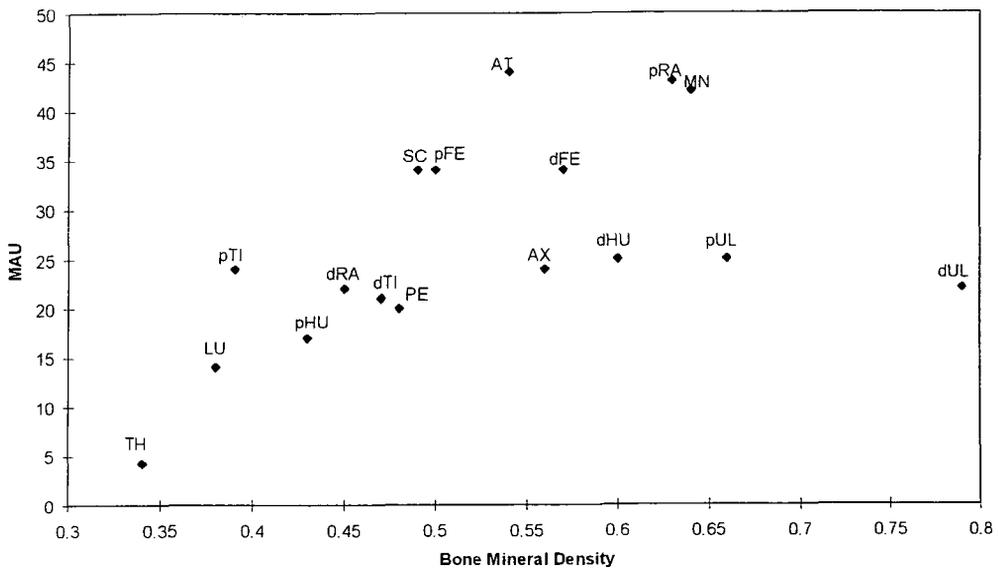


Figure 7.9 Seal bone mineral density vs. MAU at Bergeby 18 (MAU=551)

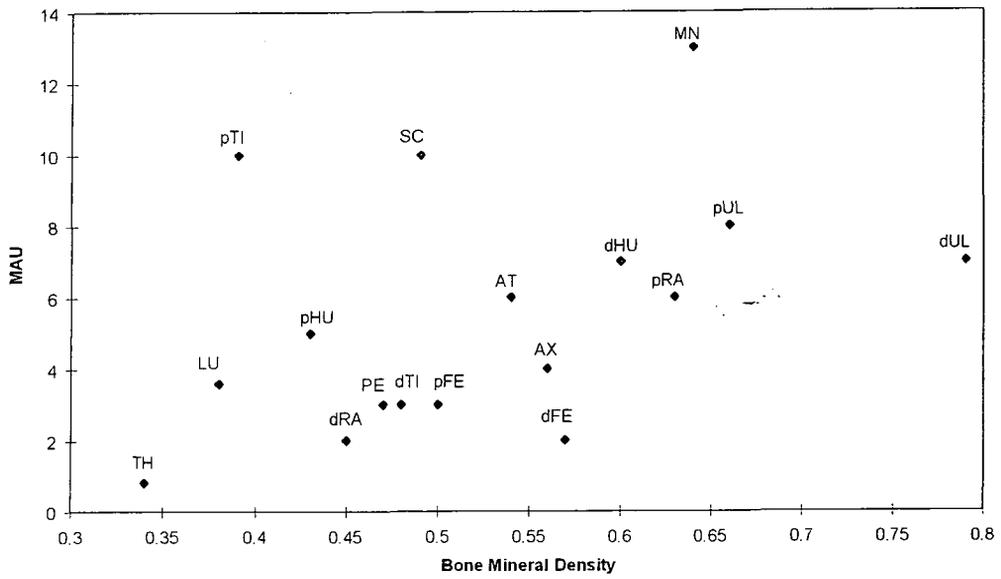


Figure 7.10 Seal bone mineral density vs. MAU at Advik B (MAU=106)

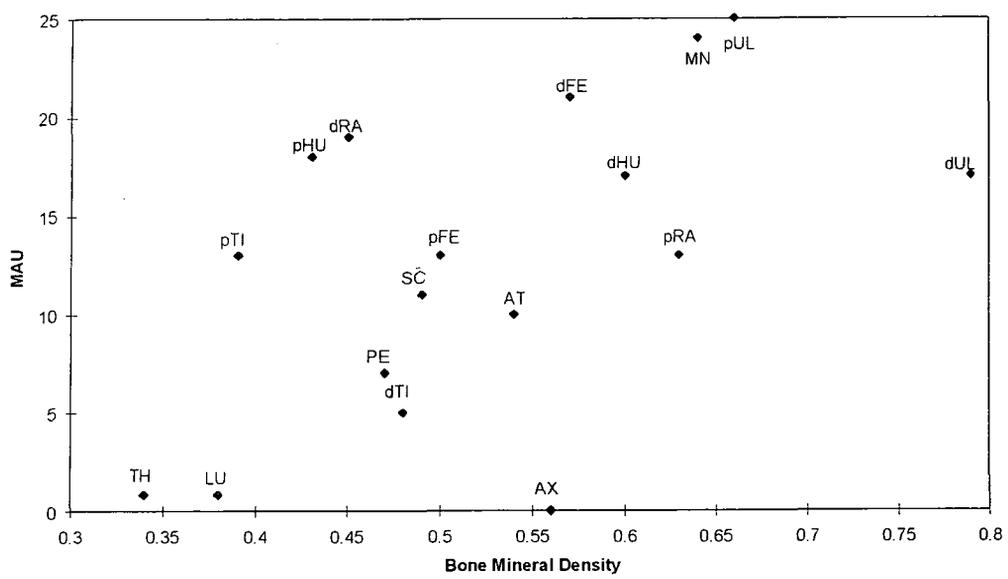


Figure 7.11 Seal bone mineral density vs. MAU at Karlebotnbakken (MAU=255)

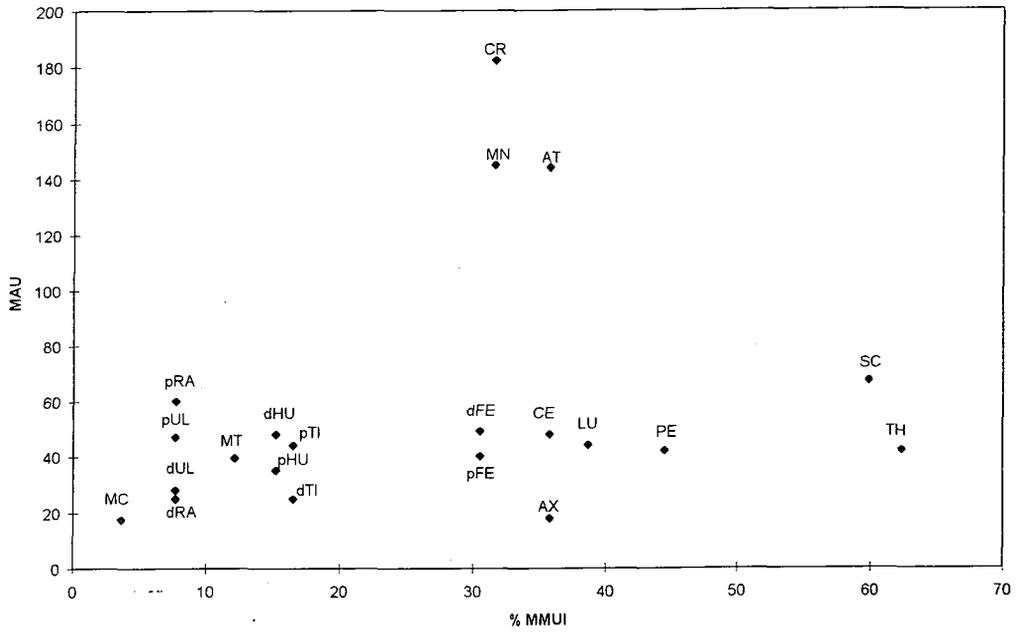


Figure 7.12 Seal modified meat utility index vs. MAU at Gressbakken House 3

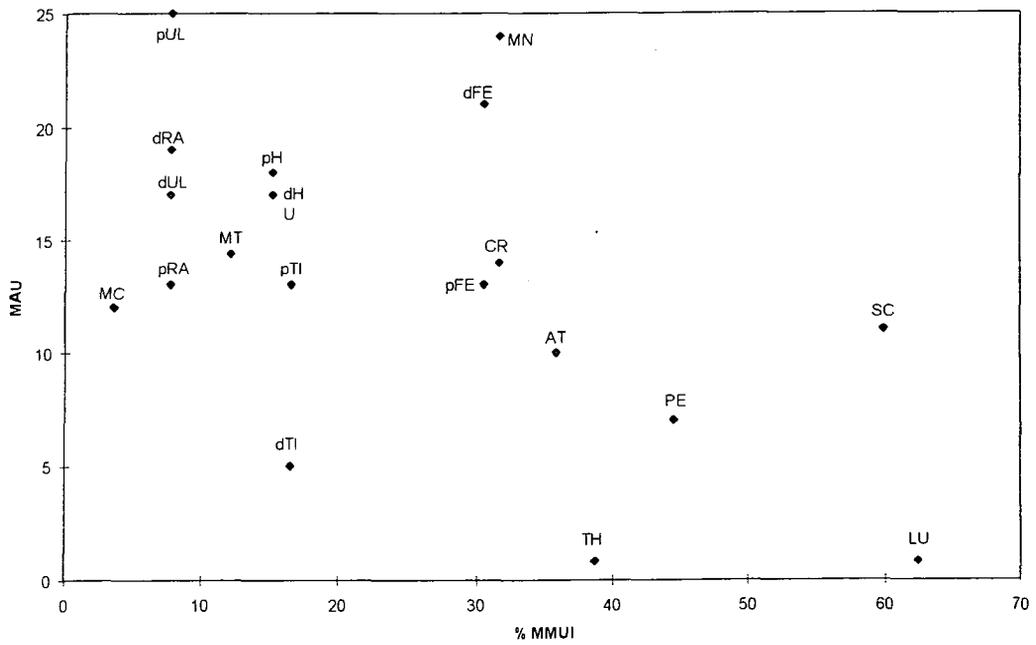
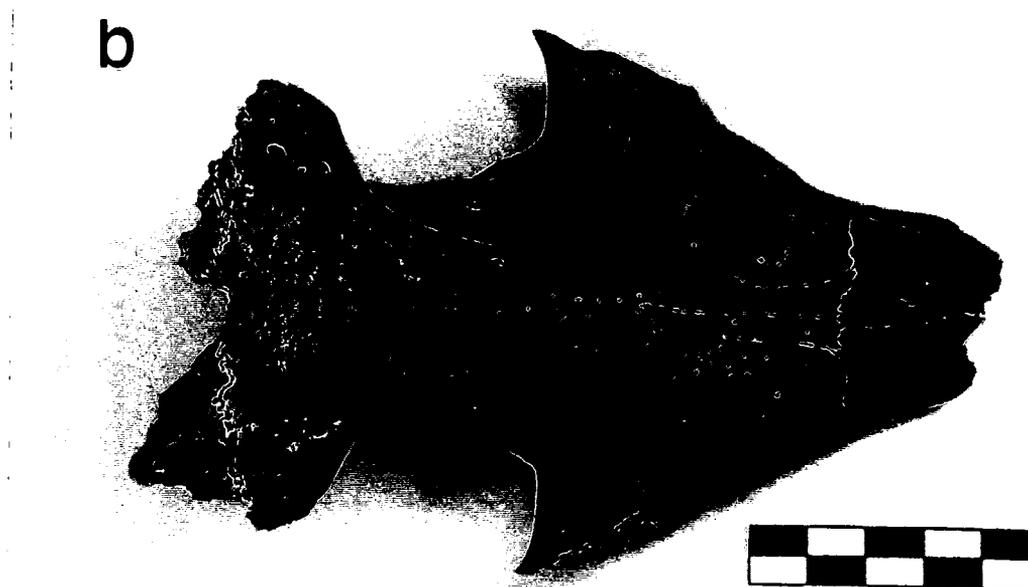


Figure 7.13 Seal modified meat utility index vs. MAU at Karlebotn 1



**Figure 7.14** Harp seal crania from the north-east midden at Gressbakken 4  
a) Five harp seal crania, 10 cm scale; b) Close up of harp seal skull (second from right above) to show skinning marks across nasal region, 5 cm scale

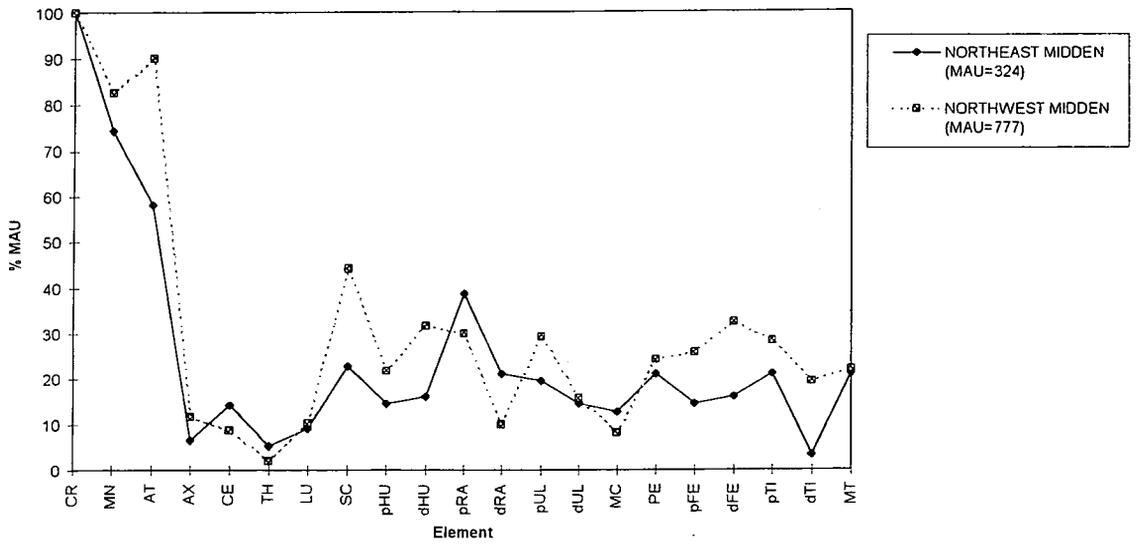


Figure 7.15 Seal element frequency in each of the middens at Gressbakken 3

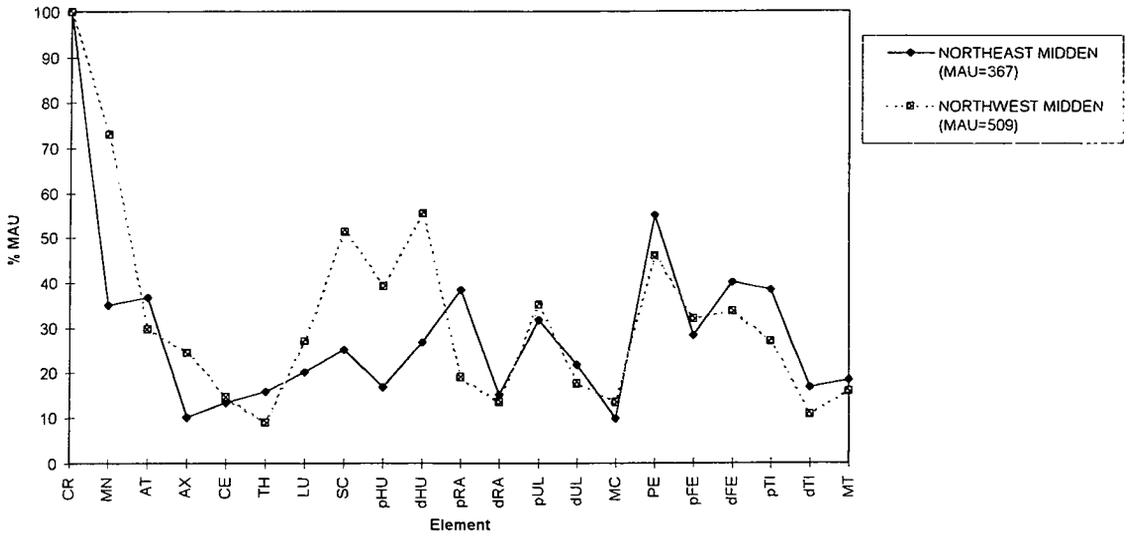


Figure 7.16 Seal element frequency in each of the middens at Gressbakken 4

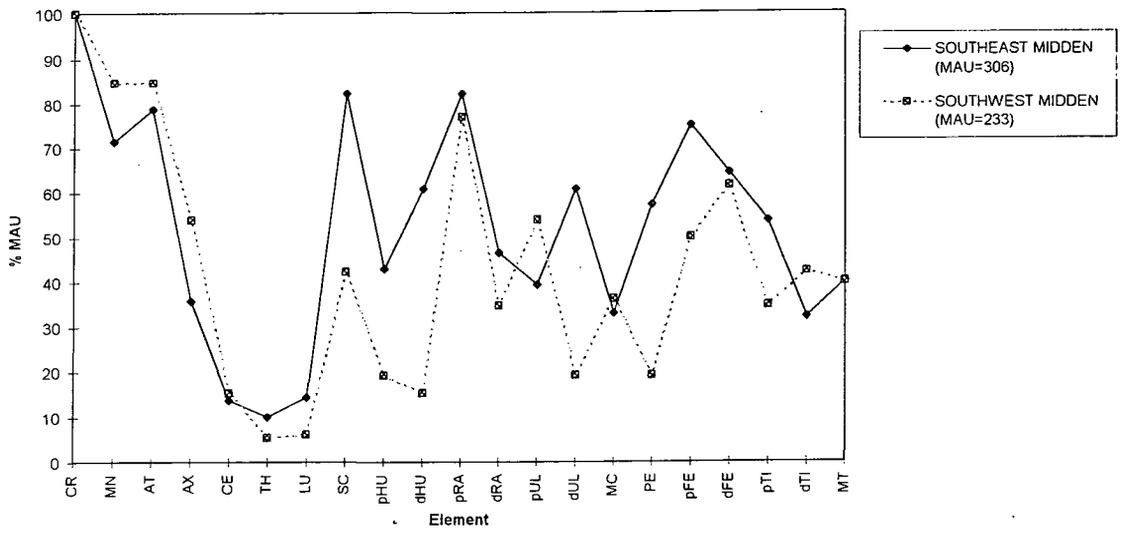


Figure 7.17 Seal element frequency in each of the middens at Bergeby 18

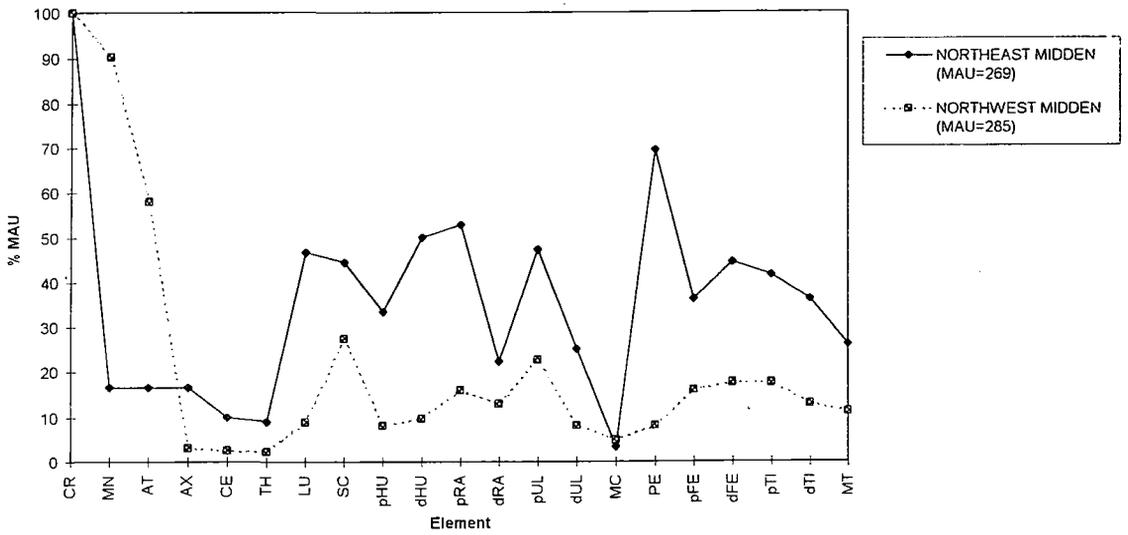
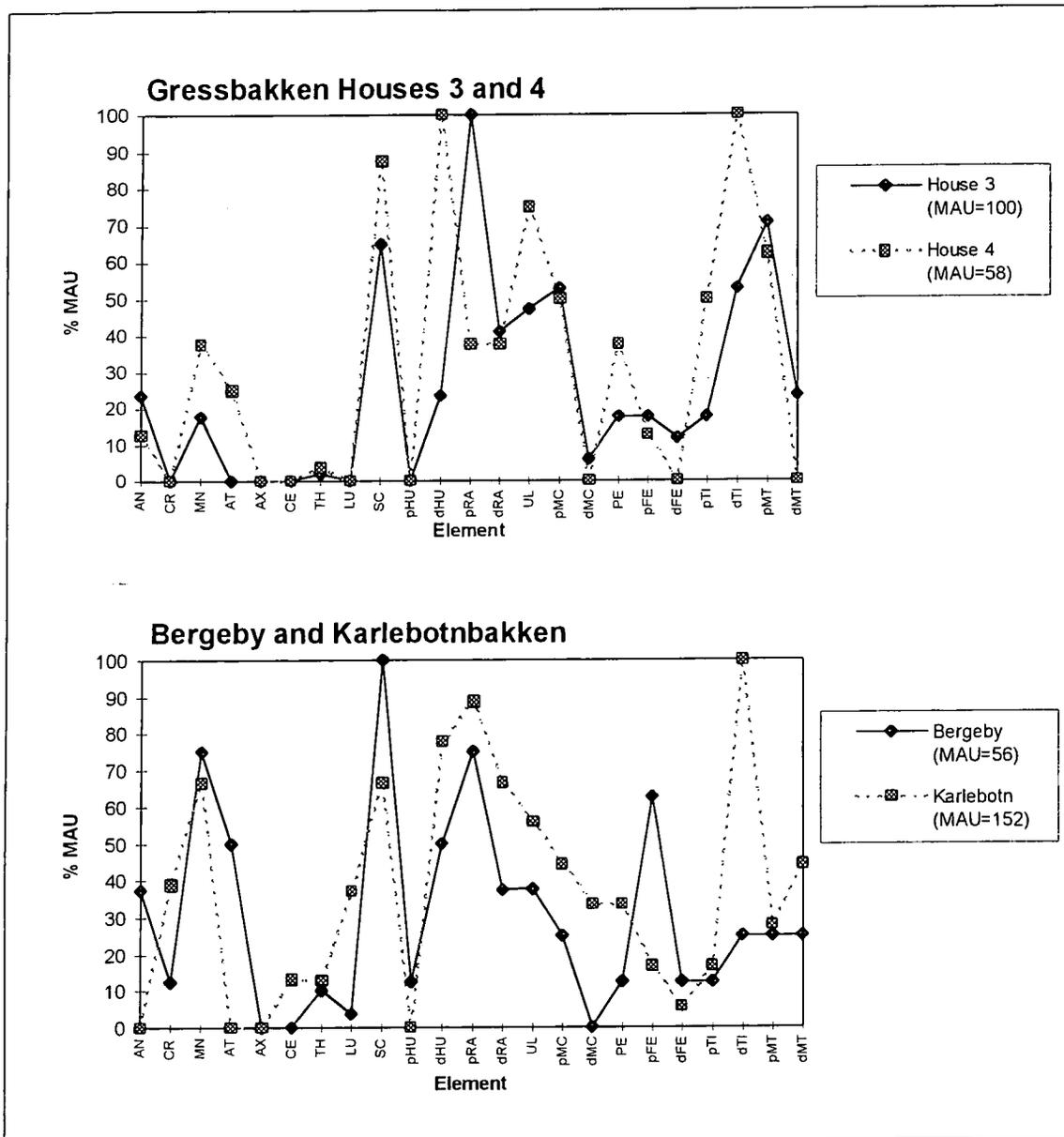
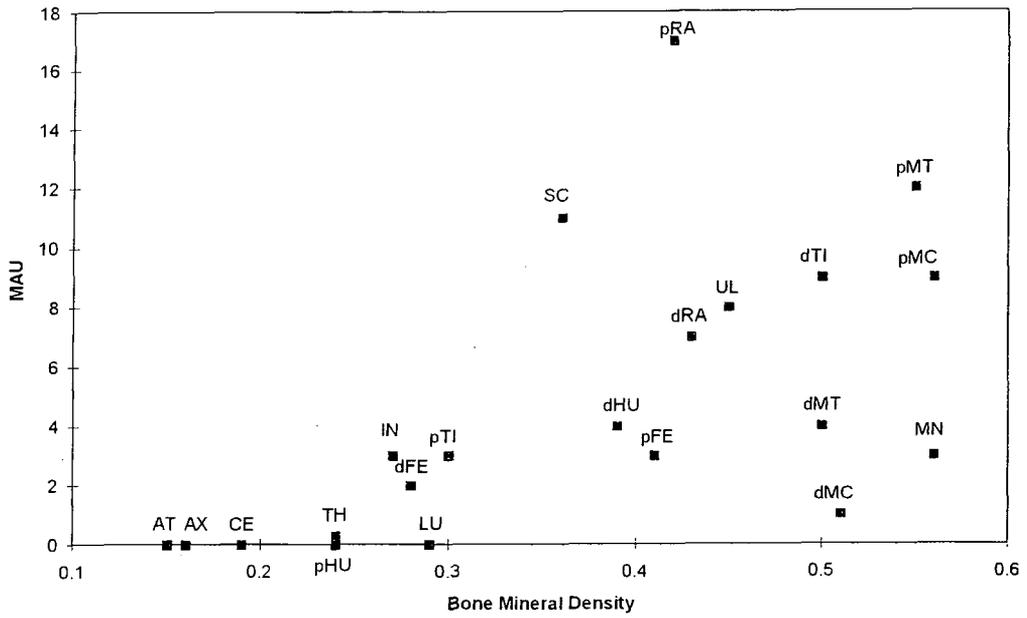


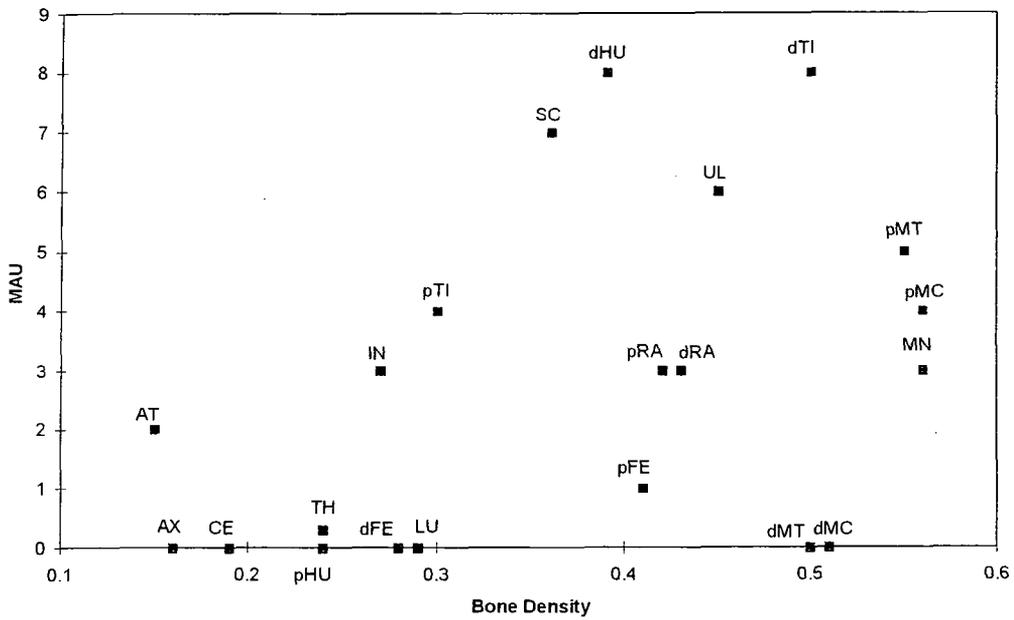
Figure 7.18 Seal element frequency in each of the middens at Gressbakken 5



**Figure 7.19** Reindeer element frequencies at Gressbakken Houses 3 and 4 (above) and Bergeby and Karlebotnbakken (below)  
 note: element codes as for seal with the addition of AN=antler



**Figure 7.20** Reindeer bone mineral density vs. MAU at Gressbakken 3 (MAU=100)



**Figure 7.21** Reindeer bone mineral density vs. MAU at Gressbakken 4 (MAU=58)

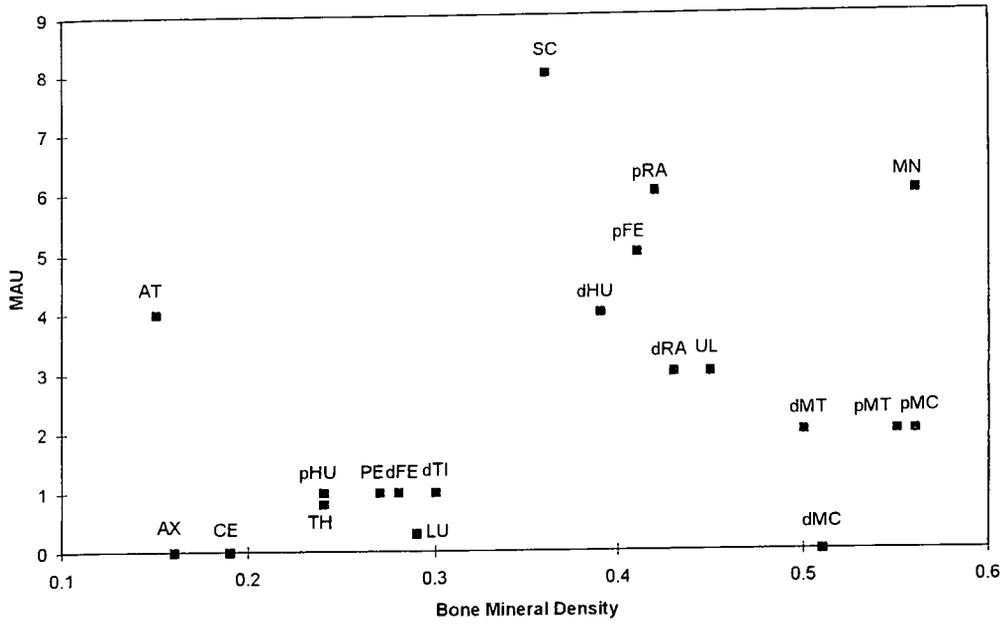


Figure 7.22 Reindeer bone mineral density vs. MAU at Bergeby 18 (MAU=55)

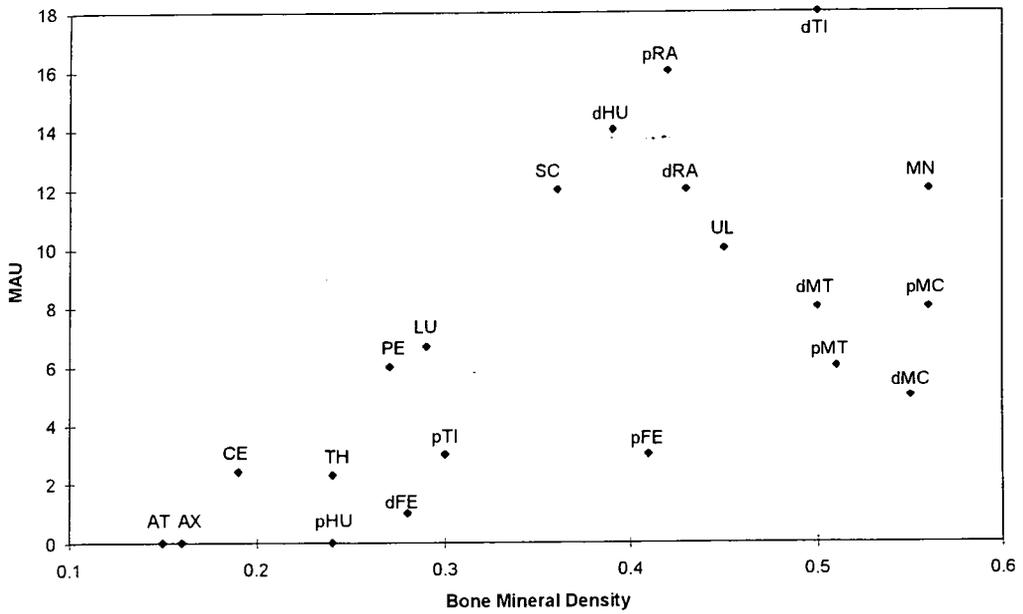


Figure 7.23 Reindeer bone mineral density vs. MAU at Karlebotnbakken (MAU=152)

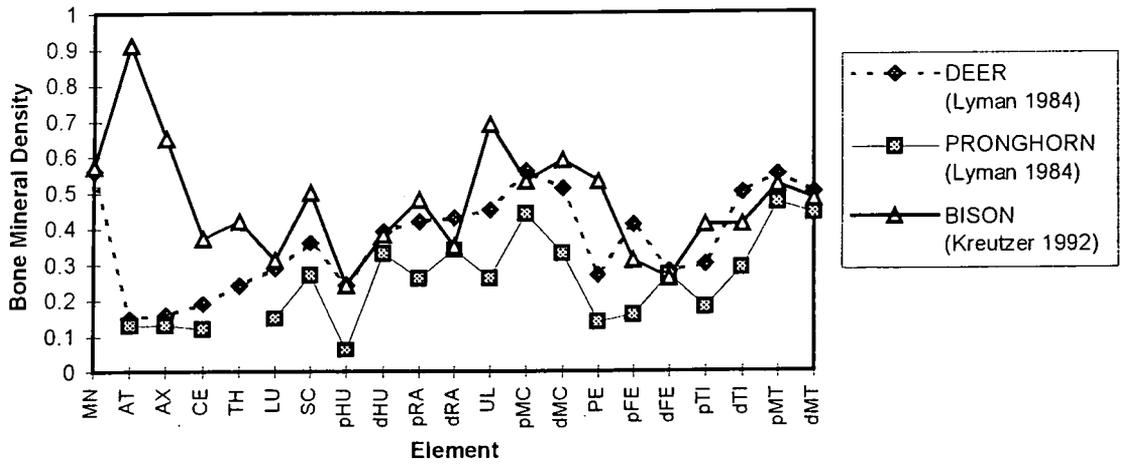


Figure 7.24 Ungulate bone mineral density

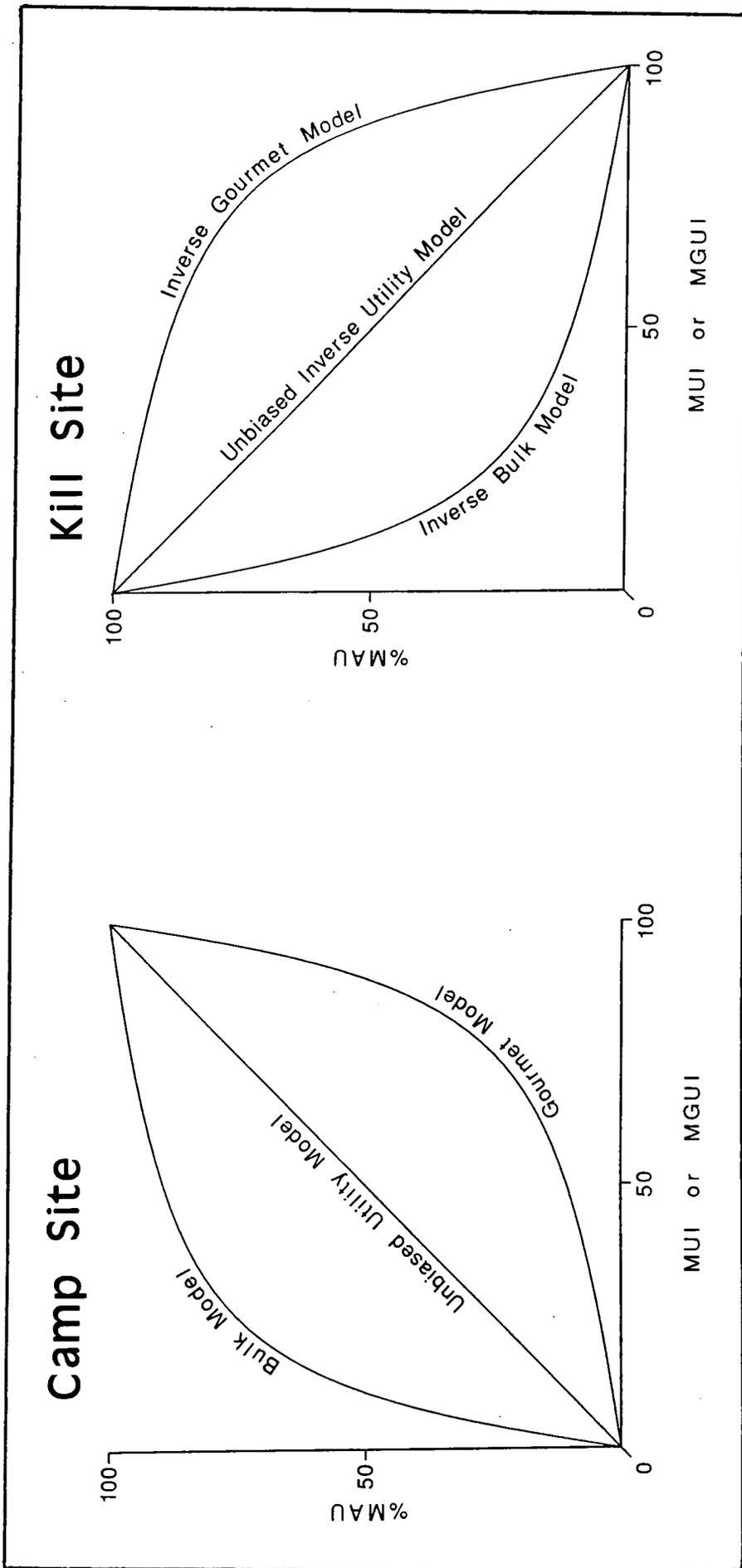
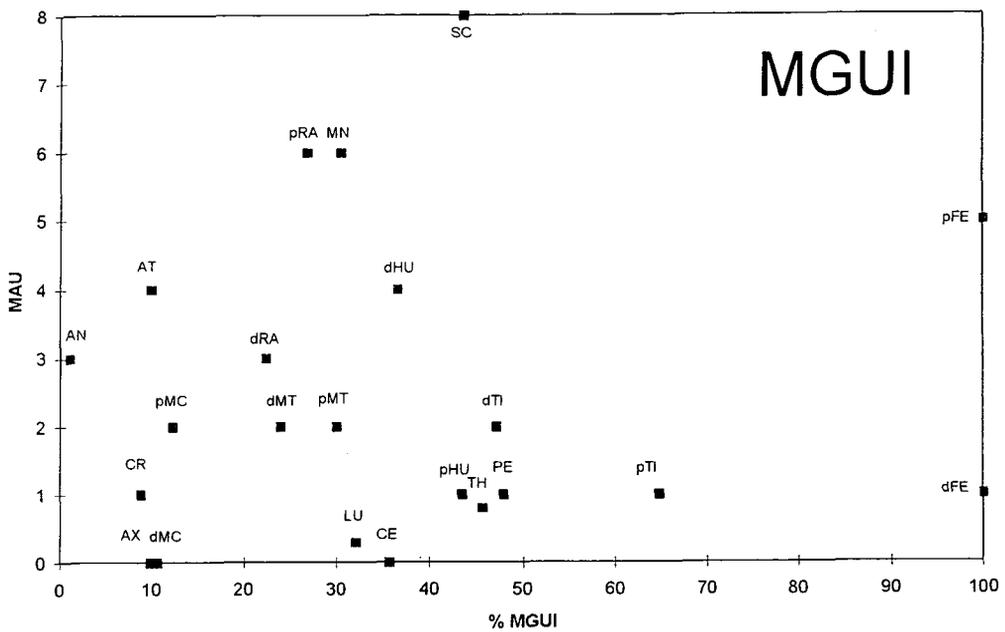
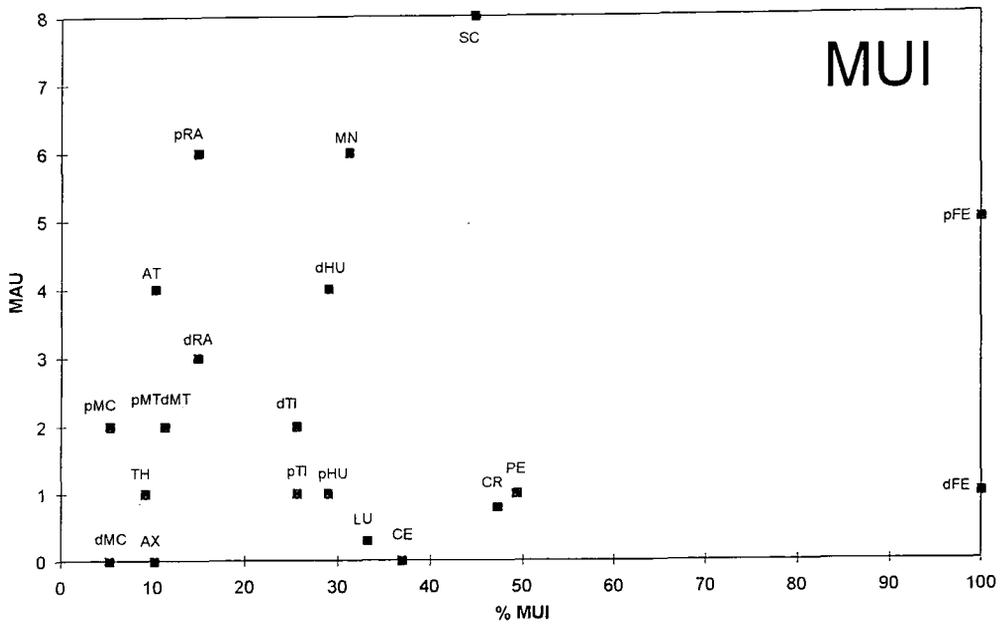


Figure 7.25 Binford's transport strategy models (after Binford 1978: Figure 2.18)

# Bergeby 18



**Figure 7.26** Reindeer meat utility index (above) and modified general utility index (below) vs. MAU at Bergeby House 18

# Gressbakken 3

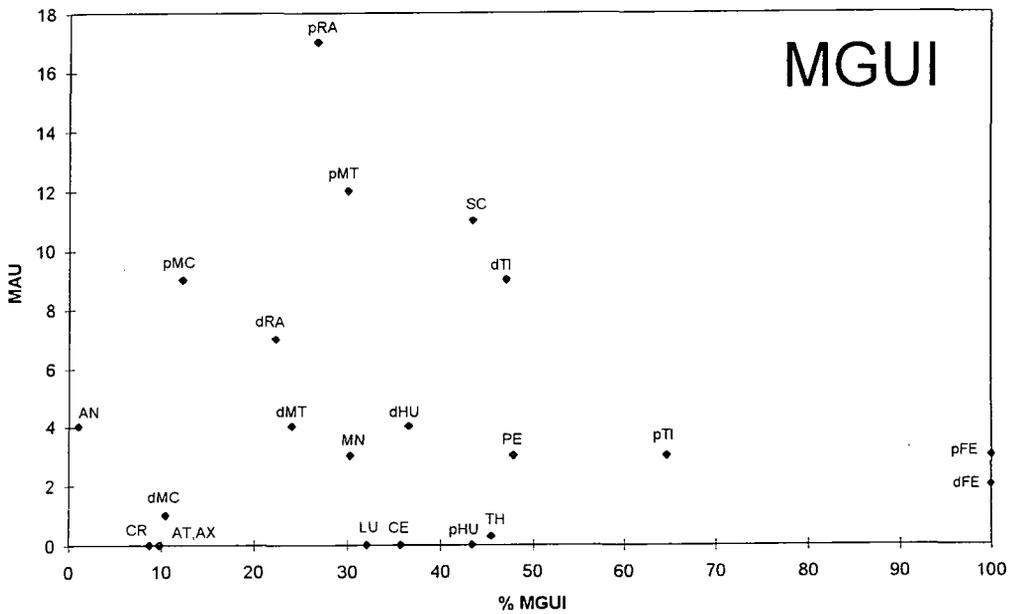
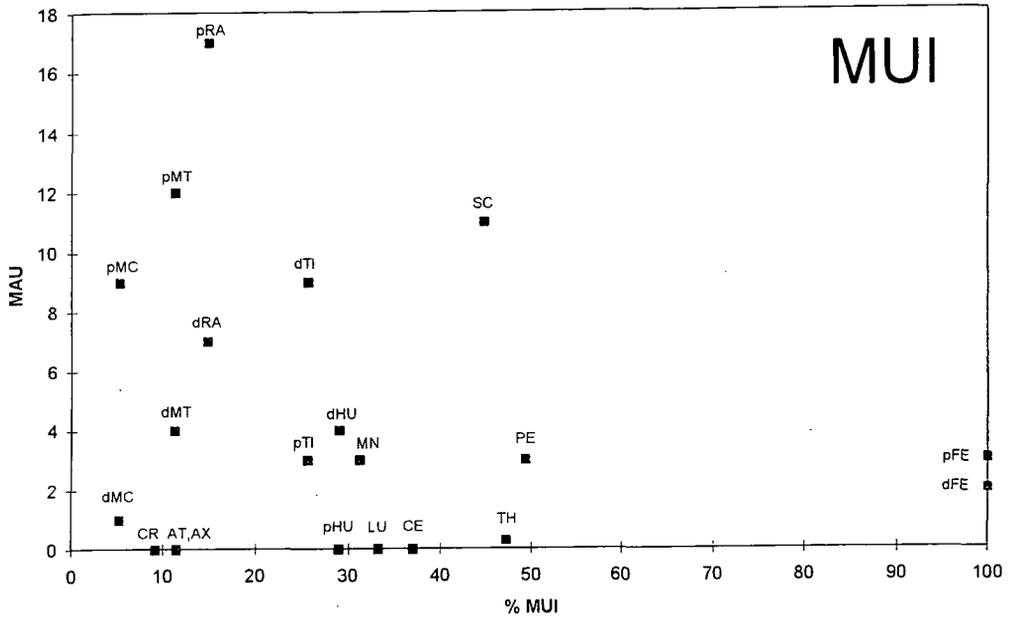


Figure 7.27 Reindeer meat utility index (above) and modified general utility index (below) vs. MAU at Gressbakken House 3

# Gressbakken 4

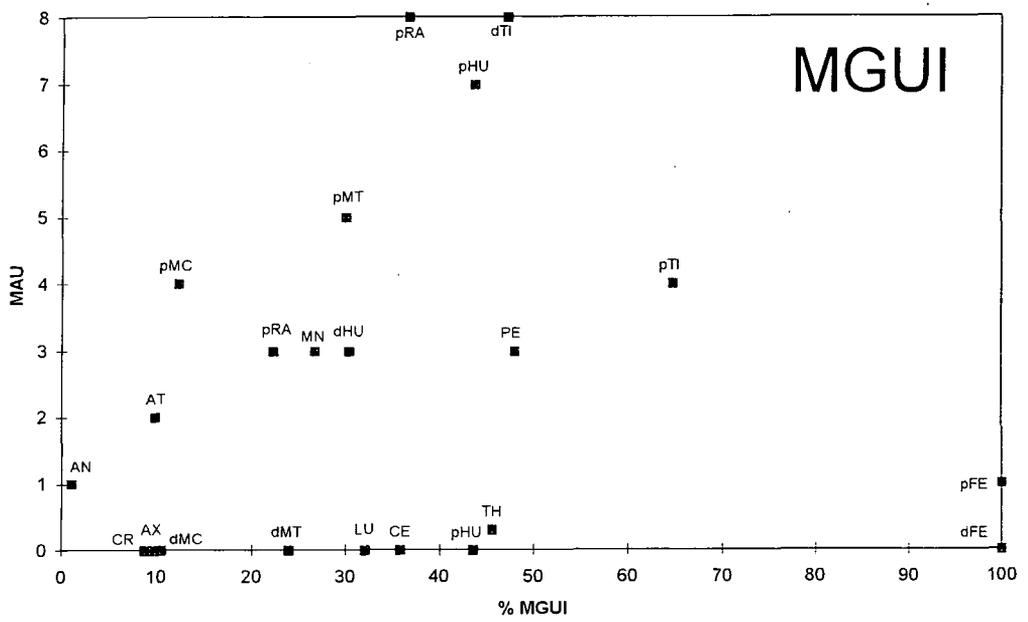
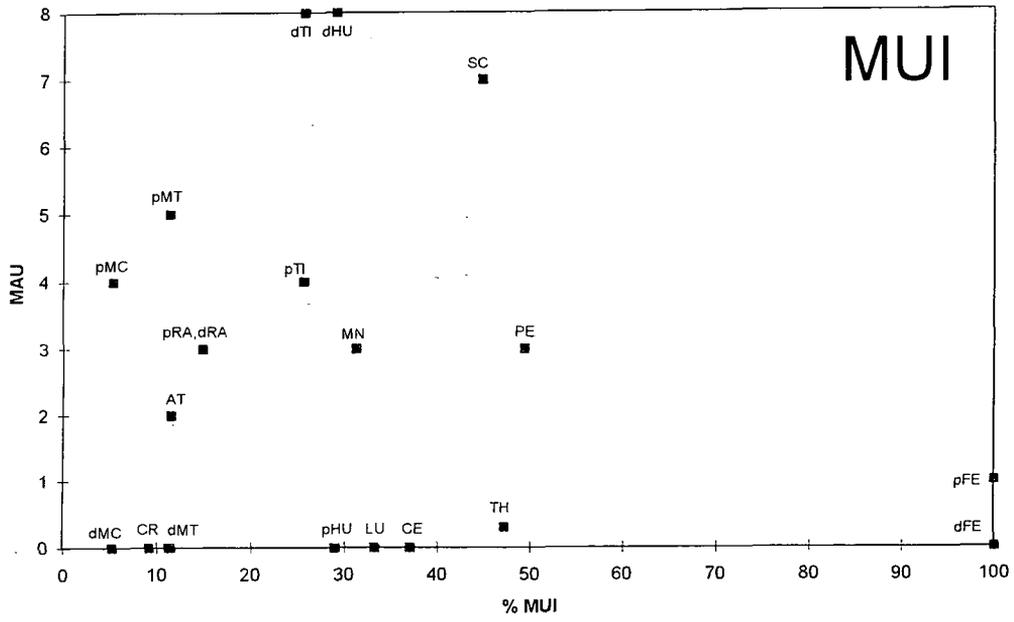


Figure 7.28 Reindeer meat utility index (above) and modified general utility index (below) vs. MAU at Gressbakken House 4

# Karlebotnbakken

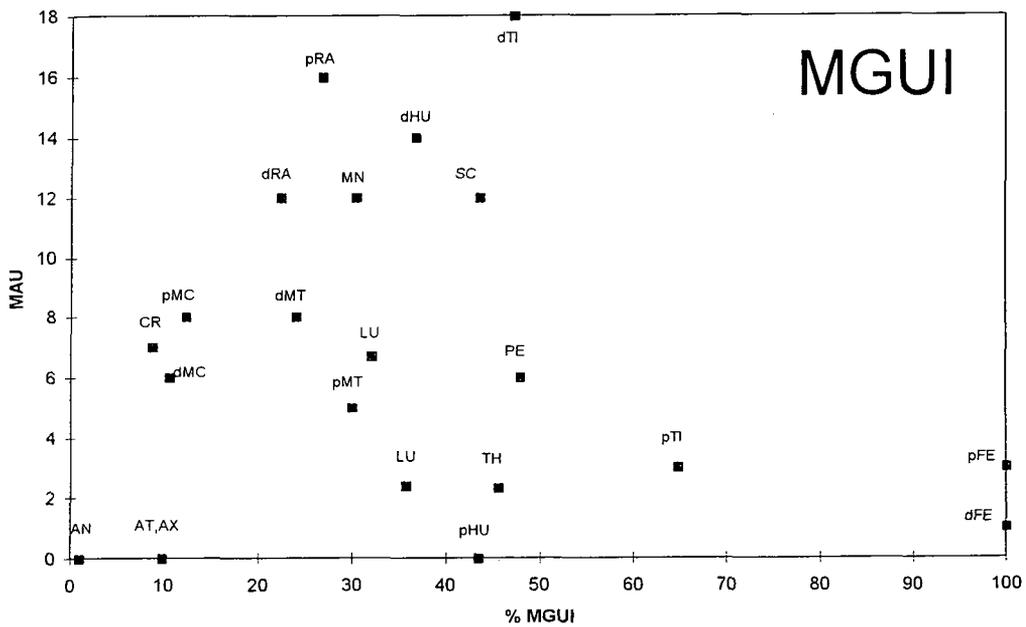
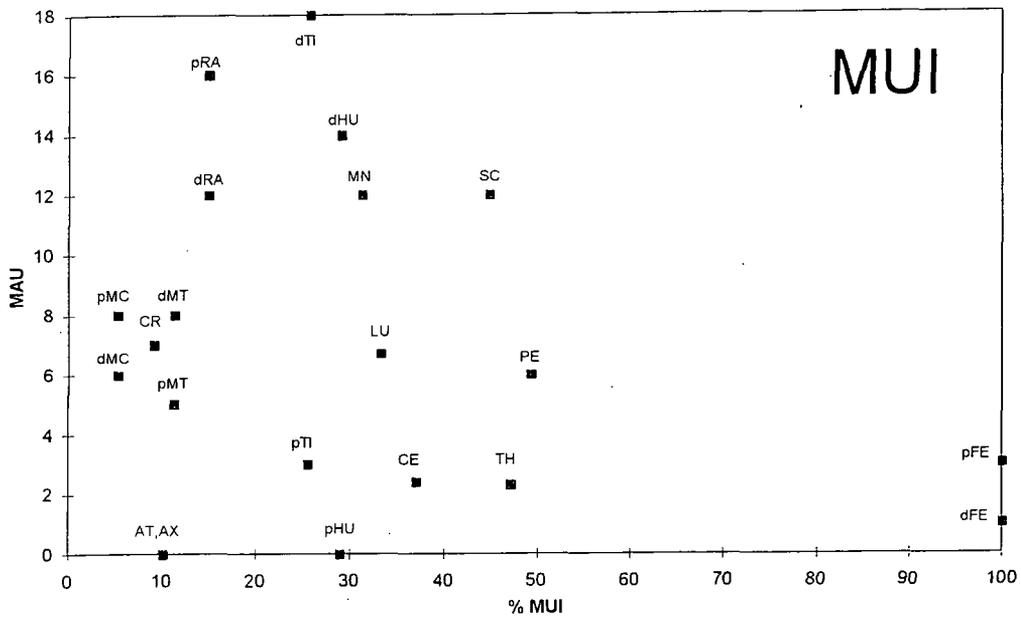


Figure 7.29 Reindeer meat utility index (above) and modified general utility index (below) vs. MAU at Karlebotnbakken

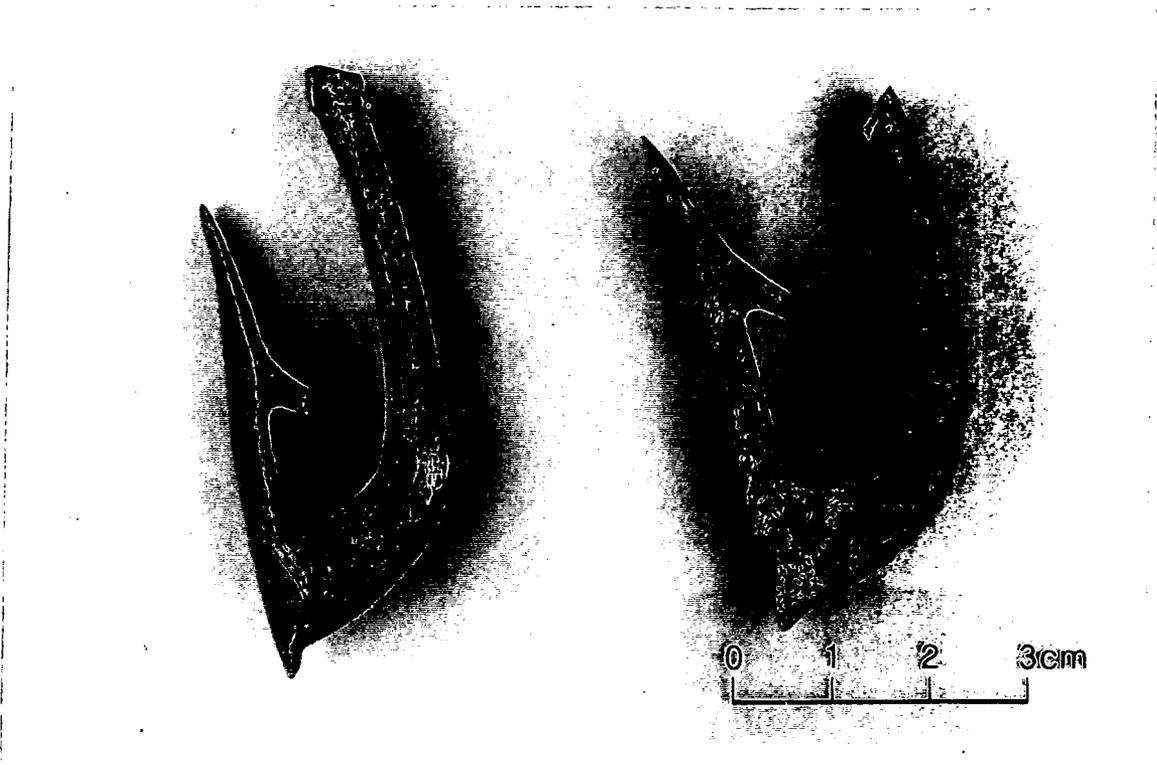


Figure 7.30 Antler fish hooks from Gressbakken 3 and Gressbakken 4

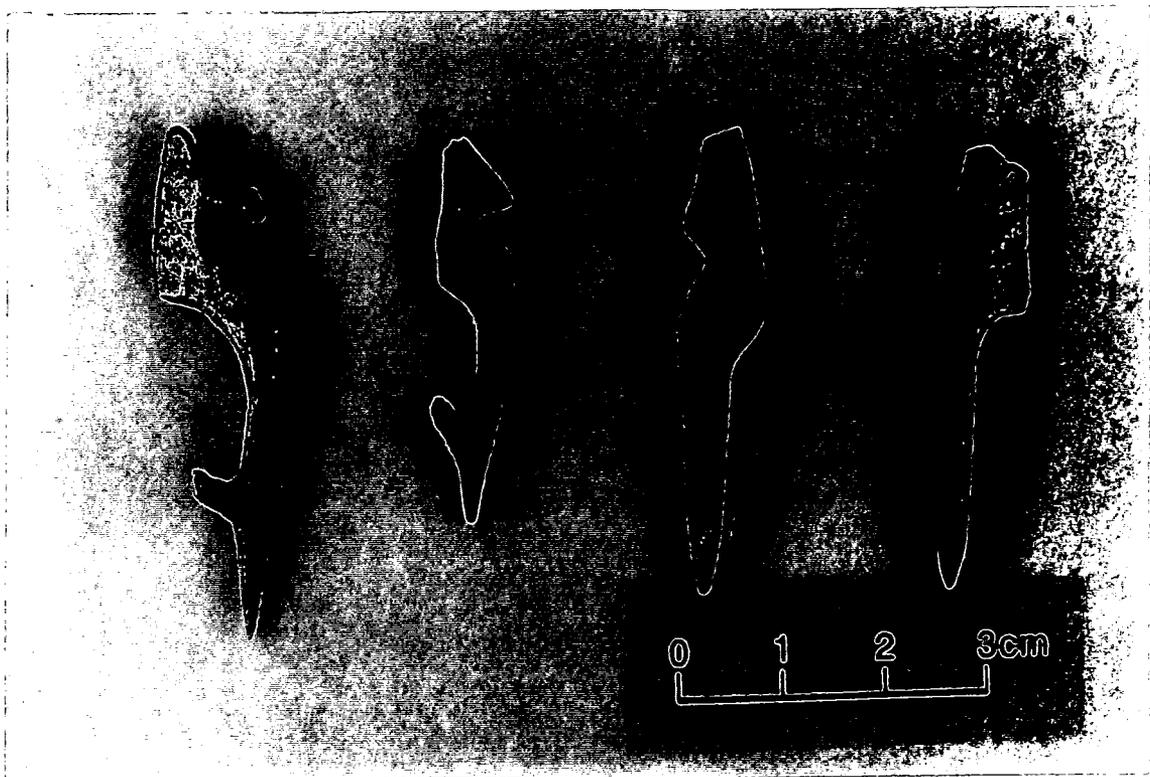
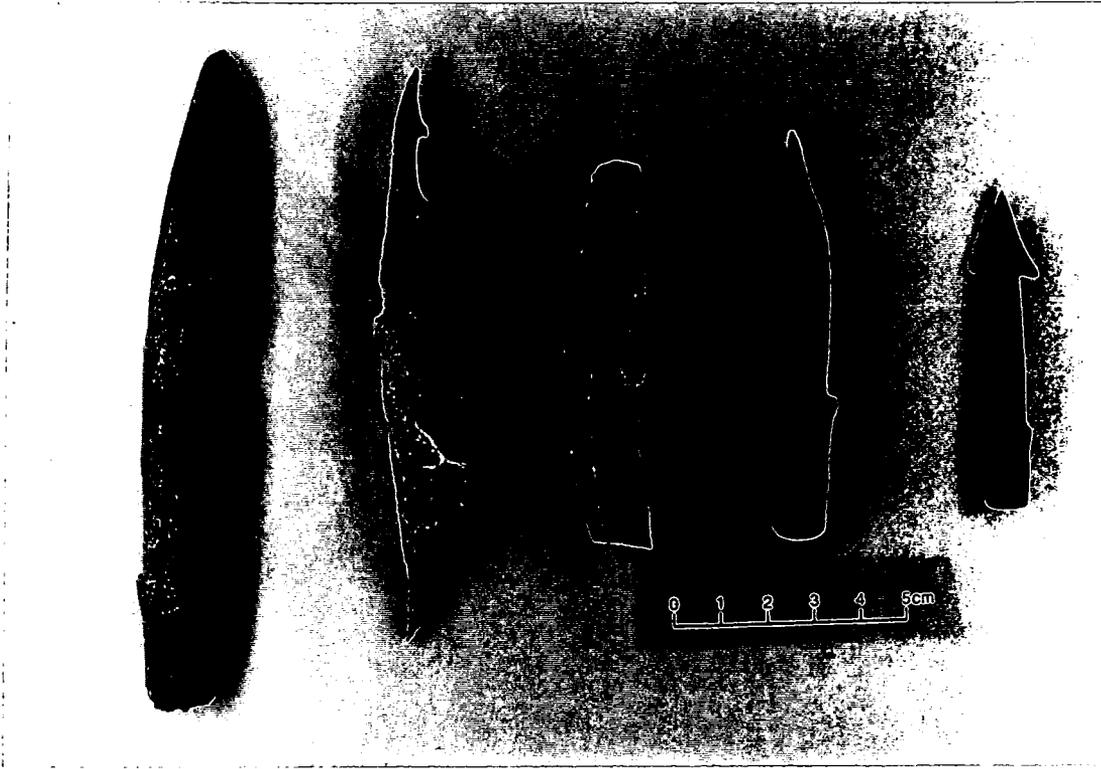
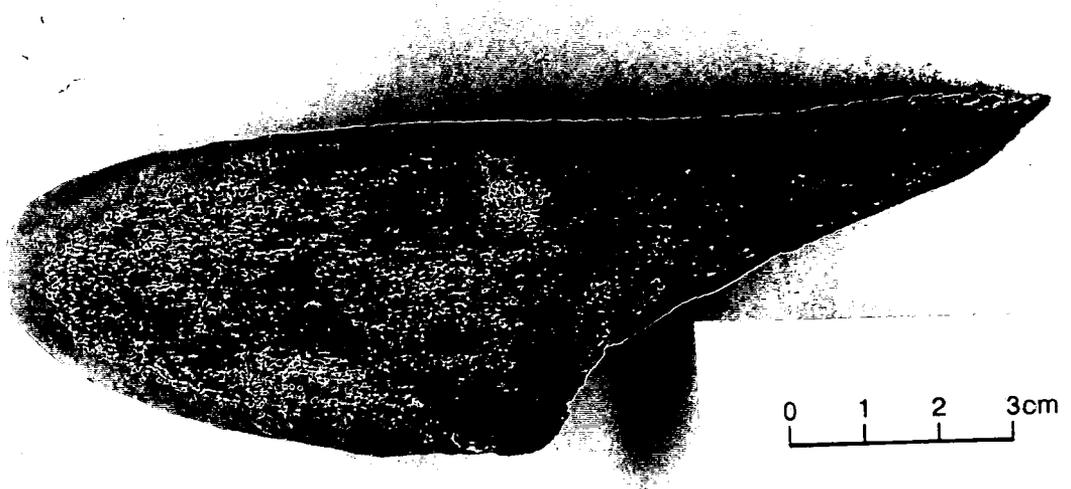


Figure 7.31 Antler barbs from Gressbakken 3



**Figure 7.32** Antler harpoons from Gressbakken 3 and 4  
Left to right: 1) simple harpoon preform; 2) harpoon preform?; 3) harpoon socket from composite toggling harpoon; 4) and 5) arming tips from composite harpoons



**Figure 7.33** Antler chisel from Gressbakken 3

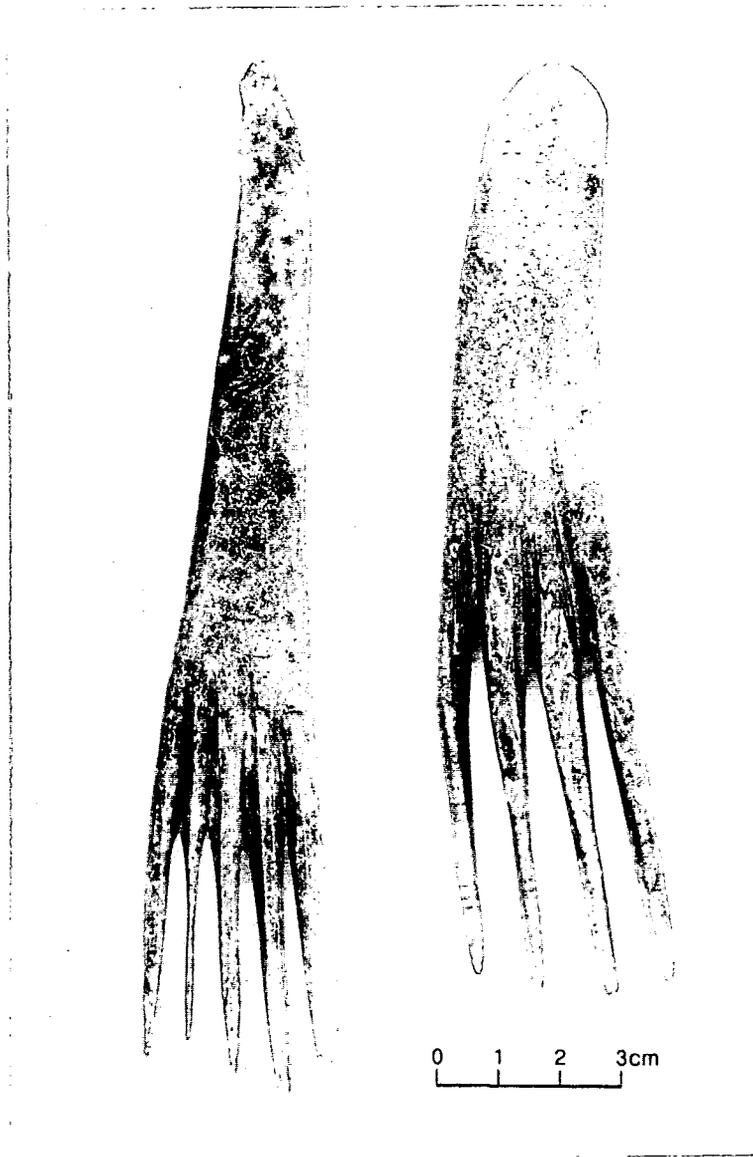


Figure 7.34 Antler combs from Gressbakken 3 and 4

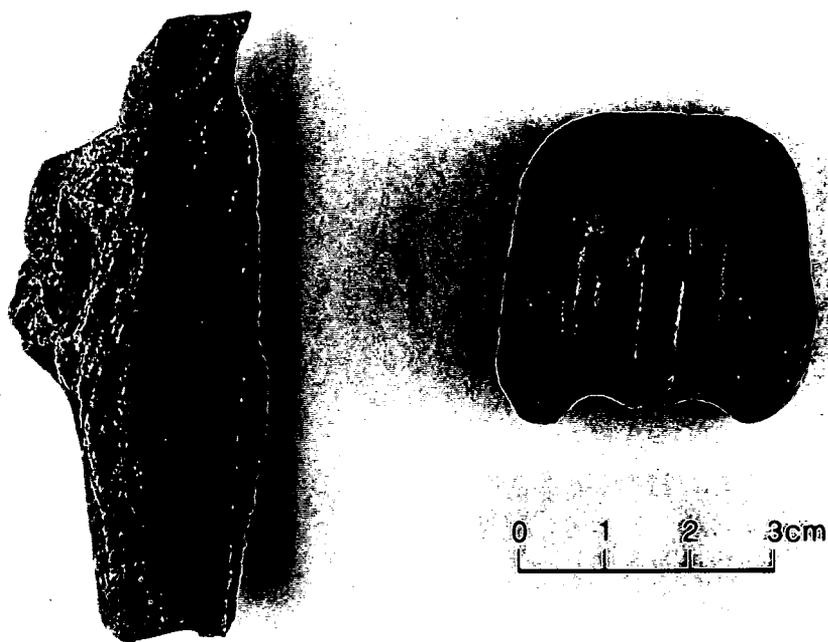


Figure 7.35 Possible skin boat fittings of antler from Gressbakken 3 and 4



Figure 7.36 Antler tines from Gressbakken 3 and 4 scored and snapped using the “chocolate block” technique (central tine shows evidence of carnivore gnawing)

a



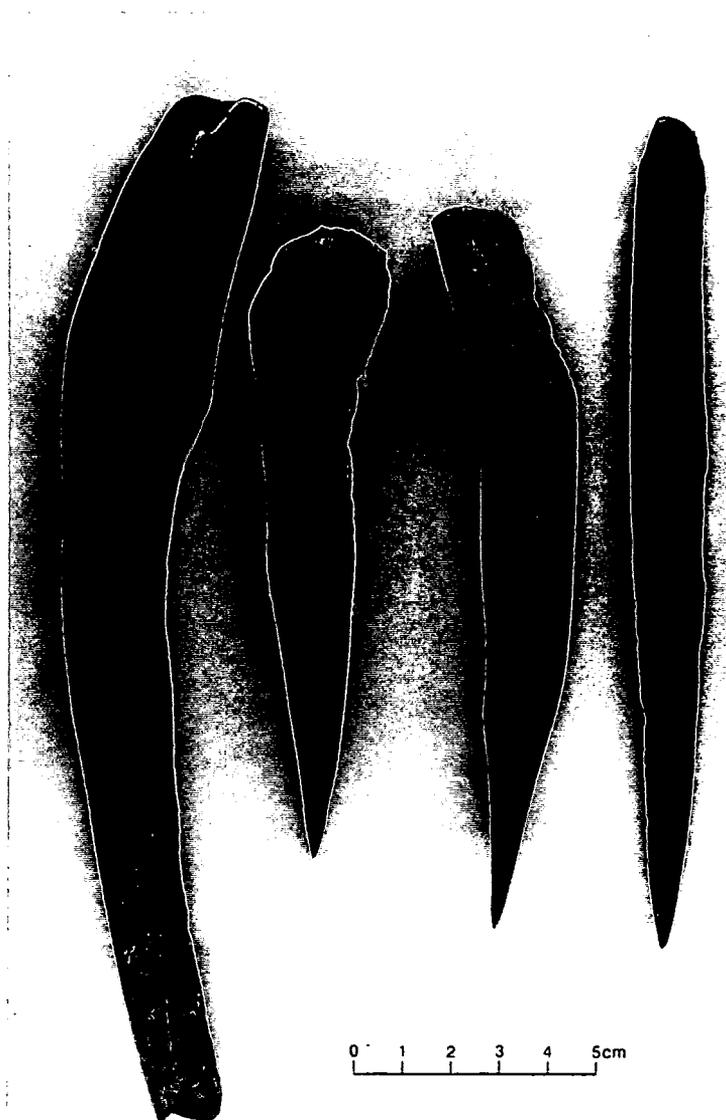
0 1 2 3 4 5cm

b



0 1 2 3 4 5cm

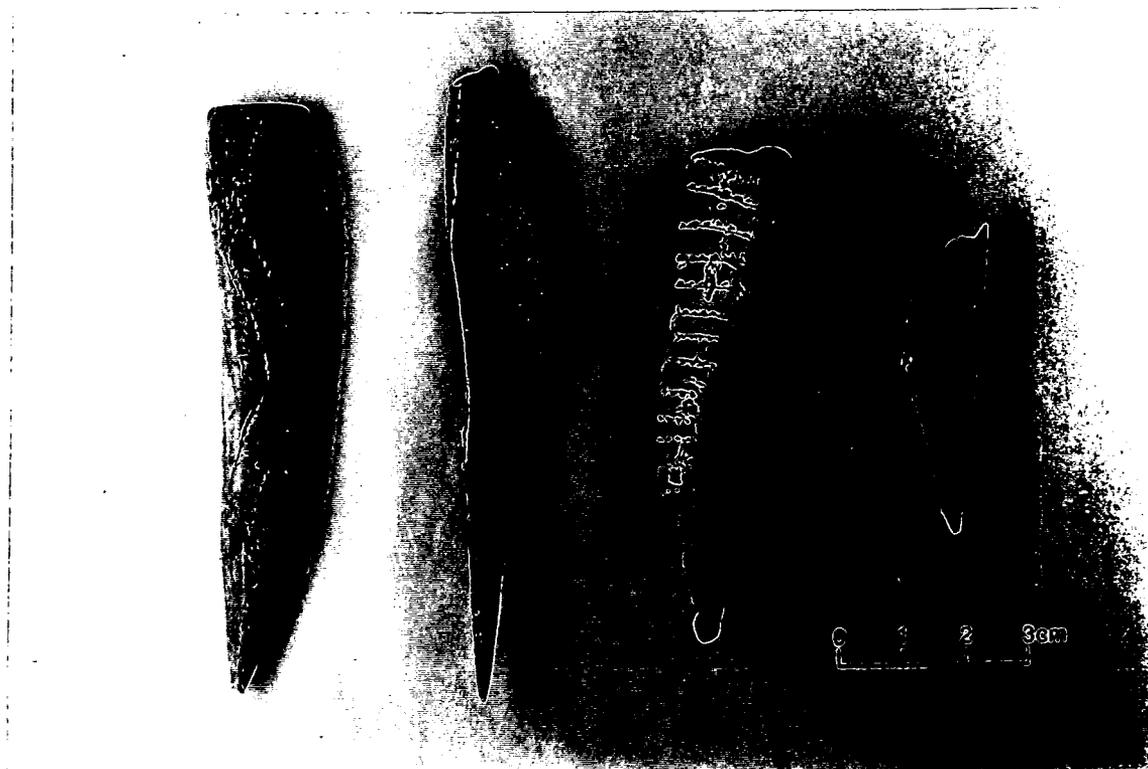
**Figure 7.37** Two views of a worked reindeer antler burr from Gressbakken 3.  
a) The left side shows where it had been shed naturally, the right side where it was scored and snapped for artefact manufacture. b) The antler was also partly hollowed out as part of the early stages of artefact manufacture.



**Figure 7.38** Reindeer longbone artefacts from Gressbakken 4  
Left to right: 1) ulna scraper; 2) ulna awl; 3) distal humerus awl or "dagger"; 4)  
metapodial point



**Figure 7.39** Reindeer longbone artefacts from Gressbakken and 4 and Karlebotn 1.  
 Left to right: 1) proximal radius scraper; 2) distal radius scraper; 3) proximal radius point;  
 4) and 5) ulna awls



**Figure 7.40** Decorated artefacts of large terrestrial mammal (probably reindeer)  
 longbone from Gressbakken 3 and 4

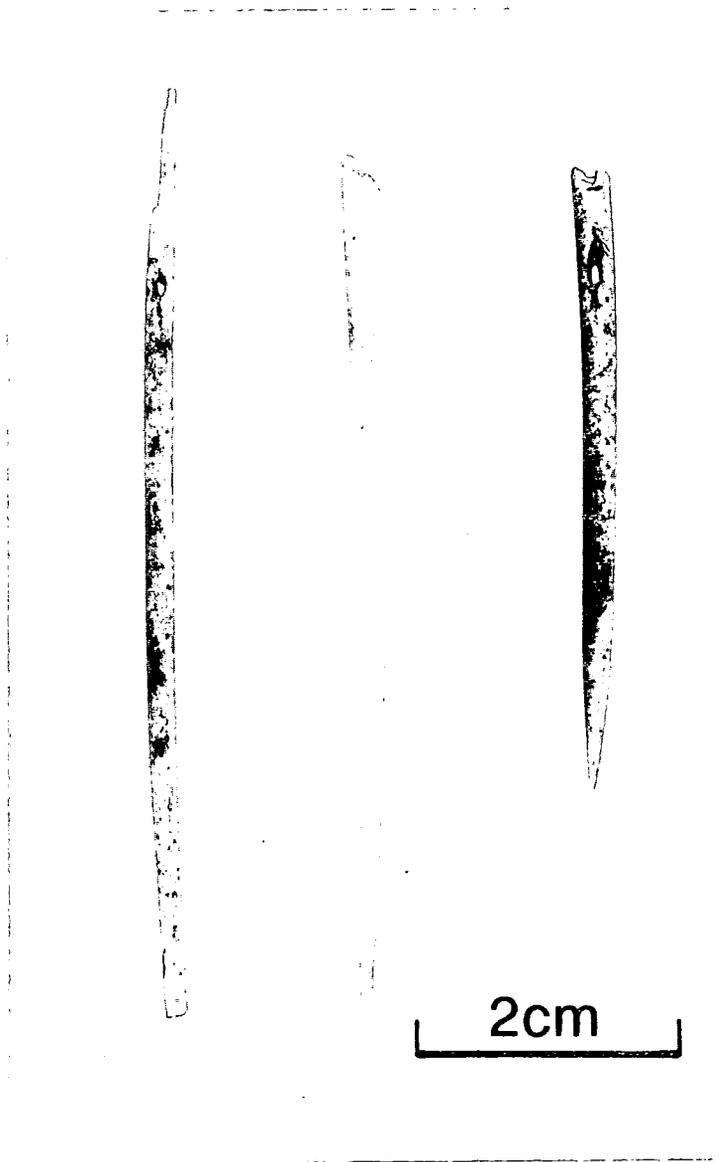


Figure 7.41 Bird bone needles from Gressbakken 3

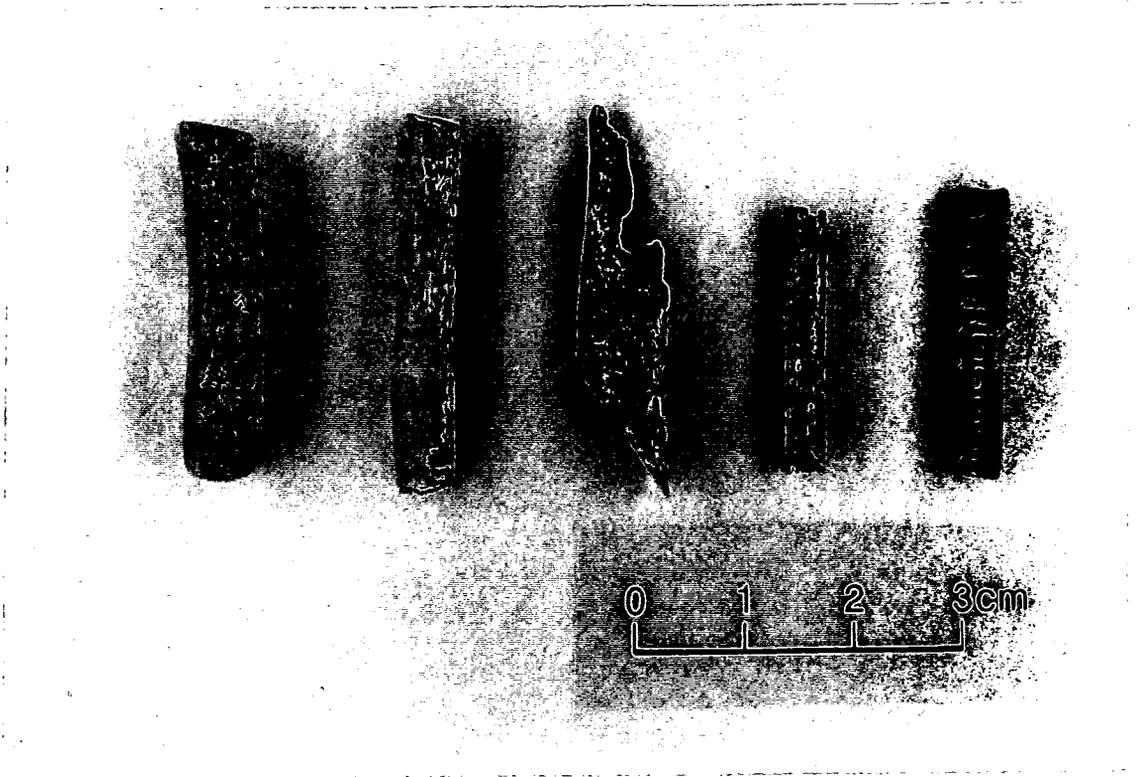
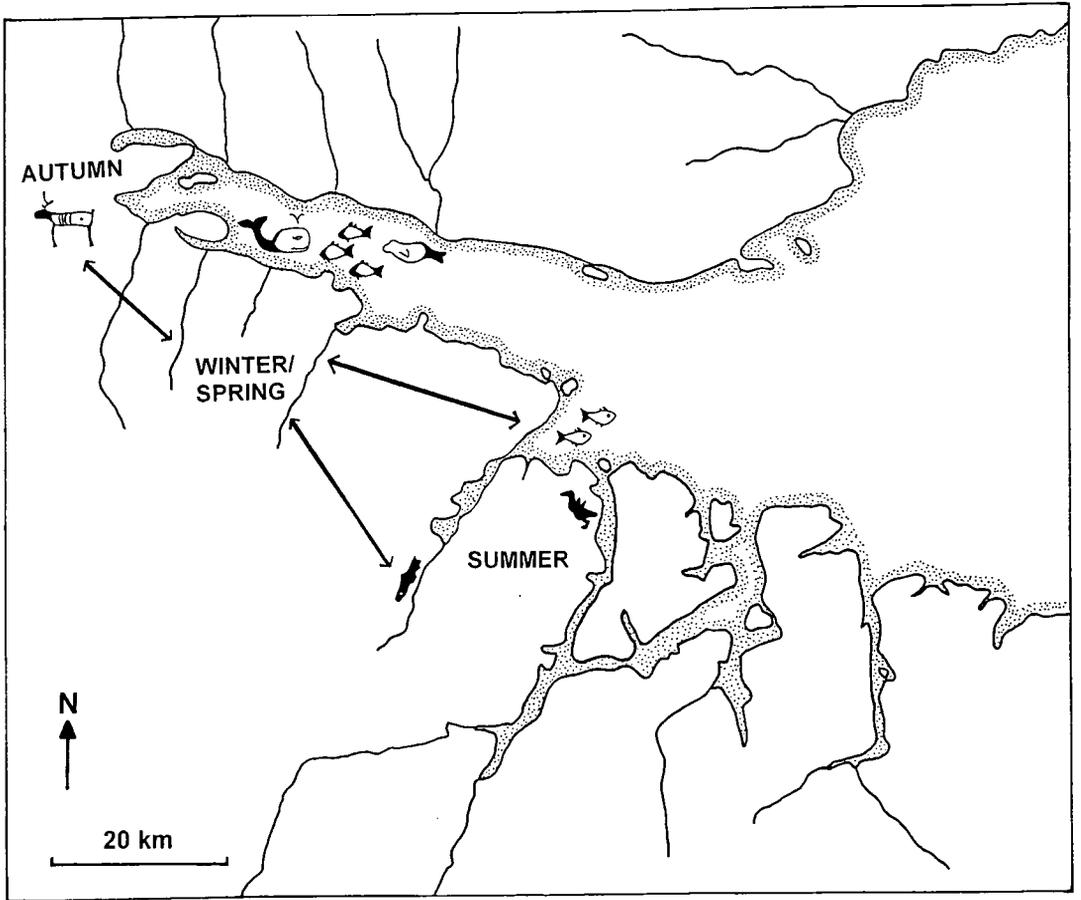
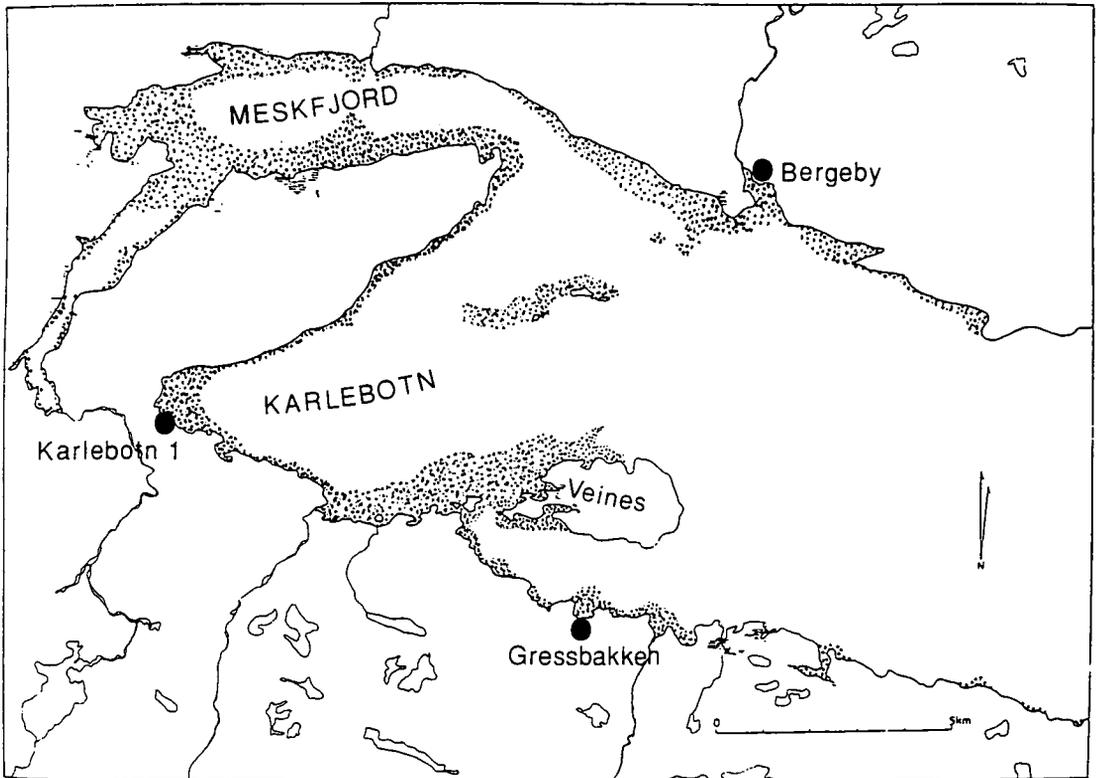


Figure 7.42 Bird bone beads from Gressbakken 3 and 4



**Figure 8.1** A generalised model of late YSA settlement patterns in Varangerfjord



**Figure 8.2** Map of inner Varangerfjord circa 4000 BP  
 Circles indicate all known sites with Gressbakken-type houses (after Schanche 1994. fig. 37).  
 Dots indicate areas of shallow foreshore.

## APPENDIX A

### CUTMARKS, MARROW EXTRACTION, CARNIVORE DAMAGE AND FRAGMENTATION

**Table A.1** Cutmarks on mammal bones from the late YSA sites in Varangerfjord.  
Values indicate number of specimens (NISP) displaying cutmarks. Individual specimens often have multiple cutmarks. GB=Gressbakken; KB=Karlebotn

	GB 3	GB 4	GB 5	KB 1
<b>Phocidae adult</b>				
rib		7	1	
mandible	2			
atlas		4		
cervical	1	2		
thoracic		1		
scapula	3	1	2	
humerus		1		
metacarpal	1			
pelvis	3	4		
femur	1	1		1
tibia		2		
fibula		2		
metatarsal	1	1	2	
phalanx		1		
<b>Phocidae juvenile</b>				
rib		6		
atlas		1		
scapula		3		
humerus		3		
ulna	1			
pelvis	1	1		
tibia		5	1	
fibula			1	
<b><i>Phoca groenlandica</i> adult</b>				
cranium	2	6		
mandible	1		1	
scapula	4	3		
humerus	5	2	1	1
radius		1		
ulna	1	1	1	
pelvis		4		
femur	1	3	1	
tibia	1			
fibula		2	3	
calcaneus				1
<b><i>P. groenlandica</i> juvenile</b>				
scapula	4	1		
humerus	3	2	1	
radius		1		
ulna		1		
femur	1	2		
tibia		1		

**Table A.1** continued

GB=Gressbakken; KB=Karlebotn

	GB 3	GB 4	GB 5	KB 1
<b><i>Phoca hispida/Phoca vitulina</i>* adult</b>				
mandible		2		
ulna		1		
<b><i>P. hispida/P. vitulina</i>* juvenile</b>				
scapula	1		2	
humerus	5	12	5	
radius			1	
ulna		4	3	
pelvis		3	1	
femur	4	1	1	
tibia		1	3	
fibula		1		
metatarsal			1	
<b>Cetacea</b>				
rib		19	1	
cranium		1		
humerus		1		
ulna		1		
<b><i>Lagenorhynchus</i> sp.</b>				
rib		1	3	
uoideum		1		
atlas		1		
thoracic		1		
scapula		1	2	
humerus		1		
radius			1	
ulna			1	
<b><i>Rangifer tarandus</i></b>				
mandible	1			
scapula		1		
humerus	1	2		
radius	1			1
metacarpal		1		
femur	1			
tibia		2		
metatarsus		1		
longbone fragment	1	5		
<b>Unidentified mammal</b>				
rib		1		

\*The *Phoca hispida/Phoca vitulina* category includes specimens positively identified as *P. hispida* as well as those which could only be attributed to either *P. hispida* or *P. vitulina*.

Also:

**Gressbakken 23** Phocidae: 1 femur; *Phoca groenlandica*: 2 ulna, 1 pelvis

**Advik B** Phocidae: 1 radius; *Phoca groenlandica*: 1 humerus

**Bergeby 18** *Phoca groenlandica*: 1 juvenile humerus, 1 radius, 1 ulna

**Table A.2** Reindeer bone marrow extraction at the late YSA sites in Varangerfjord

In most cases, the proximal or distal end has been removed transverse to the shaft. Occasionally a longbone has been split lengthwise as indicated by (L).

	<b>GB 3</b>	<b>GB 4</b>	<b>GB 5</b>	<b>BE 18</b>	<b>KB 1</b>	<b>HB 2</b>
prox HUMERUS						
dist HUMERUS		1			5	
prox RADIUS	12	7		3	11 + 1 (L)	
dist RADIUS				2	12	
prox ULNA						
prox METACARPUS	3 (L)	2 (L)		1 (L)	3 (L)	
dist METACARPUS					1	
prox FEMUR						
dist FEMUR						
prox TIBIA					1	
dist TIBIA	7	6	1	1	15	1
prox METATARSUS	1 + 3 (L)	2 + 1 (L)	1 (L)	1 (L)	1 + 4 (L)	
dist METATARSUS	1			1 (L)	4	
PHALANX 1					1 (L)	

Site codes: GB=Gressbakken, BE=Bergeby, KB=Karlebotn, HB=Høybukt

Element codes: prox=proximal, dist=distal

**Table A.3** Carnivore chewing on mammal bone from the late YSA sites in Varangerfjord (all values are NISP)

	GB 3	GB 4	GB 5	GB 23	KB 1
<b>Phocidae adult</b>					
rib		3			
thoracic		1		1	
lumbar			1	1	
sacrum		2			
scapula	1	2	1		
humerus		5	1		
radius		1		1	
ulna	1	2	3		
metacarpal		1			
pelvis		5			
femur		1		1	
tibia	7	3	2		
fibula		2			
tarsal		2	2	1	
metatarsal	5	1	4	3	
phalanx	1	7	9	2	
<b>Phocidae juvenile</b>					
humerus		2			
ulna			6		
pelvis		1	2		
femur			1		
tibia	2	11	7	1	
fibula			1		
metatarsal	1		1		
<b><i>Phoca groenlandica</i> adult</b>					
ulna				2	
pelvis			1		
tibia			1		
<b><i>P. groenlandica</i> juvenile</b>					
humerus		1			
ulna			1		
femur			1		
tibia		2			
<b><i>Phoca hispida/Phoca vitulina</i>* adult</b>					
humerus		1			
radius		1			
tibia		3			
<b><i>P. hispida/P. vitulina</i>* juvenile</b>					
humerus	1	1	2		
ulna		1	1		
tibia	1	7			
metatarsal			1		

\*The *Phoca hispida/Phoca vitulina* category includes specimens positively identified as *P. hispida* as well as those which could only be attributed to either *P. hispida* or *P. vitulina*.

Site codes: GB=Gressbakken, KB=Karlebotn

Table A.3 continued

	GB 3	GB 4	GB 5	GB 23	KB 1
<b>Cetacea</b>					
rib		6	7		
vertebra		1	1		
scapula		1			
humerus			1		
radius		2			
ulna		1			
phalanx		2			
unidentified fragment			1		
<b><i>Lagenorhynchus</i> sp.</b>					
uoideum		2			
rib		1	1		
sternum		5	1		
vertebra		3	7		
scapula		3	6		
humerus	1	3	5		
radius		4	3		
ulna		3	6		
<b><i>Rangifer tarandus</i></b>					
antler	1	2	2		
cranium		1			
mandible					1
rib			1		1
sternum					1
scapula	1	4			2
humerus	1	5			3
radius		8			
ulna	4				1
metacarpal		1			
pelvis	5	6			3
femur		1			1
tibia	1	2			1
naviculo-cuboid		2			
astragalus		3			
calcaneus	1	7			
longbone fragment	2	23			
<b><i>Ursus arctos</i></b>					
radius		1			
phalanx		1			
<b>Unidentified mammal</b>					
radius		1			
unidentified fragment		5			
<b>TOTAL</b>	<b>37</b>	<b>180</b>	<b>91</b>	<b>13</b>	<b>14</b>

Site codes: GB=Gressbakken, KB=Karlebotn

Also:

**Advik J** Phocidae: 1 tibia; *Rangifer tarandus*: 1 antler, 1 femur

**Bergeby 18** Phocidae: 1 metatarsal, 1 baculum; *Phoca groenlandica*: 1 ulna

**Table A.4** Representation of seal longbones versus carpals, tarsals and phalanges in sieved and unsieved assemblages from Varangerfjord.  
 Values in parenthesis indicate number of each element in a complete skeleton.

SEAL	4 mm dry sieved				unsieved			
	Bergeby 18		Karlebotn 1		Gressbakken 3		Gressbakken 4	
	NISP	MNE	NISP	MNE	NISP	MNE	NISP	MNE
scapula (2)	<b>54</b>	30	<b>44</b>	11	<b>163</b>	112	<b>144</b>	71
humerus (2)	<b>36</b>	25	<b>41</b>	20	<b>91</b>	59	<b>115</b>	59
radius (2)	<b>64</b>	37	<b>34</b>	19	<b>71</b>	61	<b>47</b>	38
ulna (2)	<b>52</b>	26	<b>43</b>	26	<b>70</b>	60	<b>67</b>	48
femur (2)	<b>49</b>	36	<b>32</b>	22	<b>78</b>	54	<b>82</b>	52
tibia (2)	<b>57</b>	22	<b>38</b>	13	<b>153</b>	47	<b>119</b>	47
carpals (14)	<b>42</b>	42	<b>20</b>	20	<b>9</b>	9	<b>2</b>	2
astragalus (2)	<b>22</b>	20	<b>9</b>	8	<b>15</b>	15	<b>28</b>	26
calcaneus (2)	<b>17</b>	16	<b>10</b>	9	<b>11</b>	11	<b>15</b>	24
other tarsals (10)	<b>42</b>	42	<b>13</b>	13	<b>3</b>	3	<b>2</b>	2
phalanx 1 (20)	<b>242</b>	198	<b>38</b>	32	<b>320</b>	314	<b>162</b>	155
phalanx 2 (16)	<b>110</b>	96	<b>24</b>	20	<b>195</b>	195	<b>98</b>	97
phalanx 3 (20)	<b>114</b>	103	<b>34</b>	31	<b>181</b>	181	<b>90</b>	90

**Table A.5** Representation of reindeer longbones versus carpals, tarsals and phalanges in sieved and unsieved assemblages from Varangerfjord.  
 Values in parentheses indicate number of each element in a complete skeleton.

REIN- DEER	4 mm dry sieved				unsieved			
	Bergeby 18		Karlebotn 1		Gressbakken 3		Gressbakken 4	
	NISP	MNE	NISP	MNE	NISP	MNE	NISP	MNE
scapula (2)	<b>20</b>	8	<b>62</b>	13	<b>36</b>	10	<b>31</b>	13
humerus (2)	<b>10</b>	4	<b>51</b>	15	<b>5</b>	3	<b>14</b>	10
radius (2)	<b>22</b>	6	<b>74</b>	17	<b>40</b>	18	<b>19</b>	8
ulna (2)	<b>5</b>	3	<b>17</b>	10	<b>9</b>	8	<b>7</b>	6
femur (2)	<b>21</b>	5	<b>80</b>	5	<b>8</b>	5	<b>4</b>	1
tibia (2)	<b>15</b>	3	<b>99</b>	20	<b>17</b>	10	<b>17</b>	9
carpals (10)	<b>15</b>	15	<b>20</b>	20	<b>2</b>	2	<b>2</b>	2
astragalus (2)	<b>6</b>	3	<b>18</b>	10	<b>7</b>	7	<b>9</b>	9
calcaneus (2)	<b>10</b>	4	<b>21</b>	12	<b>16</b>	7	<b>19</b>	14
other tarsals (4)	<b>2</b>	2	<b>15</b>	14	<b>6</b>	6	<b>6</b>	6
phalanx 1 (8)	<b>1</b>	1	<b>80</b>	68	<b>4</b>	4	<b>7</b>	7
phalanx 2 (8)	<b>2</b>	2	<b>49</b>	41	<b>3</b>	3	<b>1</b>	1
phalanx 3 (8)	<b>0</b>	0	<b>18</b>	12	<b>3</b>	3	<b>2</b>	2

## APPENDIX B

### A MANUAL FOR THE IDENTIFICATION OF THE POST-CRANIAL SKELETON OF NORTH ATLANTIC PHOCID SEALS

#### B.1 Introduction

There are six phocid seal species which occupy the waters of the North Atlantic and the surrounding seas; harbour or common seal (*Phoca vitulina*), ringed seal (*Phoca hispida*), harp seal (*Phoca groenlandica*), grey seal (*Halichoerus grypus*), bearded seal (*Erignathus barbatus*) and hooded seal (*Cystophora cristata*). This guide is intended as an introduction for the zooarchaeologist to the morphological distinctions between these species. Seals display a remarkable level of intra-species variation in terms of bone morphology, and this has led to the widespread practice of identifying only a limited number of elements—cranium, mandible, humerus, ulna and femur—to the species level (Amorosi 1992). In fact, other elements of the appendicular skeleton can also be identified.

However, the traits presented in this manual are intended only as a general guide. Because of the wide range of variation within all six species, there is often overlap between species. Some of the illustrated traits are unique to each species. Others can be used to distinguish between species in some cases, *BUT NOT IN OTHERS*. Such traits will identify individuals which exhibit an extreme variant of the trait, but not those in which the trait is less pronounced and “overlaps” with another (or several other) species.

This manual is no substitute for a comparative collection of seal skeletons. It is intended to complement such a collection and not to replace it. While a comparative collection containing one individual of each species may be sufficient, though perhaps not ideal, for analysing most archaeological collections of bones, it is of little use in identifying phocid seals. Comparisons based on only one individual of each species will reveal numerous traits which appeared characteristic of each species. However, if more individuals of each species are added to the collection, many of these traits will prove unreliable in distinguishing between species. A collection of six or more individuals of each species might begin to represent the variation present within each species. This manual points out where to look for differences between the species within a large comparative

collection. In some cases, it is possible to make a positive identification, in others only to narrow the list of possible phocid species based on features such as size. Only familiarity with a wide a range of comparative material and experience with archaeological collections of seal bone will allow an analyst to consistently determine whether a positive identification (e.g. *P. hispida*), a partial identification (e.g. *P. hispida/P. vitulina*), or no identification beyond Phocidae is possible in each case.

The comparative collections of the Zoological Museum in Bergen (ZMB) were used in the creation of this manual. A minimum of six adult skeletons and six juvenile skeletons were examined for almost all of the species. Unfortunately, the museum's collection includes only three juvenile hooded seals and a single incomplete juvenile bearded seal skeleton. The characteristics described for juveniles of these two species may therefore be specific to the individual skeletons in the museum rather than to hooded seals and bearded seals in general. However, adult bearded seal bones can be easily distinguished from all other phocid species due to their large size and unique morphology. Similarly, the single comparative bearded seal juvenile displays many marked differences from the juveniles of other species. Juvenile bearded seal bones should be identifiable based on these unique morphological traits and their large size relative to stage of development (as indicated by surface texture and epiphysial fusion).

The cranial bones of all six phocid species can be identified with relative ease. The traits upon which the bony palate, auditory bulla (or pars petrosa), mandible and teeth of each species may be identified are presented in Amorosi's (1992) manuscript "Non-metric trait distinctions for the North Atlantic-Eastern Arctic Phocidae". This manuscript is based largely on the work of Ulrik and Jeppe Møhl at the Zoologiske Museum in Copenhagen. Some of the cranial trait distinctions presented here are taken from Amorosi's manuscript, others are based on personal observations by the author. Photographs are used here to highlight the most important differences between the crania and mandibles of phocid species. Some of these traits are illustrated by line drawings in Amorosi's manuscript.

Post-cranial elements vary in their utility as species indicators. Axial elements including vertebrae and ribs cannot be used to distinguish between species. Phalanges, carpals, tarsals and metatarsals are also unreliable as species indicators, although bearded seal

elements stand out due to their large size. Scapula, ulna and femur can be used to distinguish between all phocids in almost all cases. Humerus and pelvis can be used to differentiate between most species, while radius, tibia and fibula can be used to distinguish between some but not all species. This manual presents the morphological characteristics of all major appendicular elements for both adults and juveniles of each species. The traits are illustrated using both line drawings and photographs. The written descriptions give an indication of the reliability of each trait in distinguishing between species. Suites of traits, rather than single traits, should be considered when making any identification. Thanks must be given to Jan Storå at the University of Stockholm who suggested the distinctions between *P. vitulina*, *P. hispida*, *P. groenlandica* and *H. grypus* femora based on the angle of the neck, and also pointed out the distinctive nature of *P. hispida* fibula.

The line drawings and photographs are all of material in the reference collections at the Zoological Museum in Bergen. Unless otherwise indicated, all drawings are life size (1:1). The drawings may not be exactly to scale as they are intended to emphasise the morphological traits in question. All of the drawings include their ZMB catalogue numbers.

## B.2 Elements of the skull

Phocid skulls are very distinct for each species, and provide the most straightforward and reliable species distinctions in the entire phocid skeleton. The auditory bulla is probably the most useful and reliable species indicator in the phocid seal skeleton. Unlike all other skeletal elements, the bulla shows little intra-species variation, making it easily identifiable. It also preserves extremely well in most archaeological contexts. Large fragments of the nasal region and maxilla are also very reliable, as are complete mandibles and certain fragments thereof.

### B.2.1 Cranium

The teeth of each species are very characteristic. The sides of the nasal cavity are also useful in making identifications. The angle at which they drop down towards the premaxilla and their length vary between species, as does the length (anterior to posterior) of the premaxilla.

#### Ringed seal—*Phoca hispida*

- ⇒The bony ridge separating the orbits is narrower than in any other species.
- ⇒As in *P. vitulina*, the sides of the nasal cavity slope sharply down towards the premaxilla.
- ⇒Postcanines are small with multiple cusps. Cusps tend to be oriented more vertically than in *P. groenlandica*.

#### Harbour seal—*Phoca vitulina*

- ⇒Postcanines are large with multiple cusps and are usually set obliquely in the palate.
- ⇒The “snout” is short, and the sides of the nasal cavity slope sharply down towards the premaxilla.
- ⇒The ridge of bone separating the orbits is considerably wider than in *P. hispida*.

#### Harp seal—*Phoca groenlandica*

- ⇒Viewed from above, the tip of the “snout” is quite square.
- ⇒The premaxilla is characteristically flat.
- ⇒Postcanines are intermediate between *P. hispida* and *P. vitulina* in size. They have multiple cusps, which tend to curve back towards the rear of the skull more than in *P. hispida*.

#### Grey seal—*Halichoerus grypus*

- ⇒The sides of the nasal cavity are straight rather than curved as they drop down from the nasal bone towards the premaxilla. They drop less steeply and are longer when viewed side-on than in all three *Phoca* species. This gives the overall impression of a very long “snout”.
- ⇒Canines are particularly large relative to the other teeth.
- ⇒Postcanines have single cusps.

#### Bearded seal—*Erignathus barbatus*

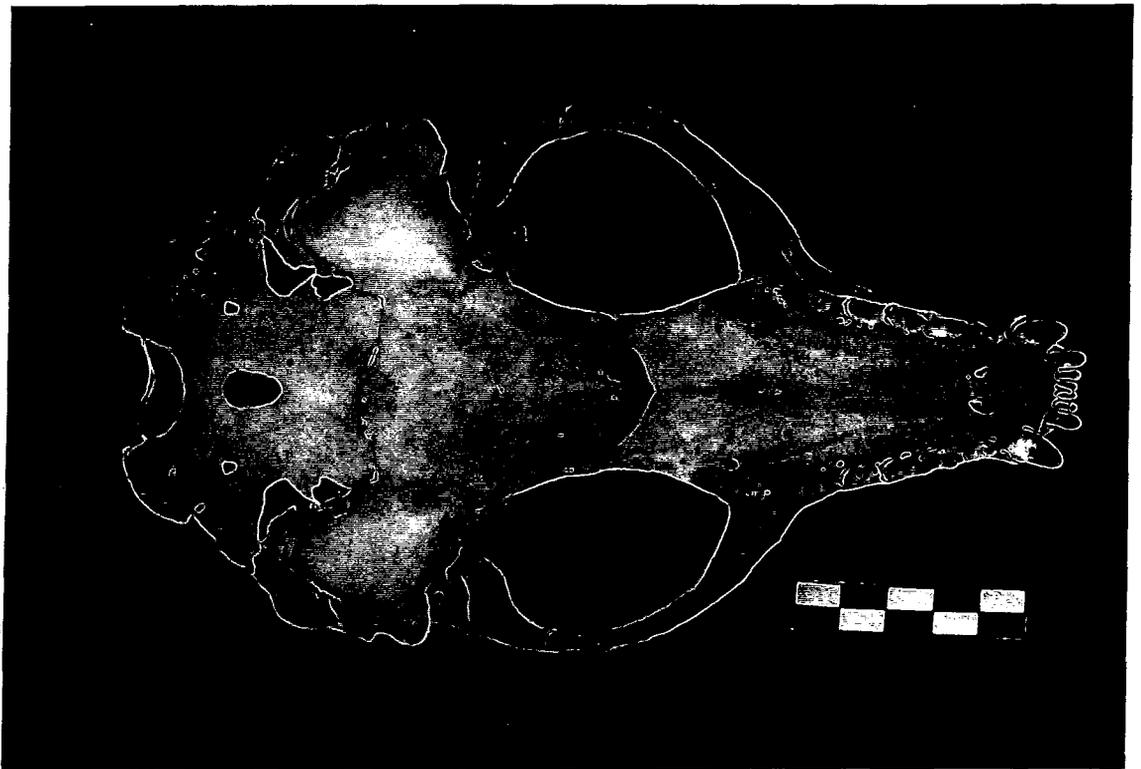
- ⇒The bony palate is extremely broad.
- ⇒The outer edges of the bony palate drop down sharply towards the toothrow, so that the maxillary teeth are situated in a pronounced ridge of bone.
- ⇒The sides of the nasal cavity are almost vertical, so that this species has the shortest “snout” of all phocids.

⇒The postcanines are large but wear down very quickly creating a characteristic “peg-like” appearance. Adults are often missing teeth and in such cases the alveoli begin to fill with bone.

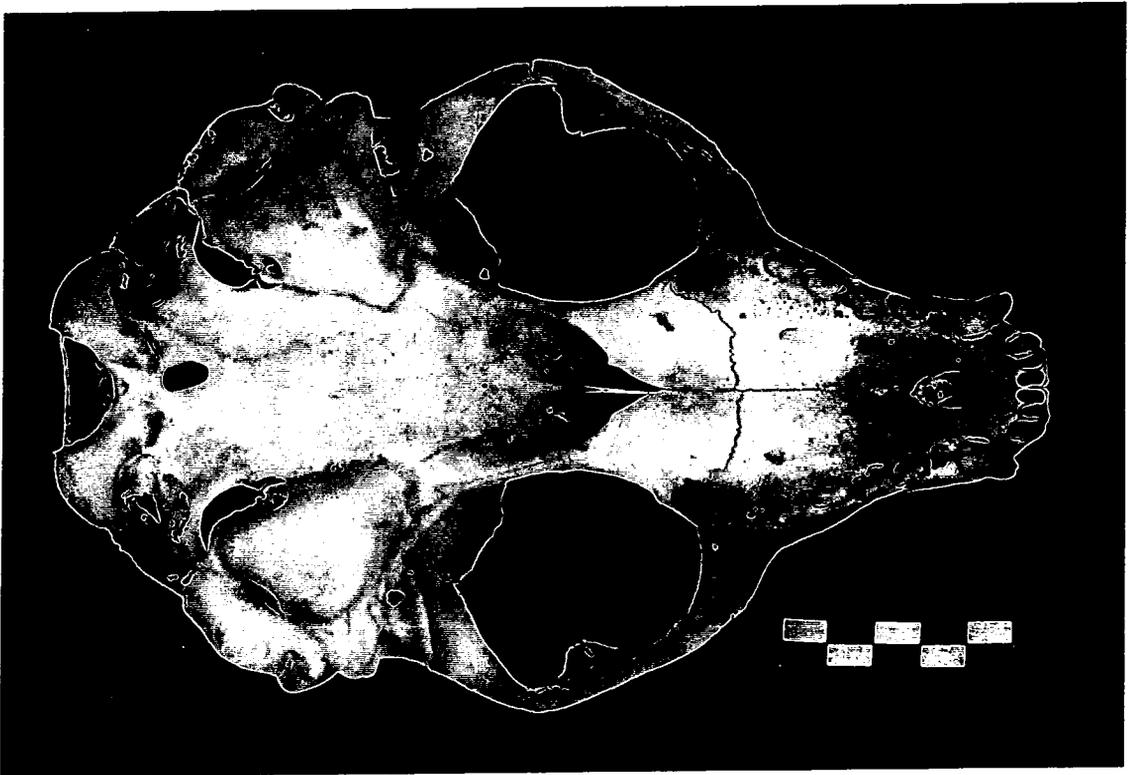
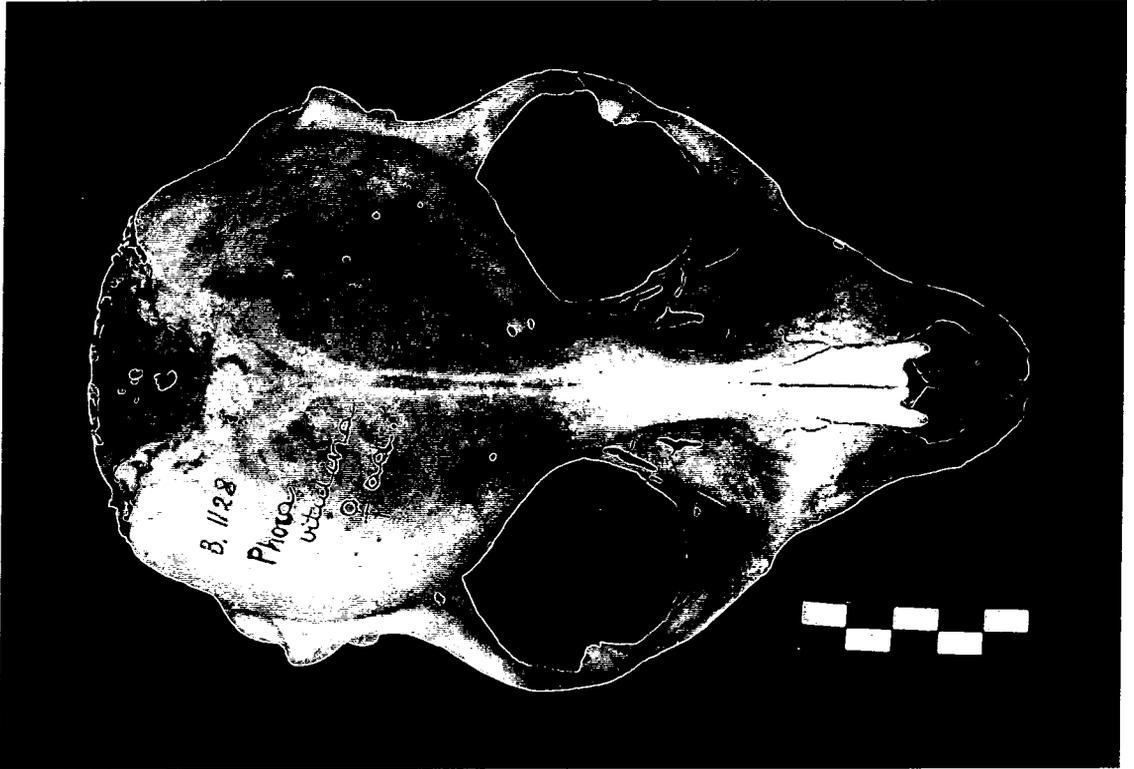
**Hooded seal—*Cystophora cristata***

- ⇒The entire cranium is much shorter and wider than in any other phocid species.
- ⇒The bony ridge between the orbits is much broader than in any other species.
- ⇒The premaxilla is long (in an anterior-posterior direction), so that the nasal cavity appears to start farther back than in any other species
- ⇒Postcanines are large with multiple cusps. All cusps have tiny vertical ridges covering their surfaces, giving the teeth a wrinkled appearance.

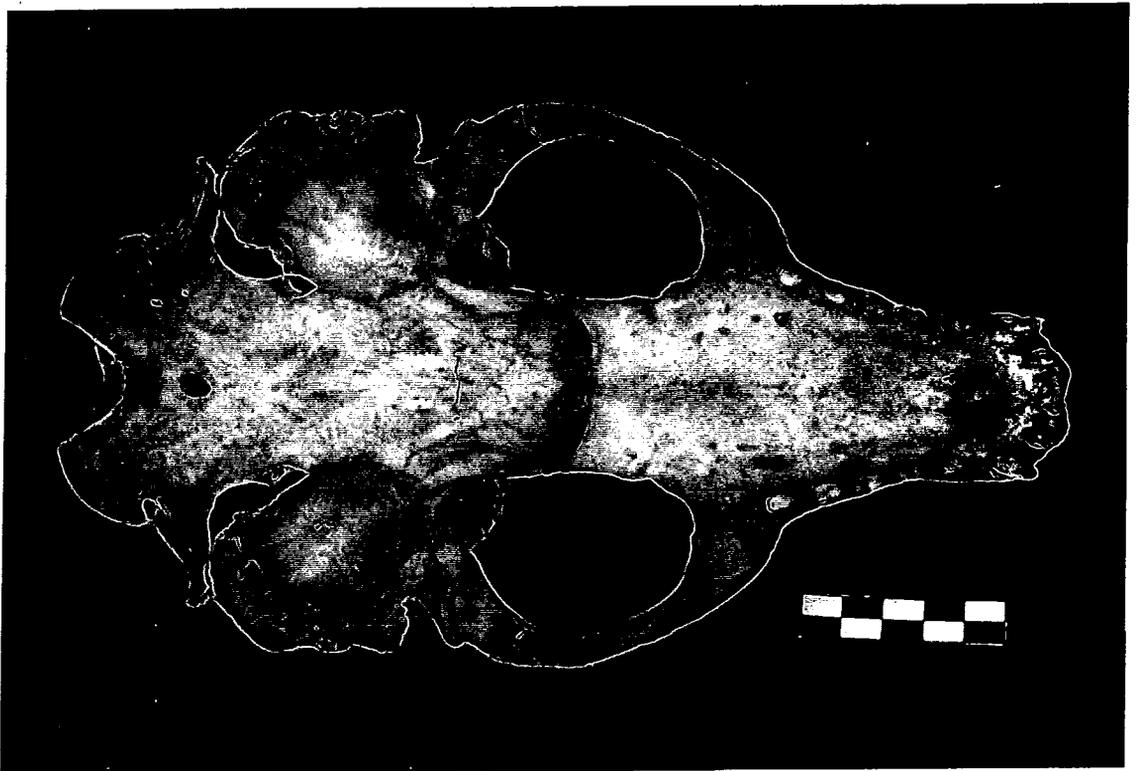
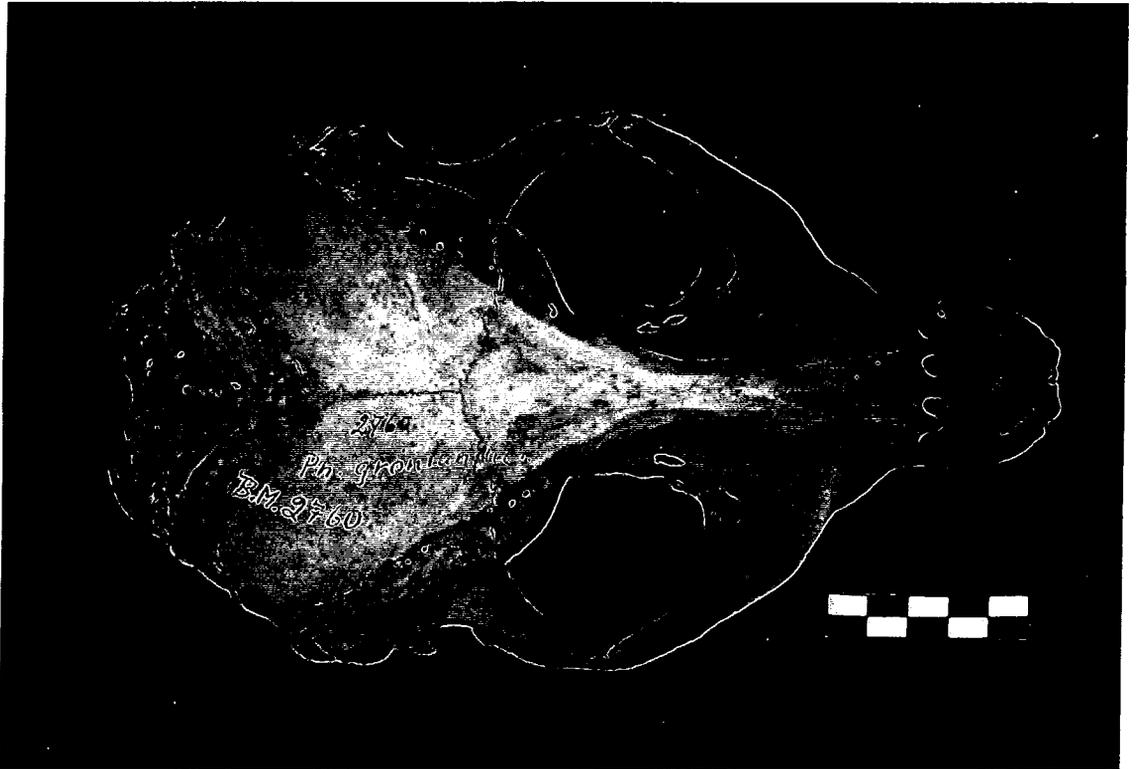
Ringed seal—*Phoca hispida*



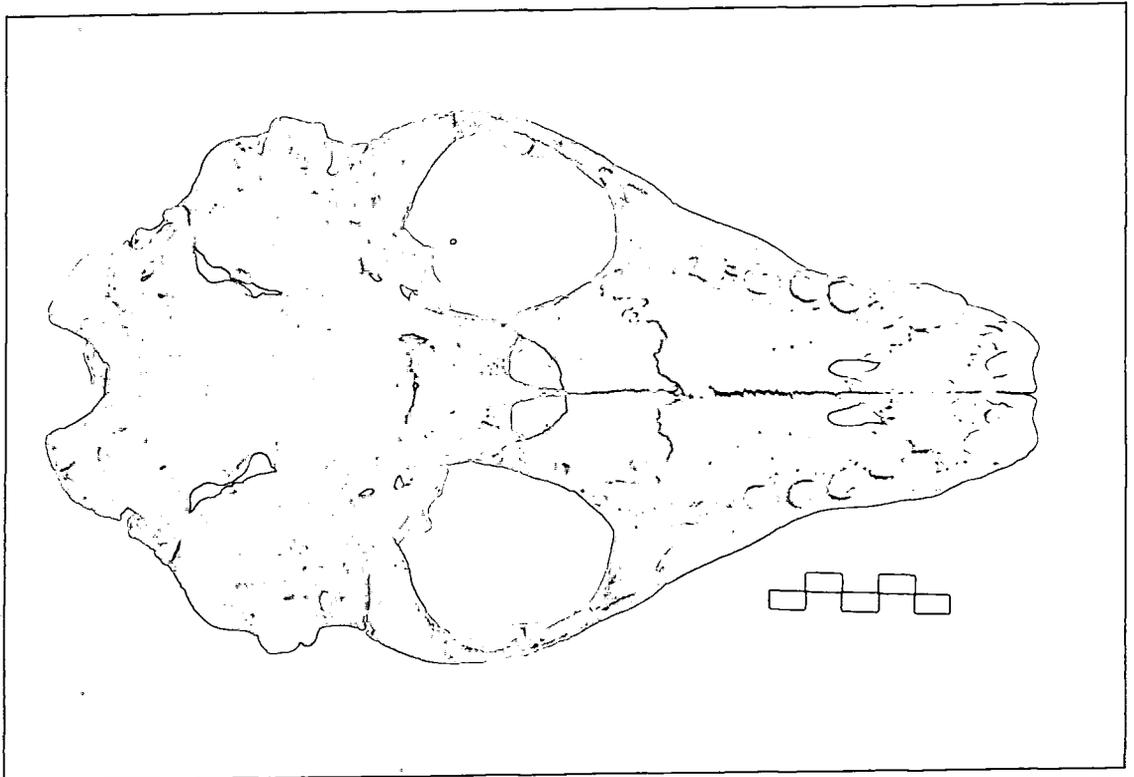
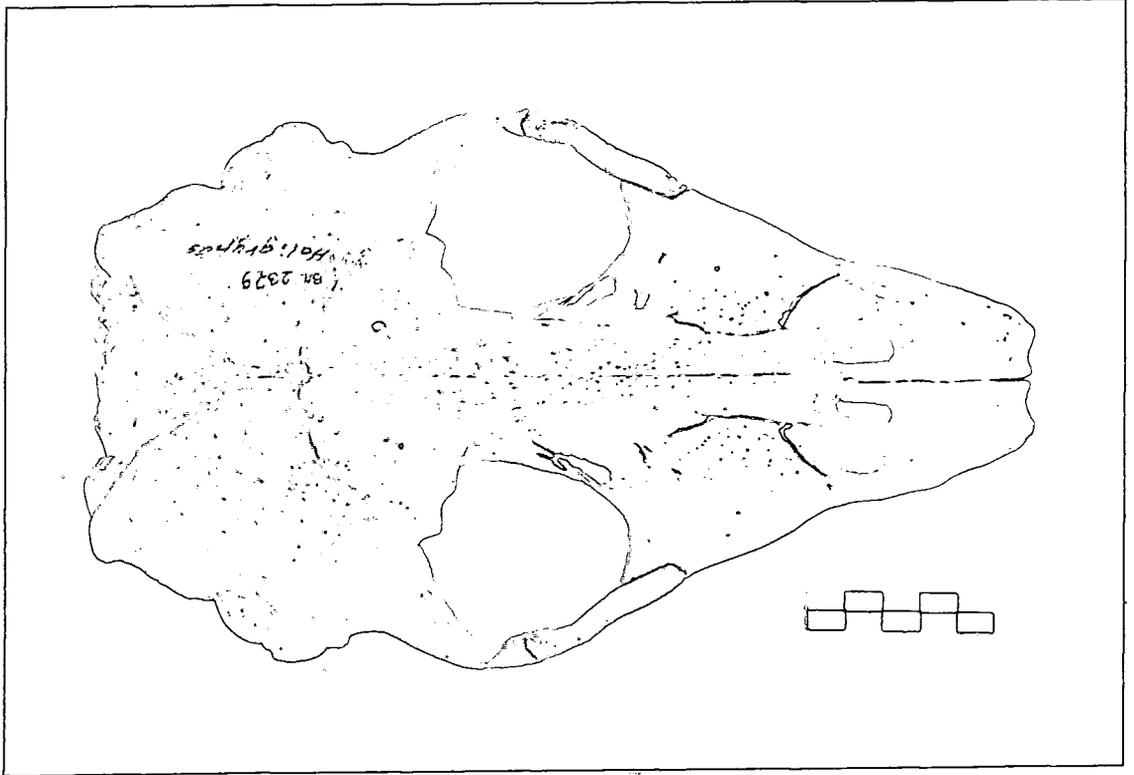
Harbour seal—*Phoca vitulina*



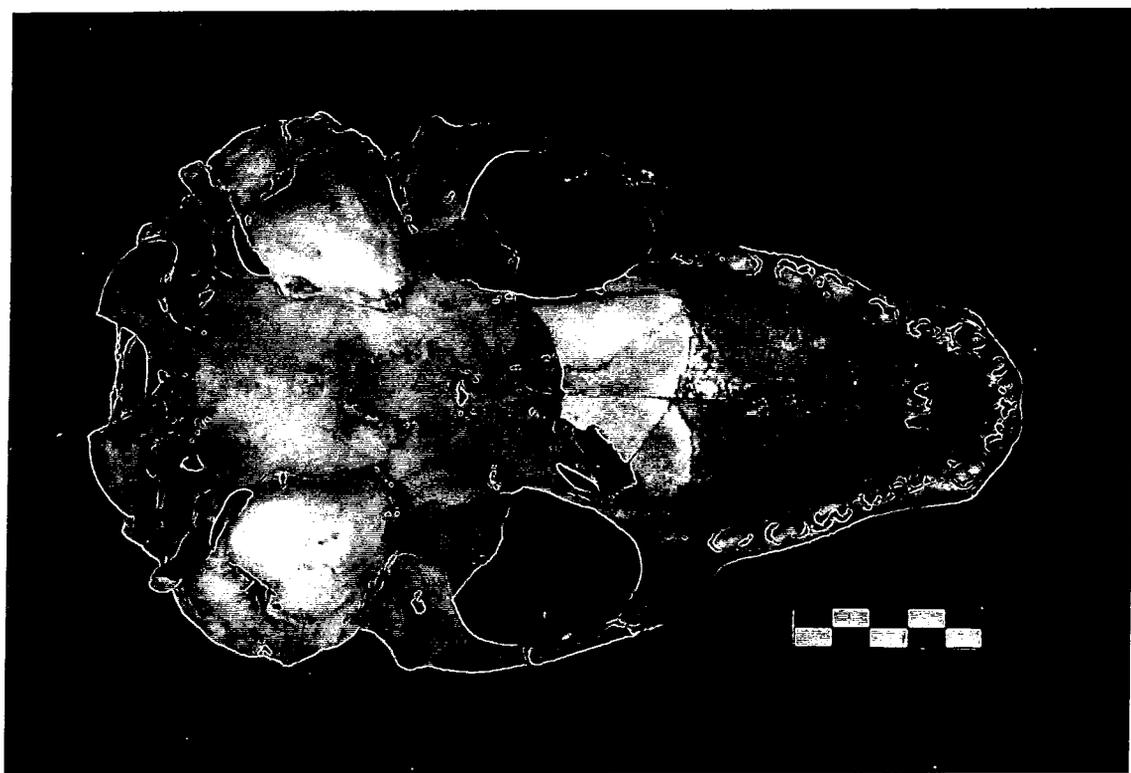
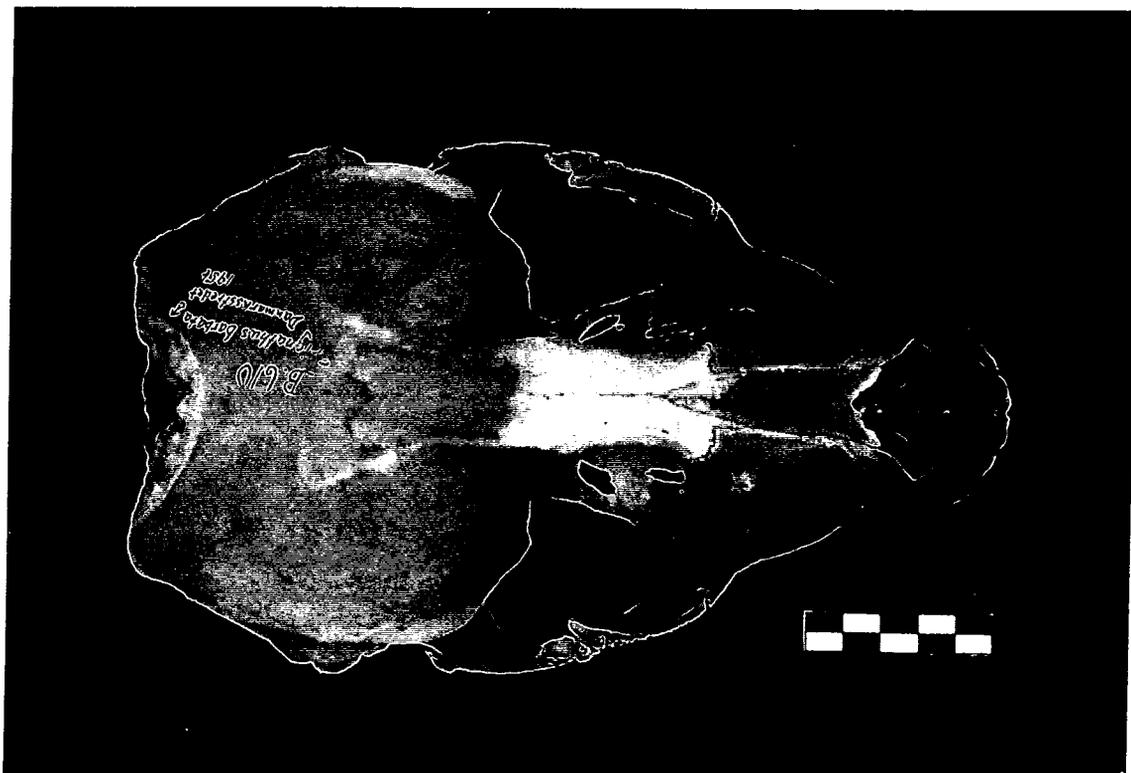
Harp seal—*Phoca groenlandica*



Grey seal—*Halichoerus grypus*



Bearded seal—*Erignathus barbatus*



Hooded seal—*Cystophora cristata*



## B.2.2 Auditory bulla (*Pars petrosa*)

The bulla consists of two distinct parts, the bulbous medial portion and the lateral portion which is more “squared” and compact. The auditory canal enters between the two. Most species possess a bony “hood” which protects the entrance to the auditory canal. The shape and location of this hood relative to the medial and lateral portions is an important diagnostic trait. The shape and size of the lateral and medial portions are also useful.

### **Ringed seal—*Phoca hispida***

- ⇒The auditory canal has a rounded hood on the ventral side.
- ⇒The hood is located on the lateral side of the division between the bulla’s medial and lateral portions.
- ⇒The bulla is shorter in length relative to width than in *P. vitulina*.

### **Harbour seal—*Phoca vitulina***

- ⇒The auditory canal has a triangular hood on the ventral side.
- ⇒The hood is located on the medial side of the division between the bulla’s medial and lateral portion.
- ⇒The bulla is quite long relative to its width.

### **Harp seal—*Phoca groenlandica***

- ⇒The auditory canal is surrounded on all sides by a continuous hood.
- ⇒On the ventral side of the auditory canal the hood is particularly thick and bulbous.
- ⇒The hood projects out from the medial portion of the bulla where it divides from the lateral portion.

### **Grey seal—*Halichoerus grypus***

- ⇒The auditory canal has a rounded hood on the ventral side.
- ⇒The hood is located on the medial side of the division between the bulla’s medial and lateral portions.
- ⇒The division between lateral and medial portions is less pronounced than in other species.

### **Bearded seal—*Erignathus barbatus***

- ⇒The auditory canal lacks a pronounced hood.
- ⇒The lateral portion has a very sharp, square lateral edge.

### **Hooded seal—*Cystophora cristata***

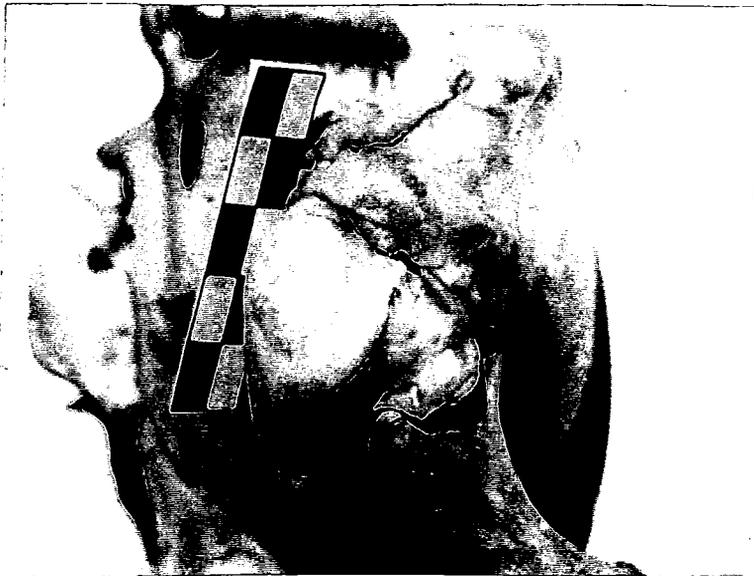
- ⇒The auditory canal has a rounded hood on the ventral side.
- ⇒The hood extends out of a wide flat area which spans the divide between the medial and lateral portions of the bulla.
- ⇒The lateral portion of the bulla is much larger relative to the medial portion than in any other species.



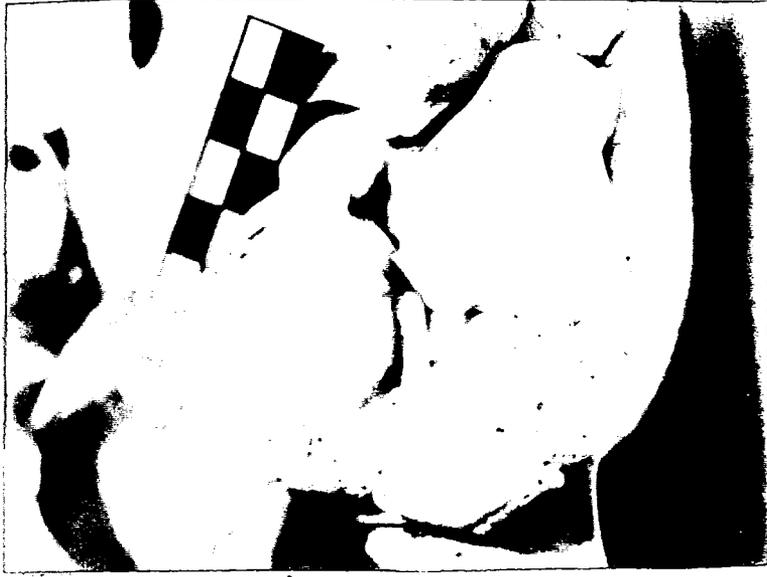
Harp seal—*Phoca groenlandica*



Harbour seal—*Phoca vitulina*



Ringed seal—*Phoca hispida*



Hooded seal—*Cystophora cristata*



Bearded seal—*Erignathus barbatus*



Grey seal—*Halichoerus grypus*

### B.2.3 Mandible

The shape of the mandible, the angle of the ramus, the location of the mandibular foramen on the lingual surface and the tooth descriptions provided in the section on crania are all useful diagnostic traits.

#### **Ringed seal—*Phoca hispida***

- ⇒The ramus is narrow and angles less sharply upward than in *P. vitulina*.
- ⇒The coronoid process is often (but not always) pointed rather than rounded.
- ⇒The mandibular foramen is smaller than in *P. vitulina* and situated farther from the mandibular condyle than in *P. groenlandica*.
- ⇒There is a more pronounced “chin” than in *P. vitulina*.

#### **Harbour seal—*Phoca vitulina***

- ⇒Postcanines are often set in the mandible on an angle (posterior-buccal to anterior-lingual).
- ⇒The ascending ramus is wider relative to the mandible itself than in *P. hispida* or *P. groenlandica*.
- ⇒The mandibular foramen is larger than in *P. hispida* or *P. groenlandica* and is situated farther from the mandibular condyle.
- ⇒The coronoid process is wider than in *P. hispida* or *P. groenlandica*.
- ⇒The “chin” is very poorly defined.

#### **Harp seal—*Phoca groenlandica***

- ⇒The ramus angles up more sharply than in either *P. vitulina* or *P. hispida*.
- ⇒The ramus is wider than in *P. hispida*.
- ⇒The mandibular foramen is smaller than in *P. vitulina* and is situated closer to the mandibular condyle than in *P. hispida* or *P. vitulina*.
- ⇒There is a more pronounced “chin” than in *P. vitulina*.

#### **Grey seal—*Halichoerus grypus***

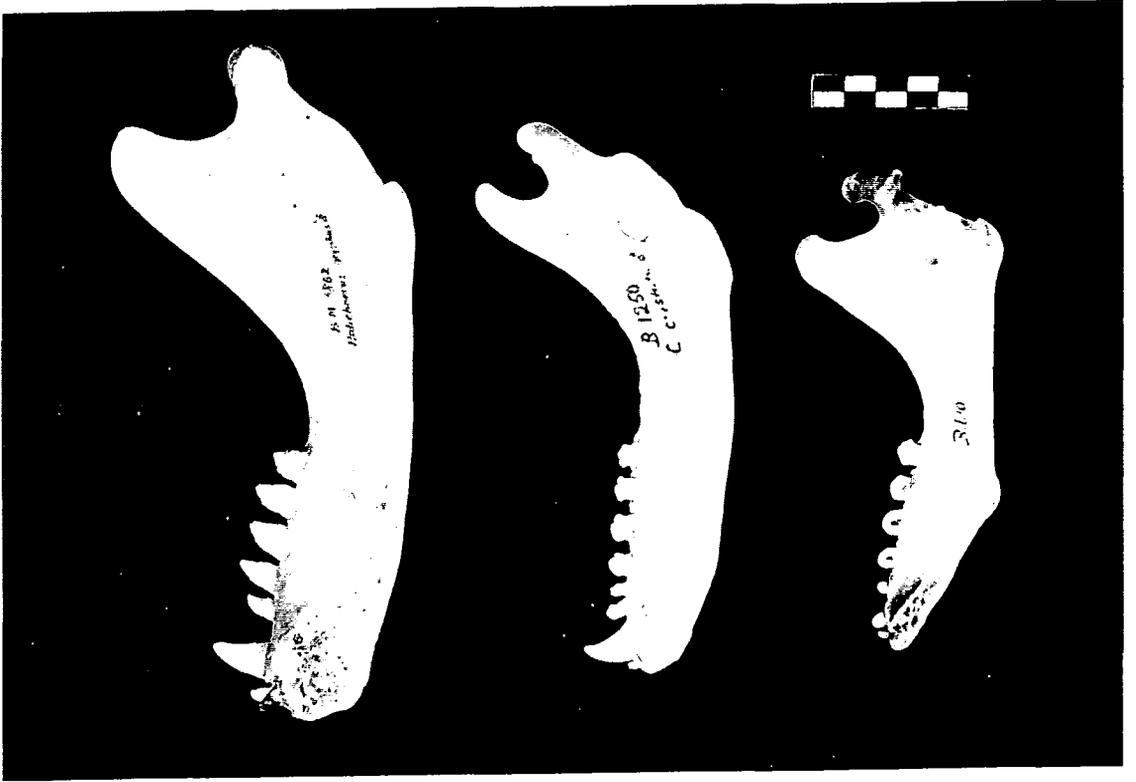
- ⇒The ramus tends to be short and wide and angles gently upwards from the mandible.
- ⇒The mandible is very narrow where it joins the ramus and often much wider around the first or second postcanine.
- ⇒The anterior part of the mandible is very thick (in a medial-lateral direction).

#### **Bearded seal—*Erignathus barbatus***

- ⇒The ramus is quite wide and angles fairly sharply upwards from the mandible.
- ⇒The toothrow angles upwards from posterior to anterior
- ⇒The mandible is very flat on its ventral edge for the posterior two thirds of its length, and then angles sharply upwards in the anterior third, creating a very pointed “chin”.

#### **Hooded seal—*Cystophora cristata***

- ⇒The ramus is relatively long and thin.
- ⇒The mandible is essentially the same width along its entire length.
- ⇒The ventral edge of the mandible is very straight with no “chin” to speak of.



Grey

Hooded

Bearded



### B.3 Scapula

The neck region of the scapula is its only diagnostic part. Both the thickness of the neck and the nature of the bony ridges between the glenoid and the spine are used in species identifications. Complete scapulae can be readily identified to species, as can fragments which include the glenoid and neck. In the following descriptions, directional terms such as “above to spine” refer to the scapula as it is oriented in the illustrations.

#### B.3.1 Adult scapula

##### **Ringed seal—*Phoca hispida***

- ⇒ The neck is extremely thin and more elongated than in *P. vitulina*.
- ⇒ As in *P. vitulina*, the two ridges of bone on the lateral surface of the neck join to form a single ridge near the glenoid.
- ⇒ The overall appearance of the scapula is more gracile than in *P. vitulina*.

##### **Harbour seal—*Phoca vitulina***

- ⇒ The neck is thinner than in *P. groenlandica*, *H. grypus* or *C. cristata*, but thicker and shorter than in *P. hispida*.
- ⇒ The two ridges of bone on the lateral surface of the neck join to form single ridge near the glenoid (see illustration).

##### **Harp seal—*Phoca groenlandica***

- ⇒ The neck is relatively thick and short.
- ⇒ There are two distinct ridges of bone on the lateral surface of the neck. One extends from the beginning of the spine towards the glenoid, and the second is situated below the first. They do not join.

##### **Grey seal—*Halichoerus grypus***

- ⇒ The neck is similar in thickness and length to *P. groenlandica*.
- ⇒ There is a single, thick ridge of bone on the lateral surface of the neck which connects the glenoid to the spine and then extends below the spine.

##### **Bearded seal—*Erignathus barbatus***

- ⇒ The blade is considerably narrower overall, and has a less rounded shape than in the other species.
- ⇒ The spine begins farther from the glenoid than in any other species.
- ⇒ The neck appears much longer than in any other species.
- ⇒ There is no ridge of bone on the lateral surface of the neck.

##### **Hooded seal—*Cystophora cristata***

- ⇒ The neck is very thick and short.
- ⇒ As in *P. groenlandica*, there are two distinct ridges of bone on the lateral surface of the neck which do not meet.
- ⇒ There is a characteristic bump on the lateral edge of the articular surface of the glenoid. This area is concave in all other species.

Grey

Hooded

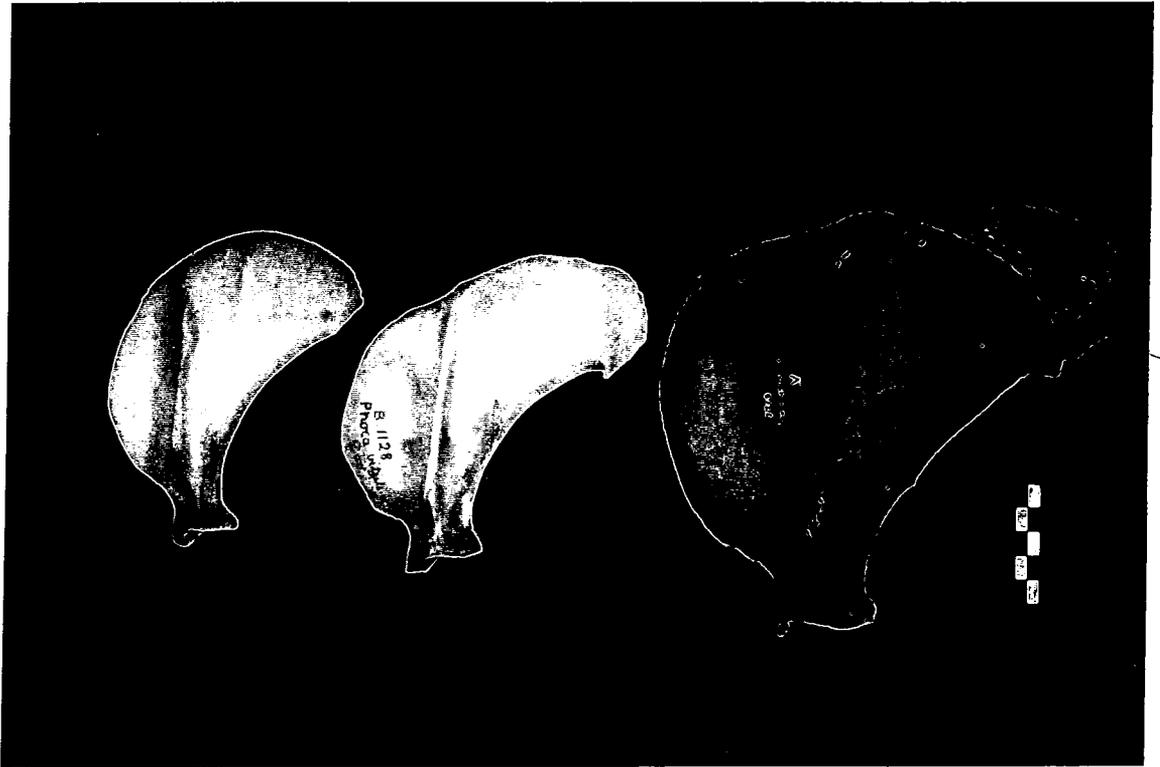
Bearded

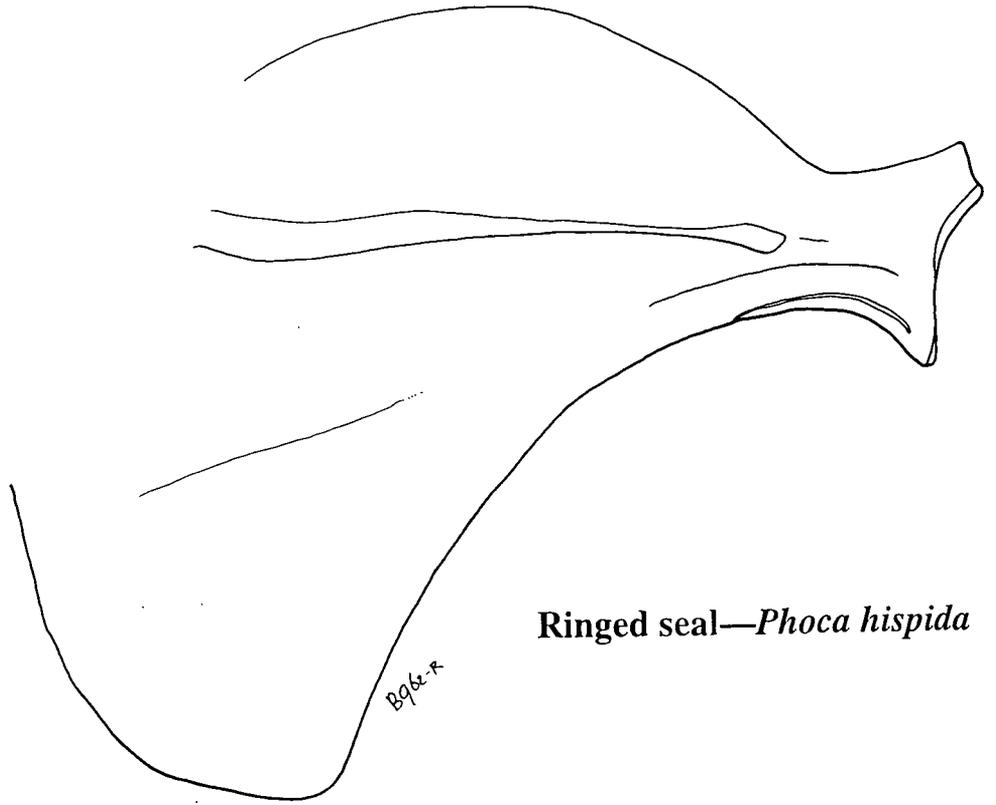


Ringed

Harbour

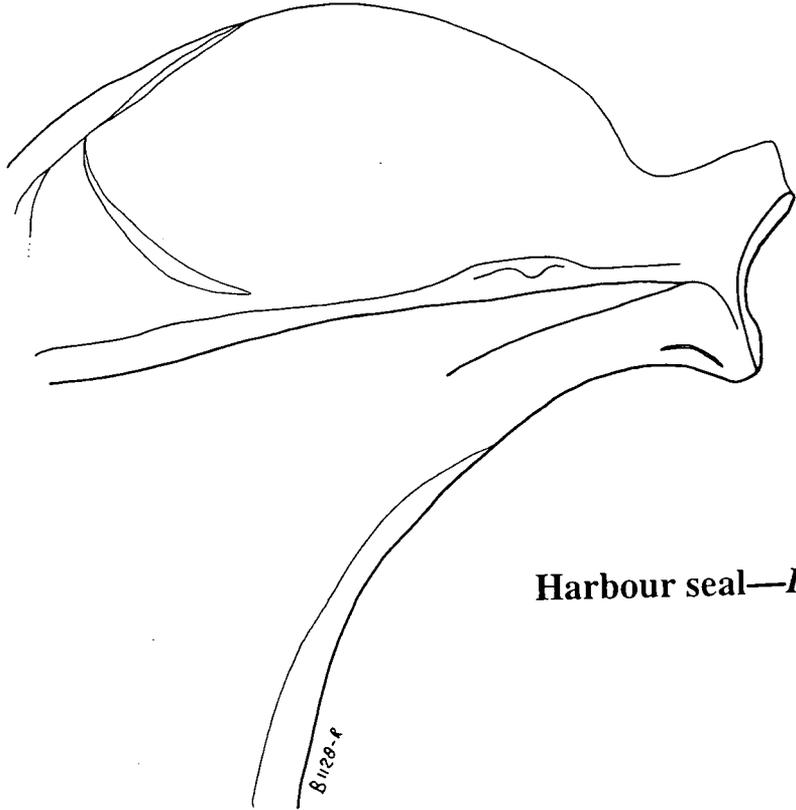
Harp





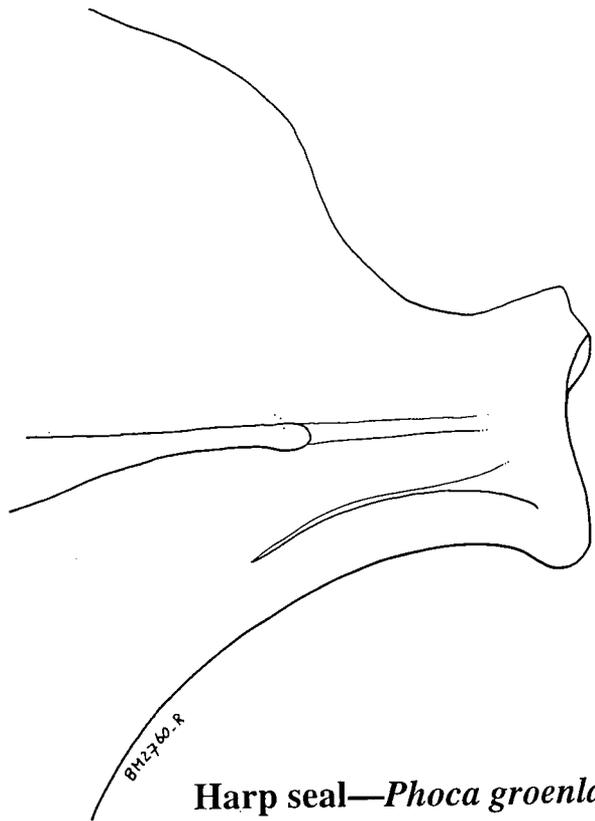
Ringed seal—*Phoca hispida*

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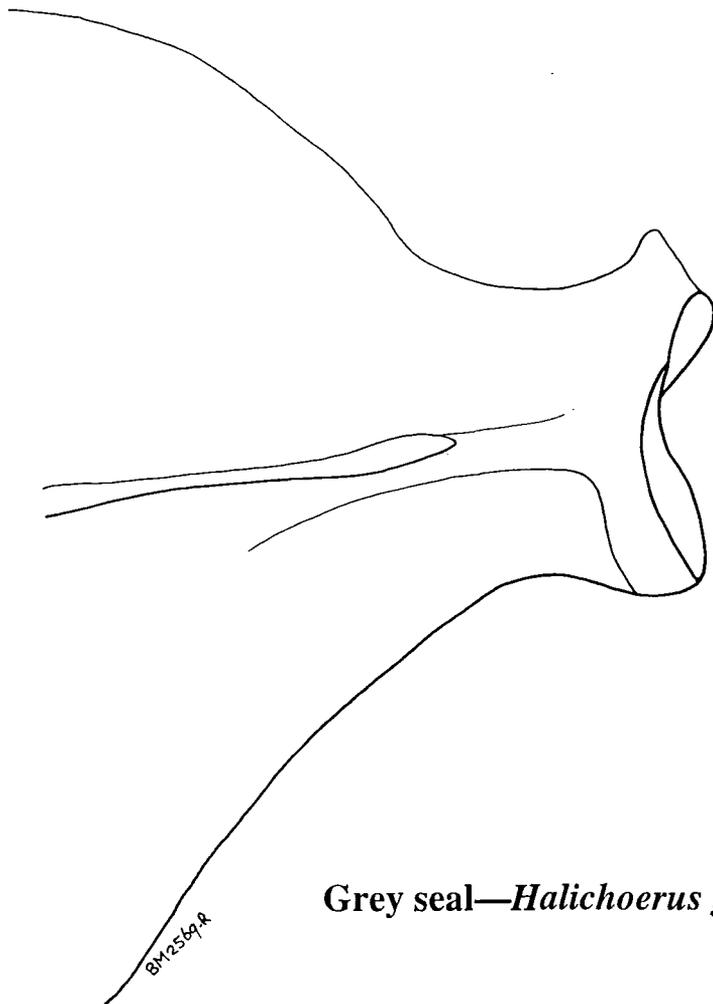


Harbour seal—*Phoca vitulina*

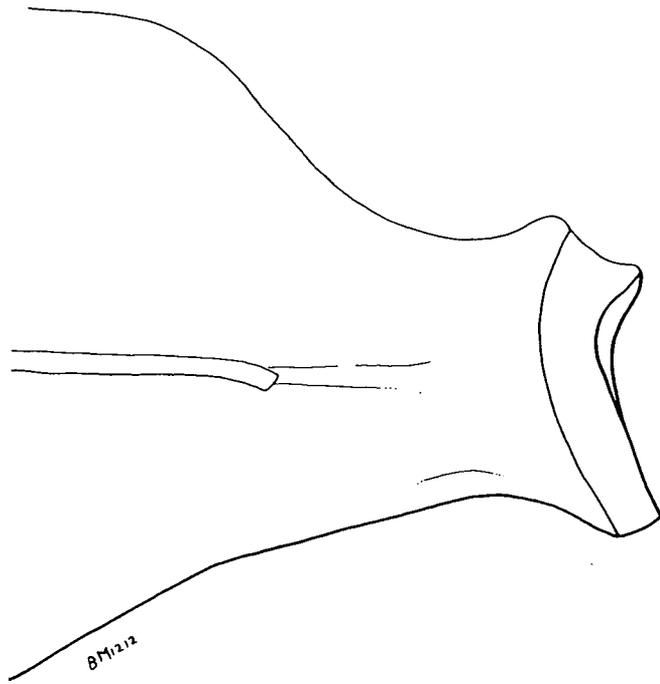
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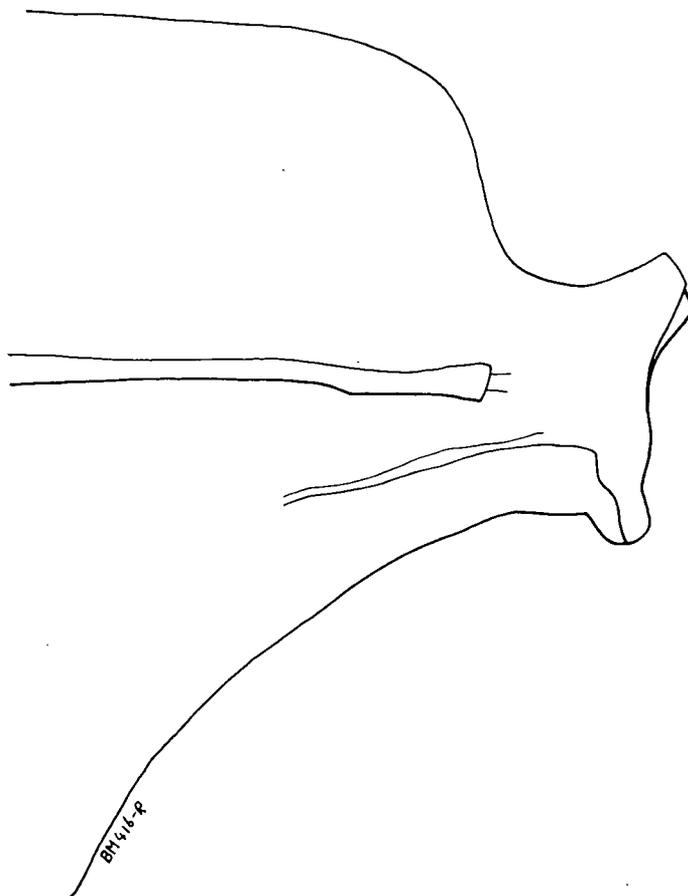
**Harp seal—*Phoca groenlandica***



**Grey seal—*Halichoerus grypus***



Bearded seal—*Erignathus barbatus*



Hooded seal—*Cystophora cristata*

### B.3.2 Juvenile scapula

Scapular distinctions between very young individuals in which the glenoid has not yet fused are more difficult than for adults. Size can help to eliminate certain species. Harp seal, grey seal, hooded seal and bearded seal scapulae reach a much larger size before fusing than either ringed seal or harbour seal.

#### **Ringed seal—*Phoca hispida***

- ⇒ Often difficult to distinguish from *P. vitulina*.
- ⇒ The two ridges on the lateral surface of the neck join to form a single ridge close to the glenoid.
- ⇒ The neck tends to be narrower and longer than in *P. vitulina*.

#### **Harbour seal—*Phoca vitulina***

- ⇒ Often difficult to distinguish from *P. hispida*.
- ⇒ The two ridges on the lateral surface of the neck join to form a single ridge close to the glenoid.
- ⇒ The neck is generally (but not always) shorter and thicker than in *P. hispida*.

#### **Harp seal—*Phoca groenlandica***

- ⇒ Often difficult to distinguish from *C. cristata*. However, *P. groenlandica* fuses at a smaller size than *C. cristata*.
- ⇒ There are two distinct ridges on the lateral surface of the neck.
- ⇒ The neck is relatively short and thick.
- ⇒ The lower edge of the neck is fairly straight.

#### **Grey seal—*Halichoerus grypus***

- ⇒ When small, can be difficult to distinguish from large *P. vitulina* and certain large, robust *P. hispida*.
- ⇒ The neck is thick and can be longer than in *P. groenlandica*.
- ⇒ The two ridges on the lateral surface of the neck meet near the glenoid.
- ⇒ The lower edge of the neck drops down towards the glenoid more than in *P. groenlandica*.
- ⇒ The spine tends to start farther from the glenoid than in the other species.

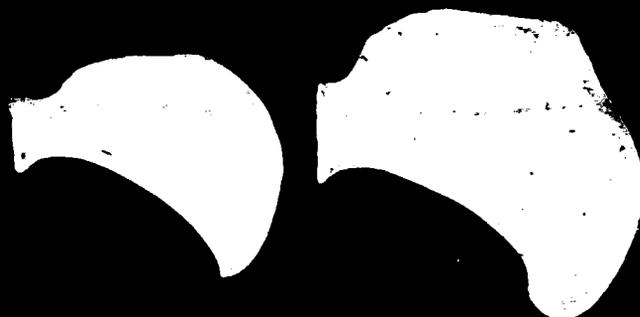
#### **Bearded seal—*Erignathus barbatus***

- ⇒ Unfortunately, the scapula is missing from the only juvenile bearded seal in the ZMB collection and it is therefore not illustrated.
- ⇒ The juvenile scapula probably shares attributes of the adult scapula such as a narrow blade, long neck, and a spine which starts farther from the glenoid than in any other species.

#### **Hooded seal—*Cystophora cristata***

- ⇒ Very similar to *P. groenlandica*.
- ⇒ The neck is relatively thick and short.
- ⇒ The two ridges on the lateral surface of the neck do not join.
- ⇒ There is a fairly long, wide bump or ridge on the lower part of the blade that is not found in juveniles of the other species.
- ⇒ Occasionally, the ridge of bone on the lower blade is very faint and the two ridges on the neck appear to join. In such cases, *C. cristata* scapulae can resemble *P. vitulina*.

Ringed



Harbour

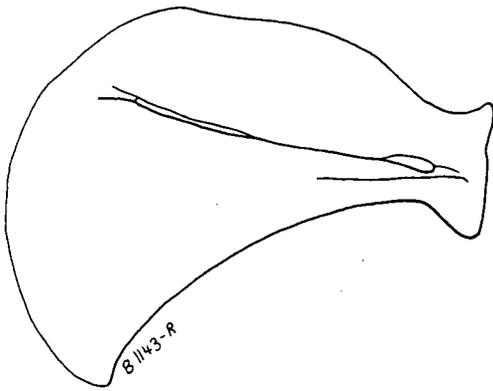
Harp



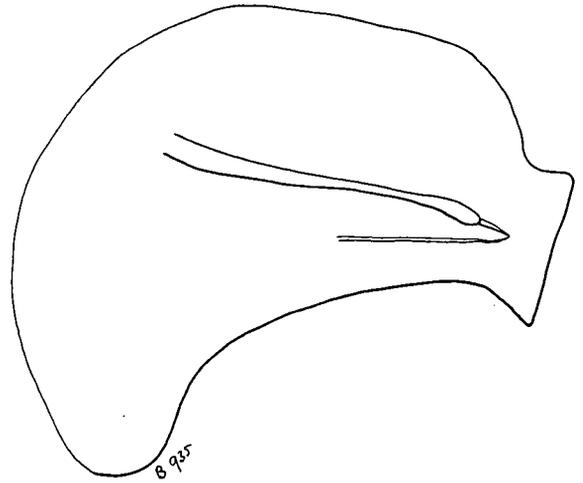
Grey

Hooded

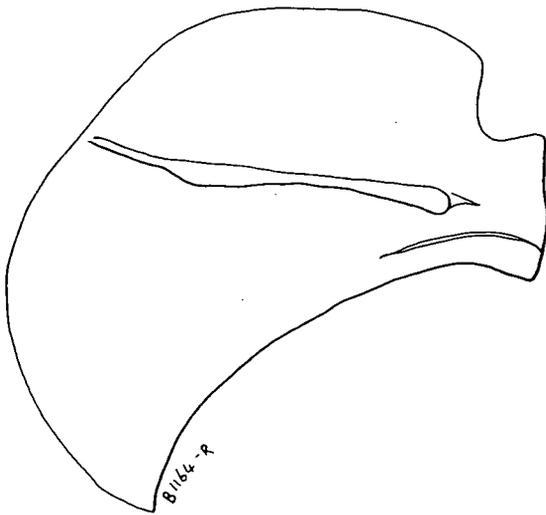




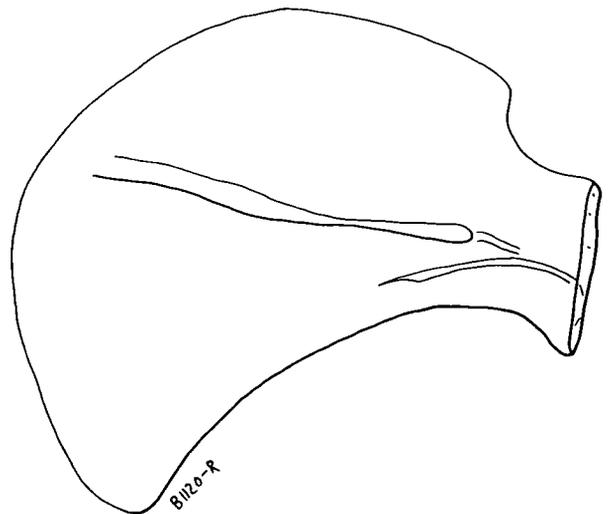
Ringed seal—*Phoca hispida*



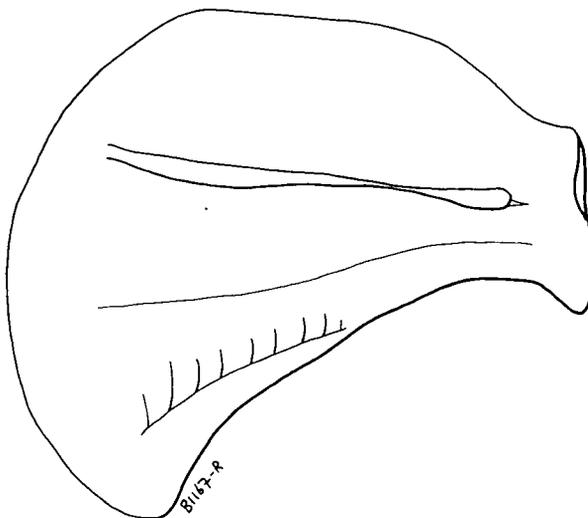
Harbour seal—*Phoca vitulina*



Harp seal—*Phoca groenlandica*



Grey seal—*Halichoerus grypus*



Hooded seal—*Cystophora cristata*

## B.4 Humerus

The proximal humerus provides reliable distinctions between most species, although harp seal and hooded seal can be difficult to separate, as can ringed seal and harbour seal. The shape and size of both the greater tubercle and the shaft are useful traits for making species distinctions.

### B.4.1 Adult humerus

#### Ringed seal—*Phoca hispida*

- ⇒ The superior crest of the greater tubercle is bifurcate (this is best seen in the medial and posterior aspects).
- ⇒ The distal shaft extends upwards from the medial epicondyle for a shorter distance than in *P. vitulina* before tapering in towards the mid-shaft (best seen in the posterior aspect).
- ⇒ Shaft is generally thinner than in *P. vitulina*.

#### Harbour seal—*Phoca vitulina*

- ⇒ Similar to *P. hispida* but generally larger overall and with a thicker shaft.
- ⇒ The superior crest of the greater tubercle is bifurcate.
- ⇒ The distal shaft extends upwards from the medial epicondyle for a greater distance than in *P. hispida* before tapering in towards the mid-shaft.

#### Harp seal—*Phoca groenlandica*

- ⇒ The superior crest of the greater tubercle has a single smooth edge.
- ⇒ Can be difficult to distinguish from *C. cristata*, though the head is often smaller and the distal end wider in *P. groenlandica*.
- ⇒ A ridge of bone divides the lesser tubercle from the shaft in the lateral aspect.
- ⇒ The distal end cannot be reliably distinguished from *H. grypus*.

#### Grey seal—*Halichoerus grypus*

- ⇒ The superior crest of the greater tubercle is bifurcate.
- ⇒ The humerus reaches a larger size than either *P. hispida* or *P. vitulina*.
- ⇒ The lesser tubercle is relatively large.

#### Bearded seal—*Erignathus barbatus*

- ⇒ The superior crest of the greater tubercle is slightly bifurcate. The length between the two “bumps” is considerably longer than in any other species.
- ⇒ The shaft is more curved than in any other species.
- ⇒ The shaft is circular, lacking the flat medial side and roughly triangular cross-section found in all other species.
- ⇒ The shaft widens very sharply into the broad distal end.

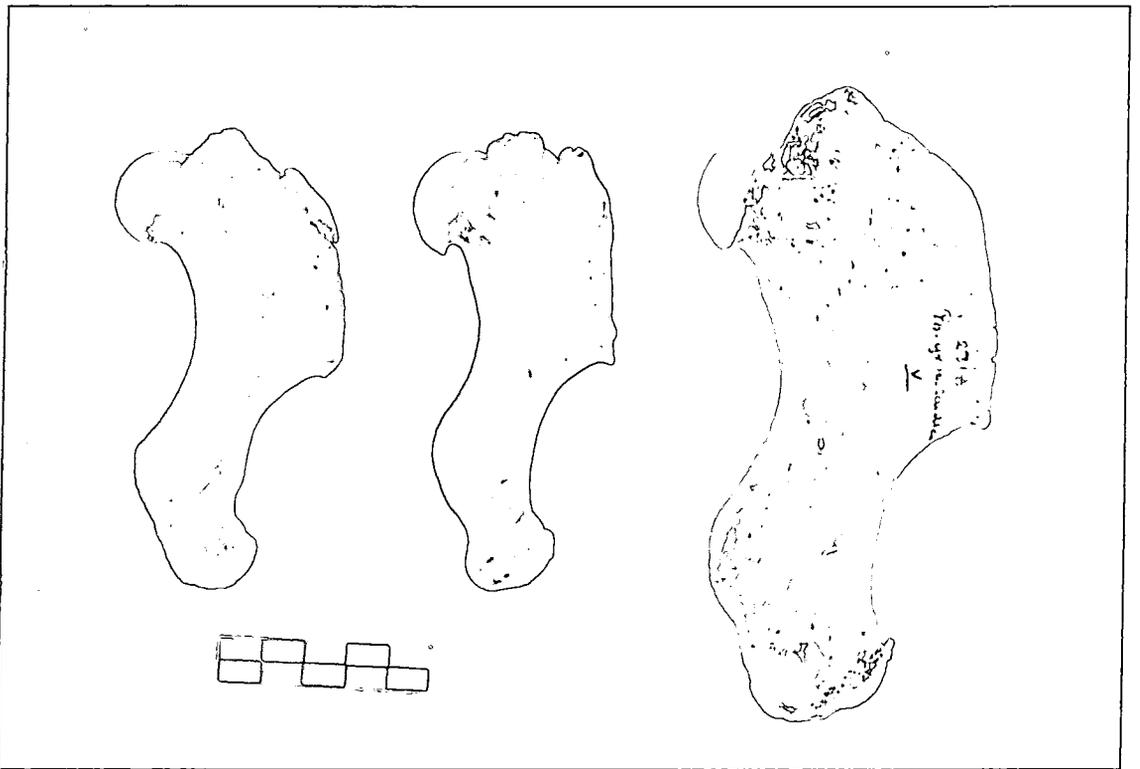
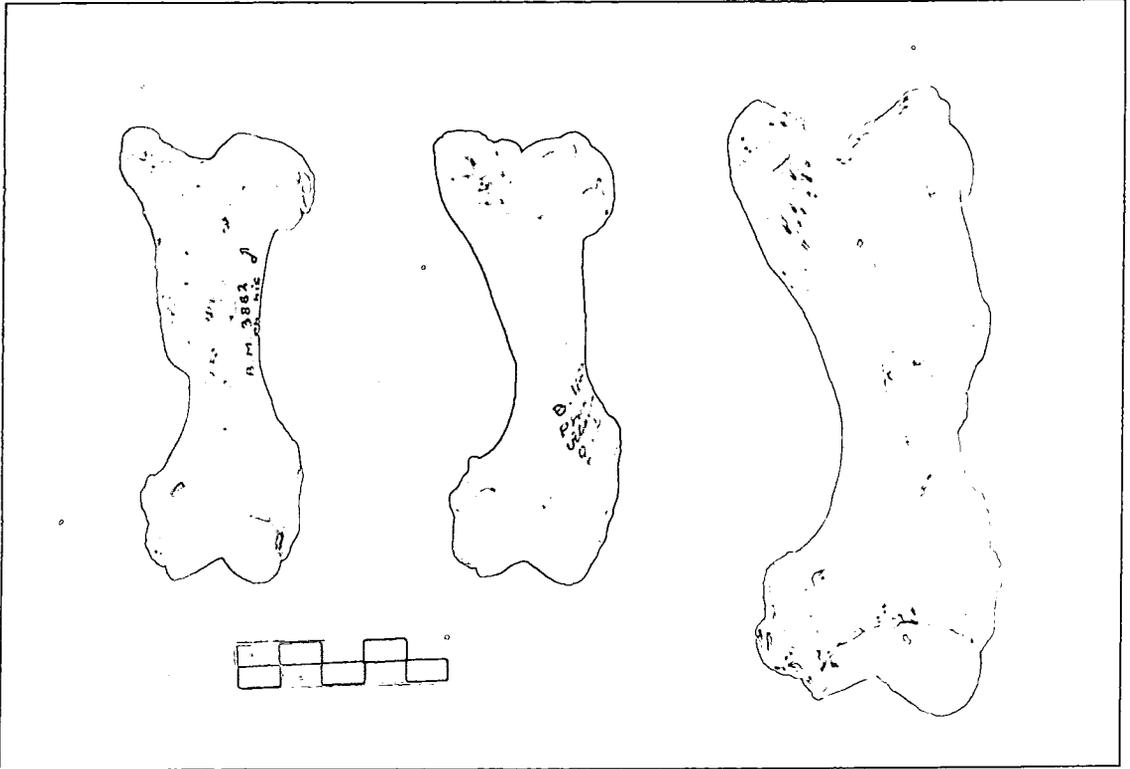
#### Hooded seal—*Cystophora cristata*

- ⇒ The superior crest of the greater tubercle has a single smooth edge. It is NOT bifurcate.
- ⇒ Difficult to distinguish from *P. groenlandica*, though the head is often larger and the distal end narrower than in *P. groenlandica*.
- ⇒ Lacks the ridge of bone which divides the lesser tubercle from the shaft in the lateral aspect of *P. groenlandica*.

Ringed

Harbour

Harp



Ringed

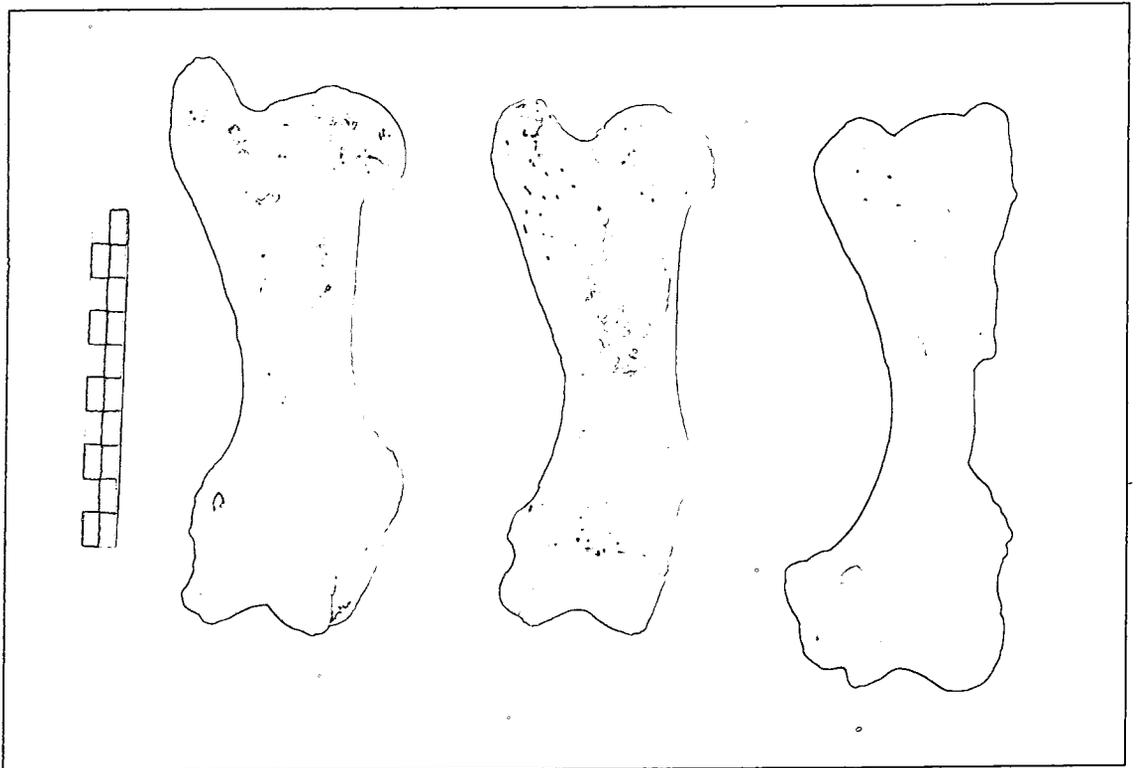
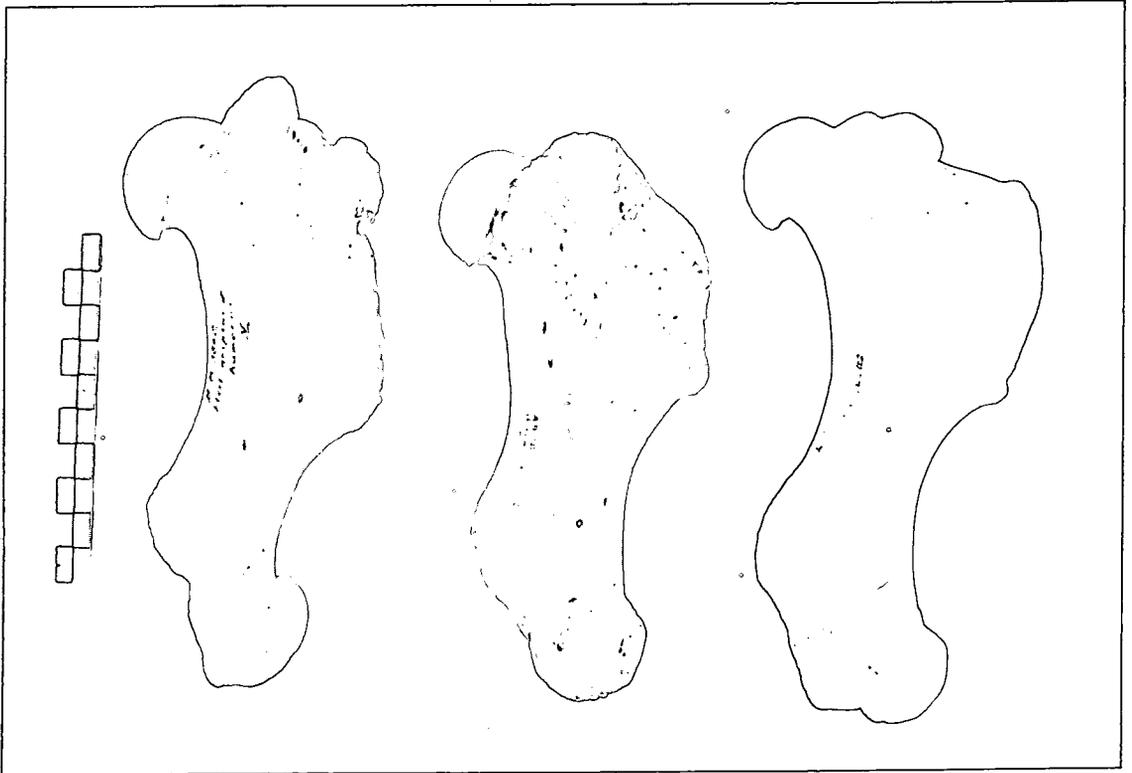
Harbour

Harp

Grey

Hooded

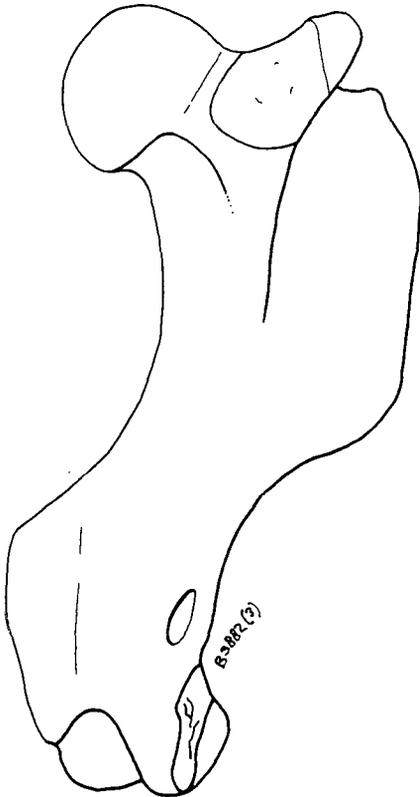
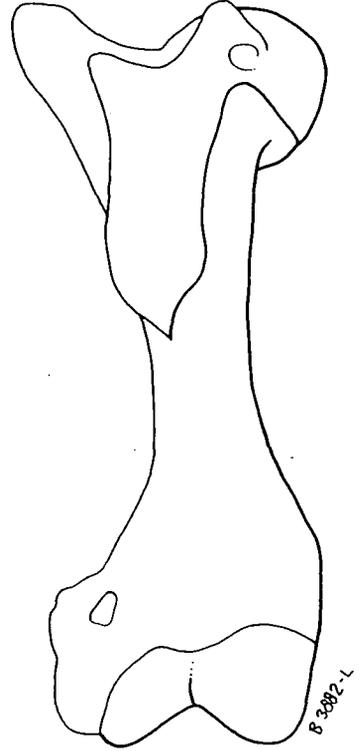
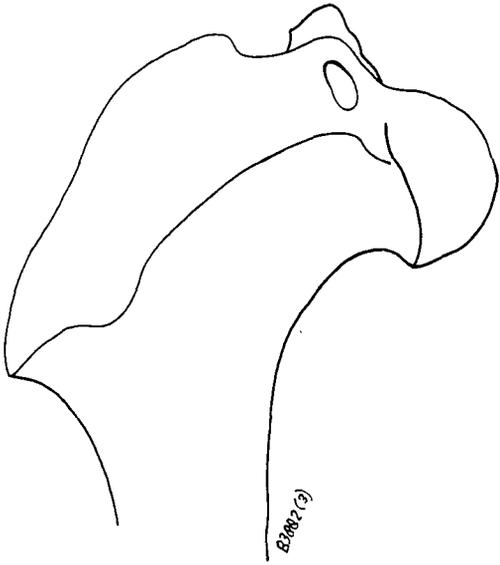
Bearded



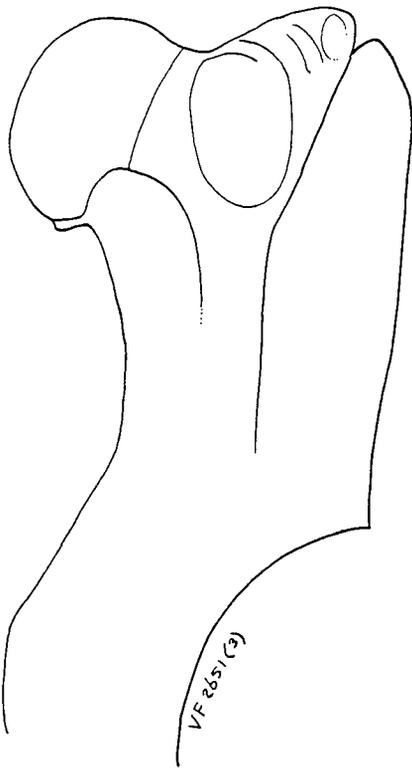
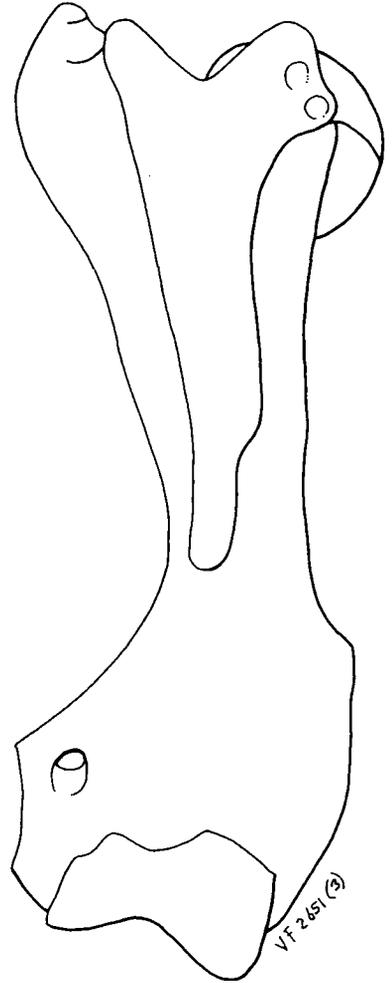
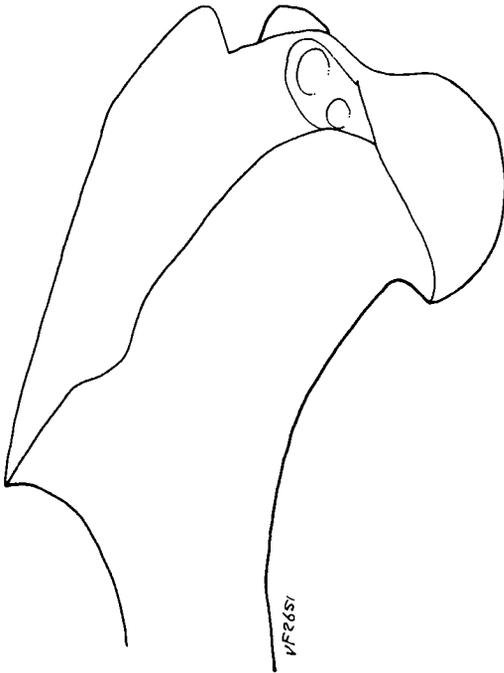
Grey

Hooded

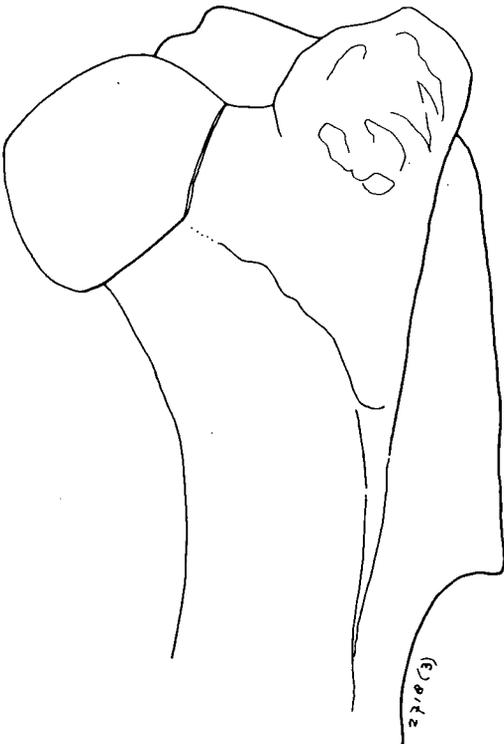
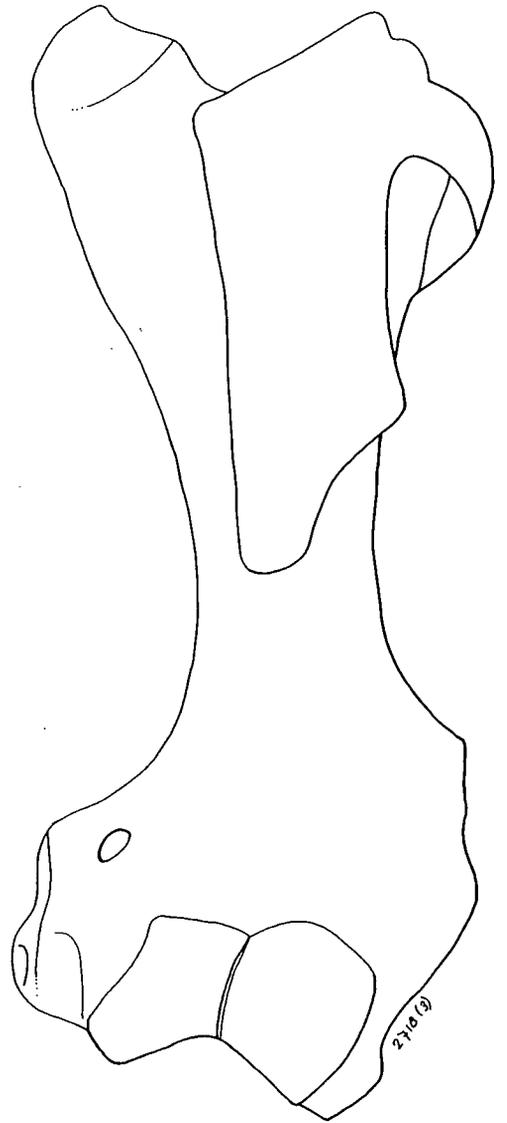
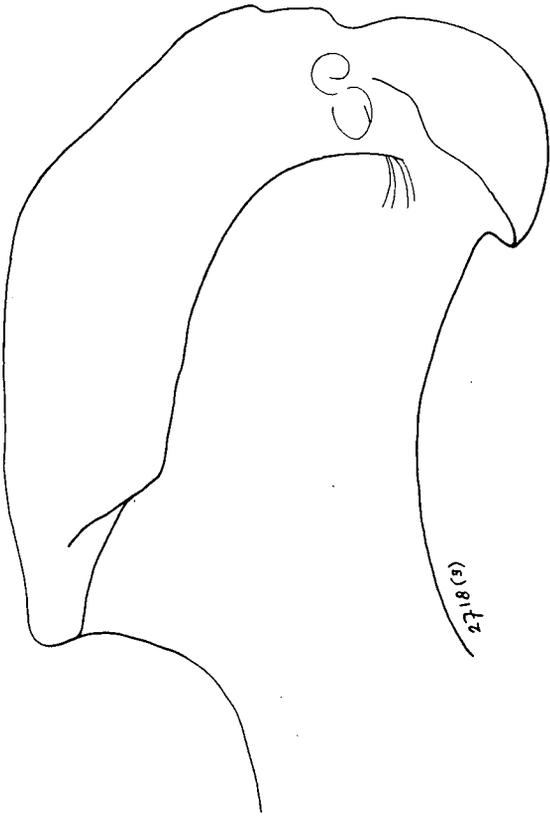
Bearded



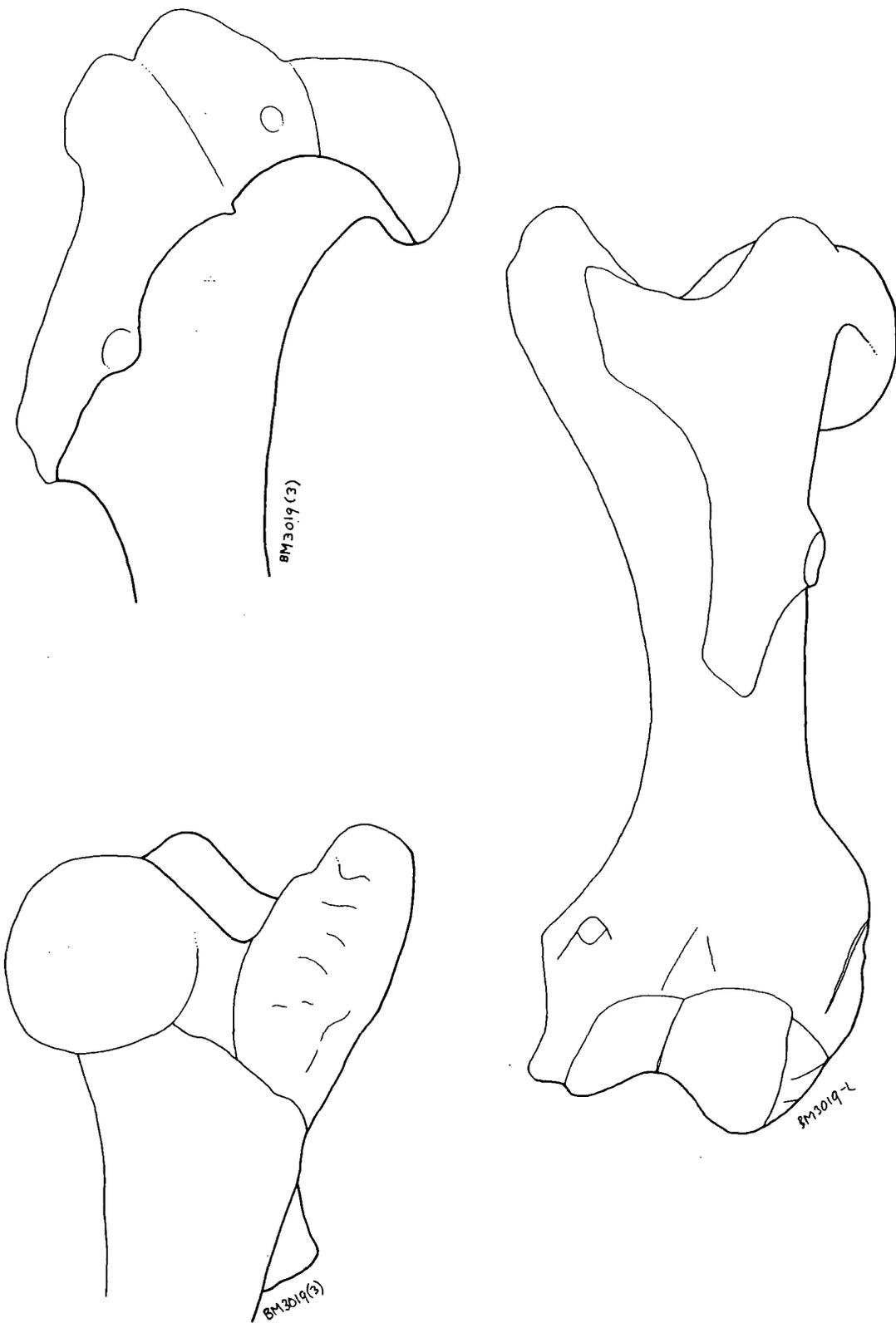
Ringed seal—*Phoca hispida*



Harbour seal—*Phoca vitulina*

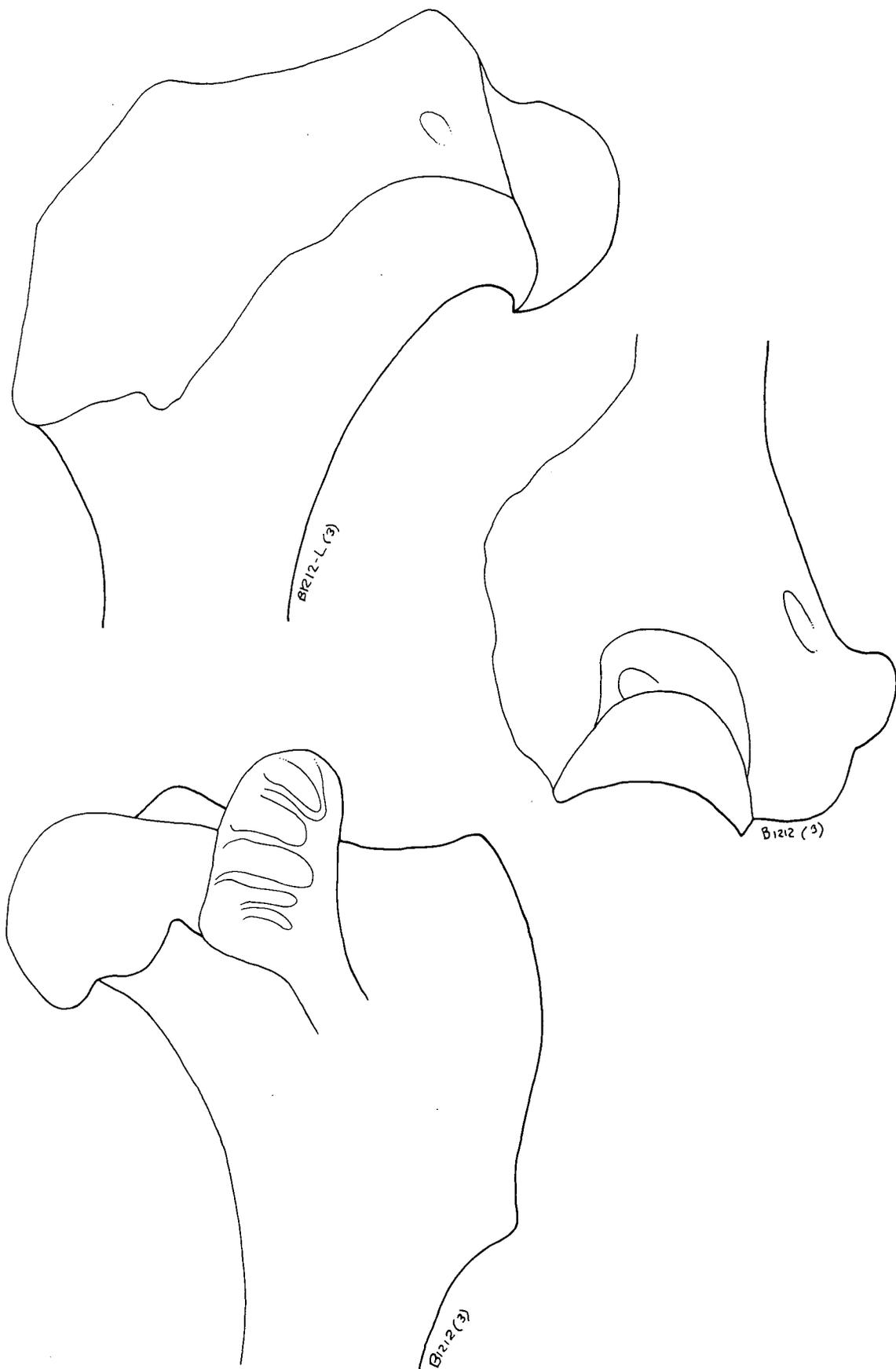


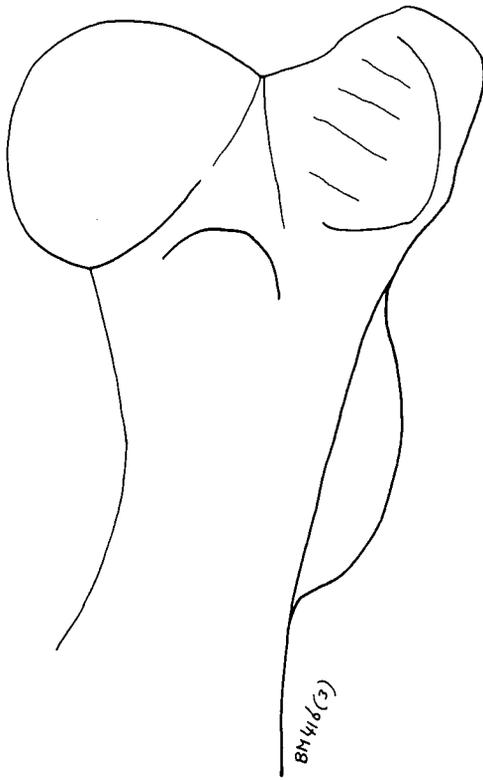
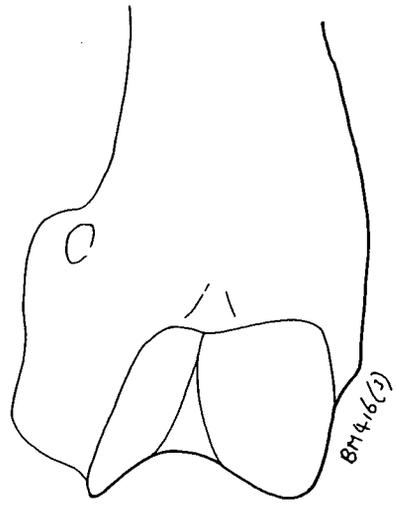
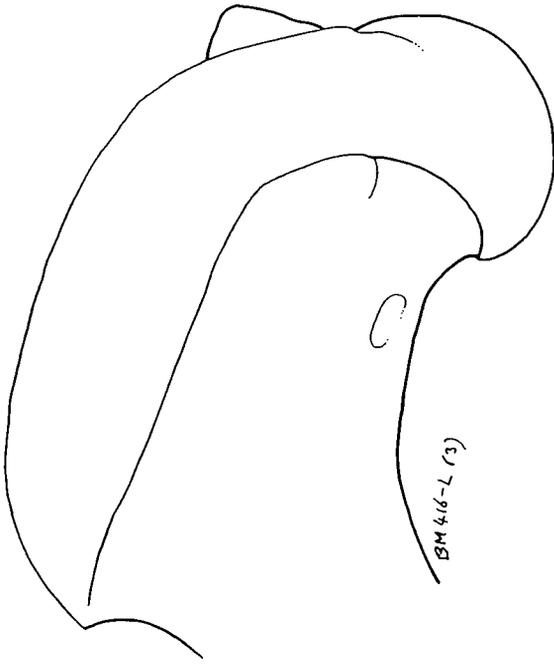
Harp seal—*Phoca groenlandica*



Grey seal—*Halichoerus grypus*

Bearded seal—*Erignathus barbatus*





Hooded seal—*Cystophora cristata*

## B.4.2 Juvenile humerus

The distal humerus is more useful than the proximal humerus in distinguishing between species among juveniles. It is extremely difficult, however, to separate harp seal from hooded seal and ringed seal from harbour seal. The width, thickness and curvature of the distal end are important distinguishing characteristics.

### **Ringed seal—*Phoca hispida***

- ⇒ Difficult to distinguish from *P. vitulina*.
- ⇒ The shaft is longer and thinner than in *P. groenlandica*.
- ⇒ Viewed end-on, the distal end is very thin.
- ⇒ In medial aspect, the distal end appears flatter and less “twisted” than in *P. vitulina*.

### **Harbour seal—*Phoca vitulina***

- ⇒ Difficult to distinguish from *P. hispida*.
- ⇒ The shaft is longer and thinner than in *P. groenlandica*, but the distal shaft is somewhat thicker when viewed in anterior aspect than in *P. hispida*.
- ⇒ Viewed end-on, the distal end is thin, but is often somewhat thicker than in *P. hispida*.
- ⇒ In medial aspect, the distal end appears more “twisted” than in *P. hispida*.

### **Harp seal—*Phoca groenlandica***

- ⇒ Cannot be reliably distinguished from *C. cristata*.
- ⇒ Overall appearance is “short and stubby”.
- ⇒ Viewed end-on, the distal end is much thicker relative to its width than in *P. hispida*, *P. vitulina* or *H. grypus*.
- ⇒ The shaft is shorter relative to the overall length of the bone than in *P. hispida*, *P. vitulina* or *H. grypus* (this is particularly obvious in the anterior aspect).

### **Grey seal—*Halichoerus grypus***

- ⇒ Viewed end-on, the distal end is both wider and thinner than in *P. groenlandica*.
- ⇒ The medial and lateral sides of the distal end (top and bottom in the end-on illustration) are straighter than in *P. hispida* and *P. vitulina*.
- ⇒ The distal shaft is generally thinner in anterior aspect than in *P. groenlandica*.

### **Bearded seal—*Erignathus barbatus***

- ⇒ Unfortunately, the humerus is missing from the only juvenile bearded seal in the ZMB collection and it is therefore not illustrated.
- ⇒ However, as with adult bearded seal, the humerus can probably be easily distinguished from all other species by its rounded shaft and particularly wide proximal end.

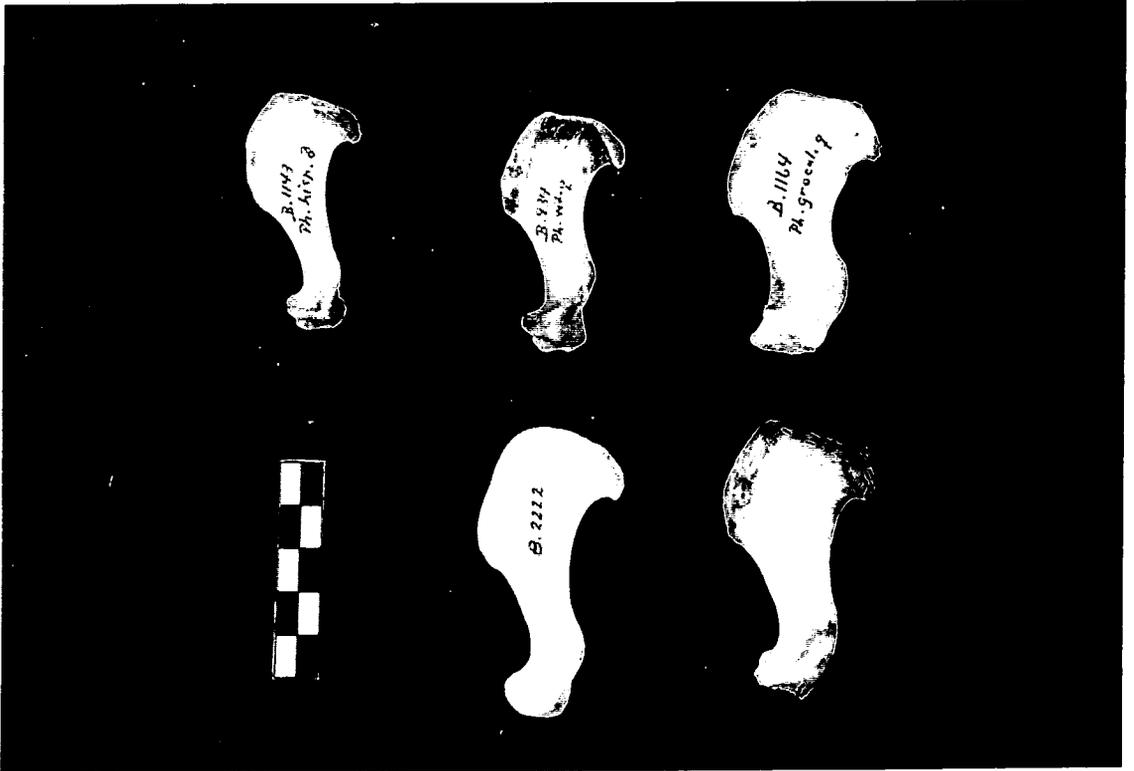
### **Hooded seal—*Cystophora cristata***

- ⇒ Cannot be reliably distinguished from *P. groenlandica*.
- ⇒ The shaft is relatively short and thick.
- ⇒ The medial aspect of the distal shaft is essentially flat and the ridge towards the posterior edge is often less pronounced than in *P. groenlandica*.
- ⇒ When viewed end-on, the distal end is thick relative to its width.

Ringed

Harbour

Harp



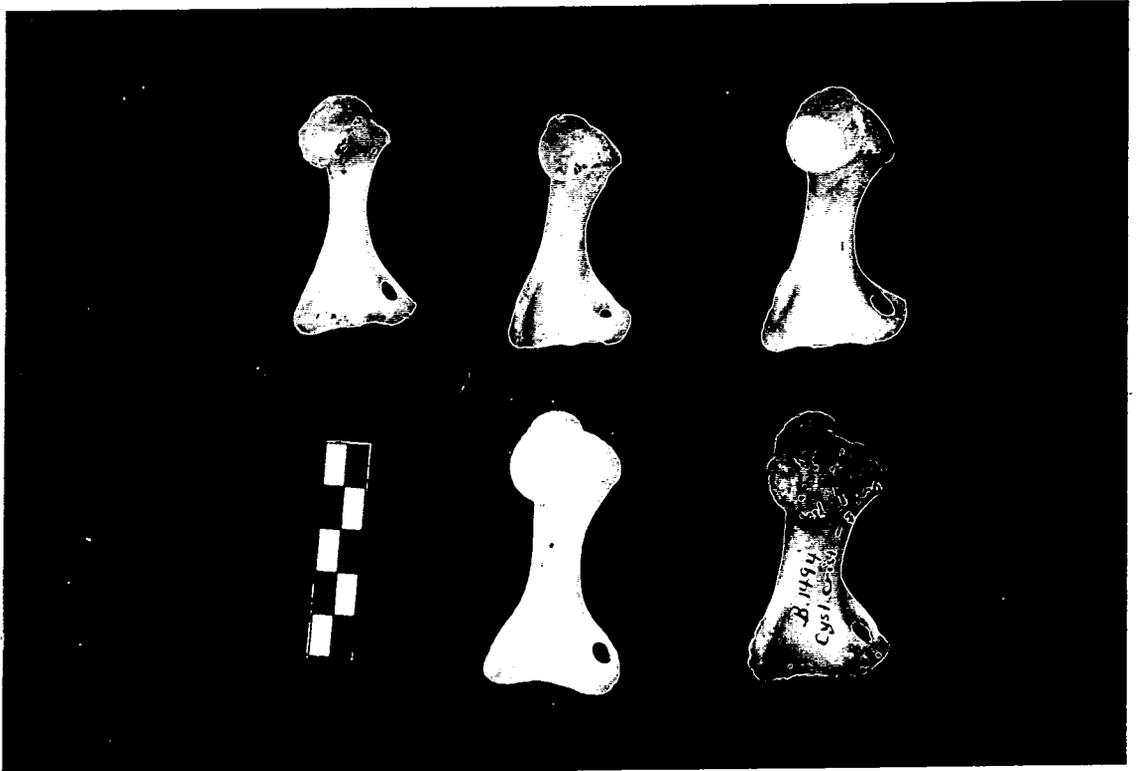
Grey

Hooded

Ringed

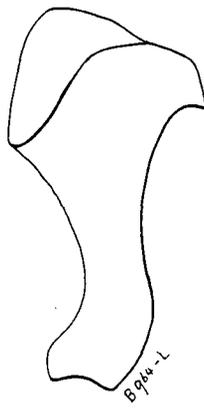
Harbour

Harp

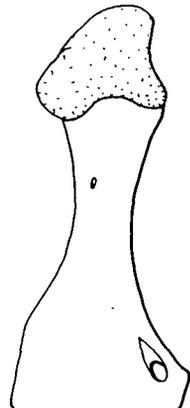


Grey

Hooded



B 964-L

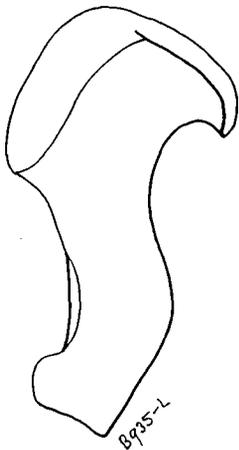


B 964-L-MED.

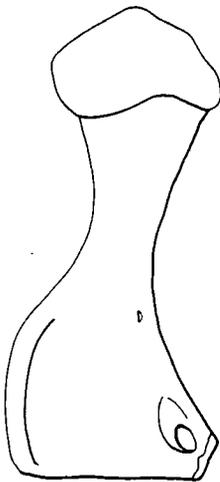


B 1143-L-DIST.

**Ringed seal—*Phoca hispida***



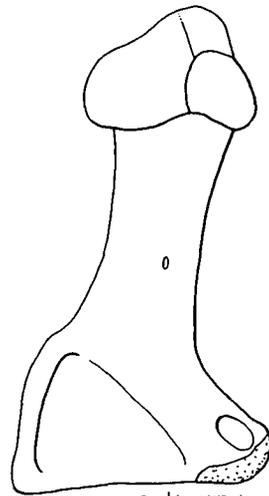
B 935-L



B 935-L-MED.

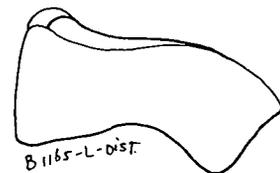


B 935-L-DIST.



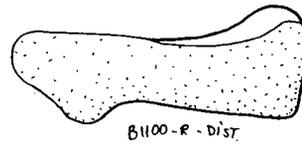
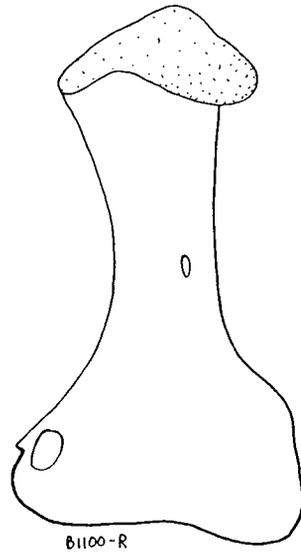
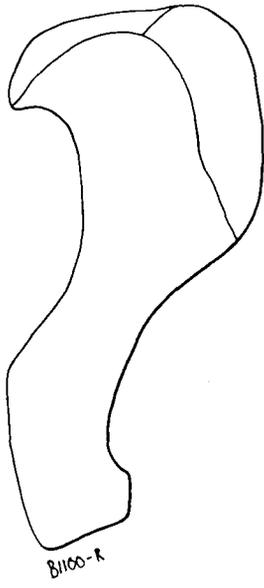
B 1164-MED-L

**Harbour seal—*Phoca vitulina***

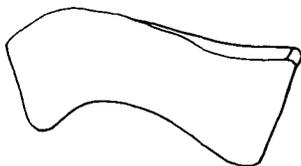
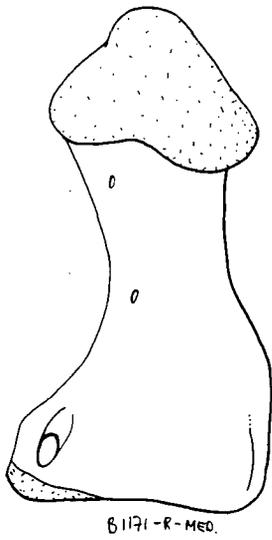


B 1165-L-DIST.

**Harp seal—*Phoca groenlandica***



Grey seal—*Halichoerus grypus*



Hooded seal—*Cystophora cristata*

## B.5 Radius

For both adults and juveniles, species identifications based on radii can be difficult. However, both ringed seal and bearded seal are very characteristic and can often be identified based on fragments of the shaft alone. For other species, identification is impossible without a complete bone. The length, angle and thickness of the shaft are particularly important when making these identifications.

### B.5.1 Adult radius

#### Ringed seal—*Phoca hispida*

- ⇒ The shaft is very slender, with its narrowest point farther from the head than in *P. vitulina*.
- ⇒ There is a “crook” in the shaft just proximal to its narrowest point.
- ⇒ Fuses at a much smaller size than *P. groenlandica*, *H. grypus*, *E. barbatus* and *C. cristata* and never attains the same size as those species.

#### Harbour seal—*Phoca vitulina*

- ⇒ The shaft is thicker than in *P. hispida*, with its narrowest point closer to the head of the radius.
- ⇒ The shaft is often straighter than in *P. hispida*.
- ⇒ Fuses at a smaller size than *P. groenlandica*, *H. grypus*, *E. barbatus* and *C. cristata* and never attains the same size as those species.

#### Harp seal—*Phoca groenlandica*

- ⇒ Similar to *C. cristata* and difficult to distinguish from it.
- ⇒ The head of the radius has relatively straight, parallel sides.
- ⇒ The shaft is thick and relatively short with a bend in the middle.
- ⇒ The radius reaches a larger size than in either *P. hispida* or *P. vitulina*.

#### Grey seal—*Halichoerus grypus*

- ⇒ The head of the radius flares out towards the proximal end.
- ⇒ The shaft is relatively thick, but is longer and straighter than in *P. groenlandica*.
- ⇒ The radius reaches a larger size than in either *P. hispida* or *P. vitulina*.

#### Bearded seal—*Erignathus barbatus*

- ⇒ Has a much longer, straighter shaft than any other species.
- ⇒ Viewed end-on, the distal end is much thicker relative to its width than in any other species.

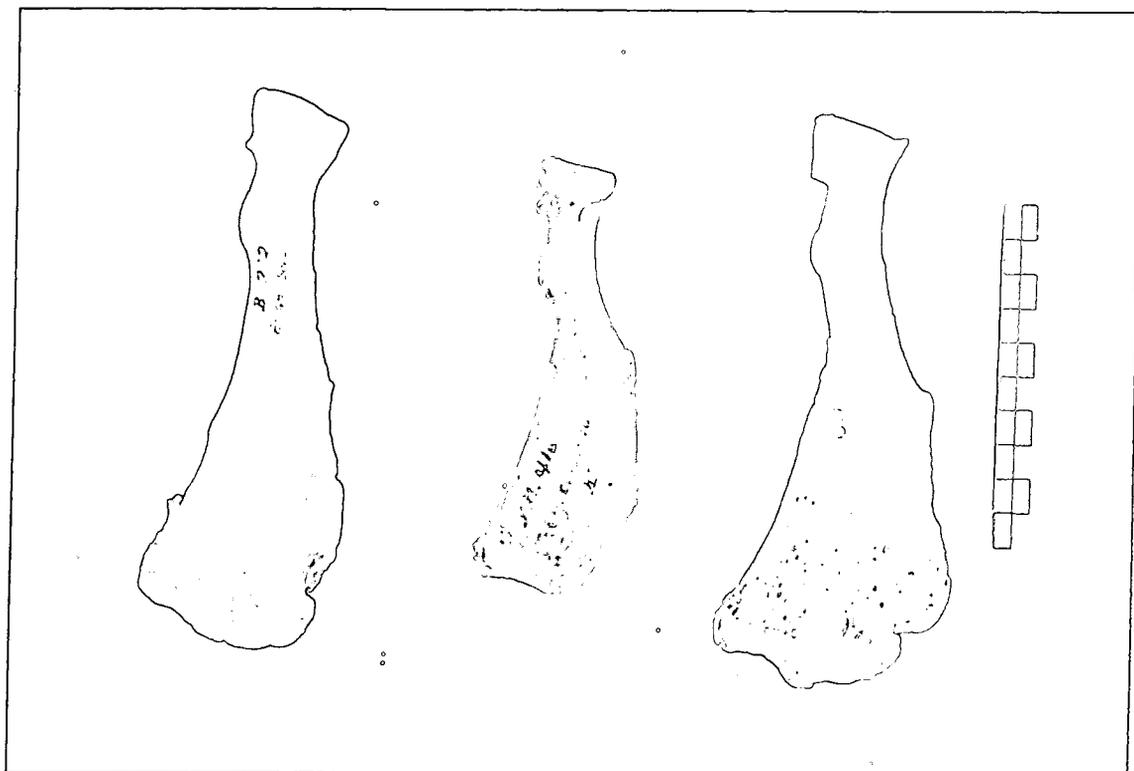
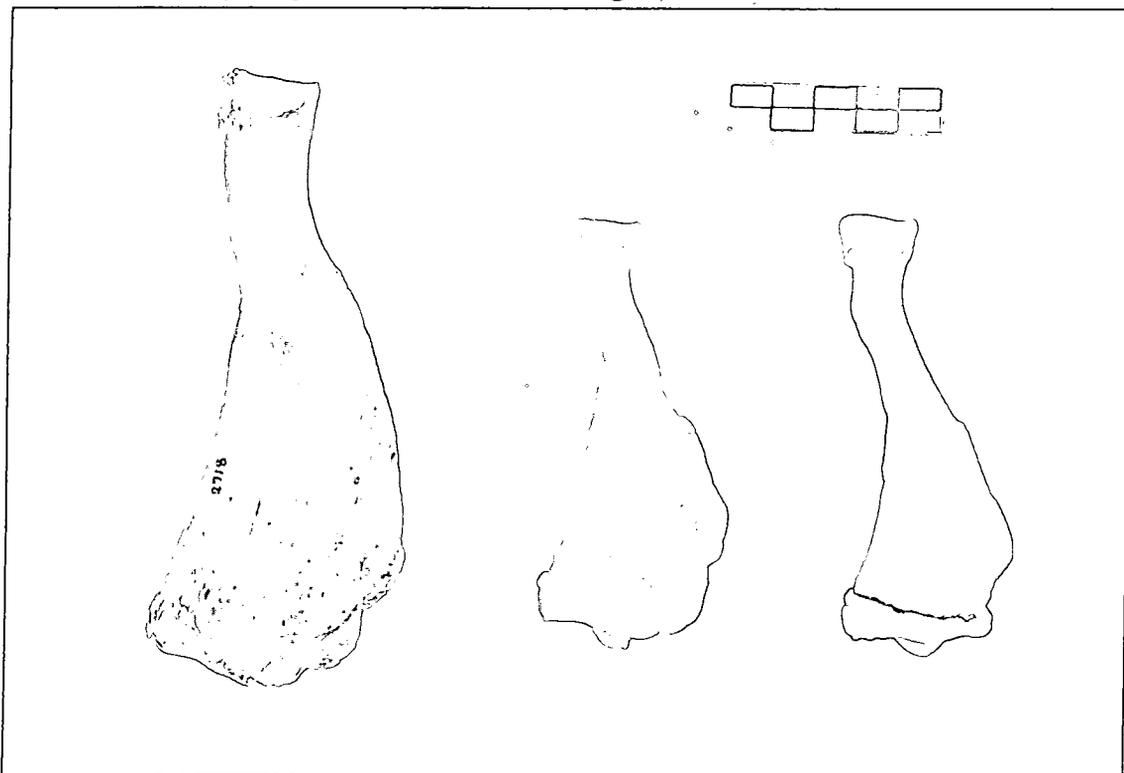
#### Hooded seal—*Cystophora cristata*

- ⇒ Similar to *P. groenlandica* and difficult to distinguish from it.
- ⇒ The shaft is relatively thick and short, and bends slightly.
- ⇒ The sides of the head can flare out towards the proximal end or be more parallel.

Harp

Harbour

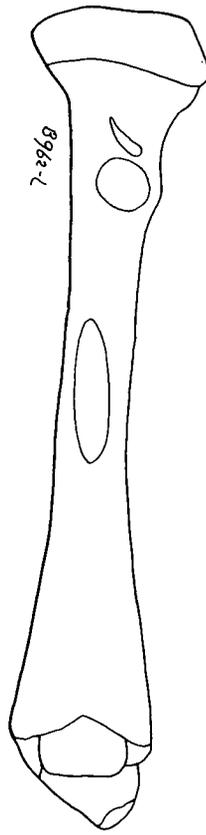
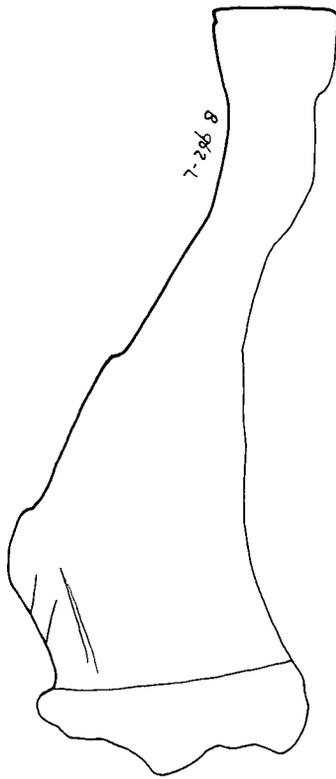
Ringed



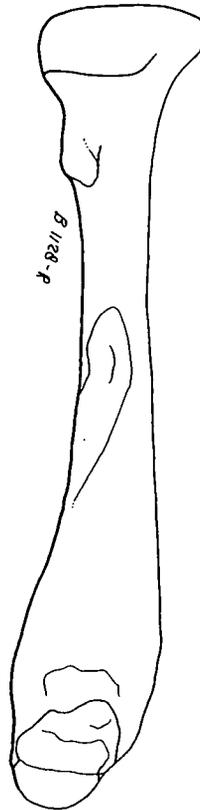
Bearded

Hooded

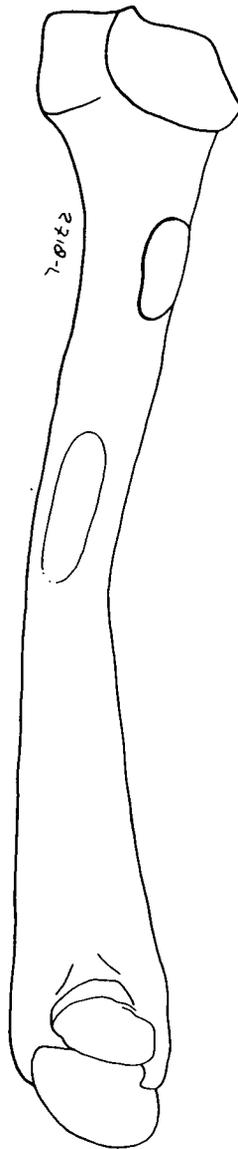
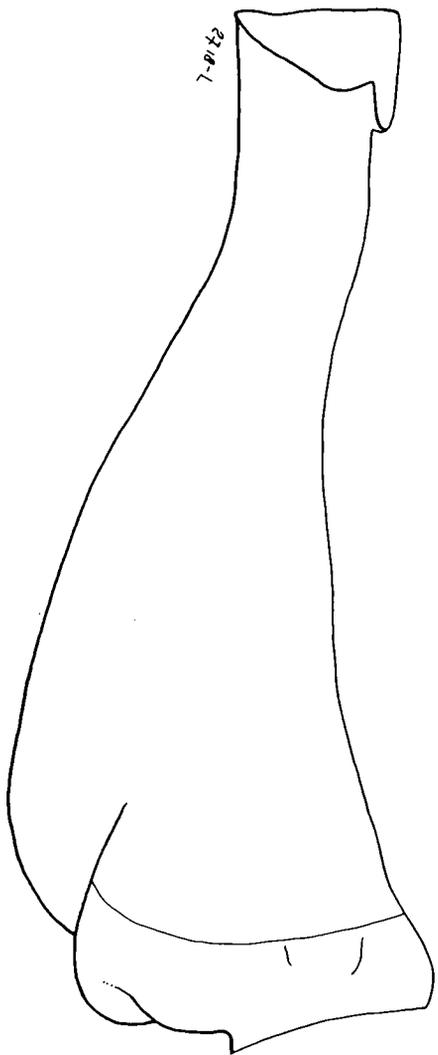
Grey



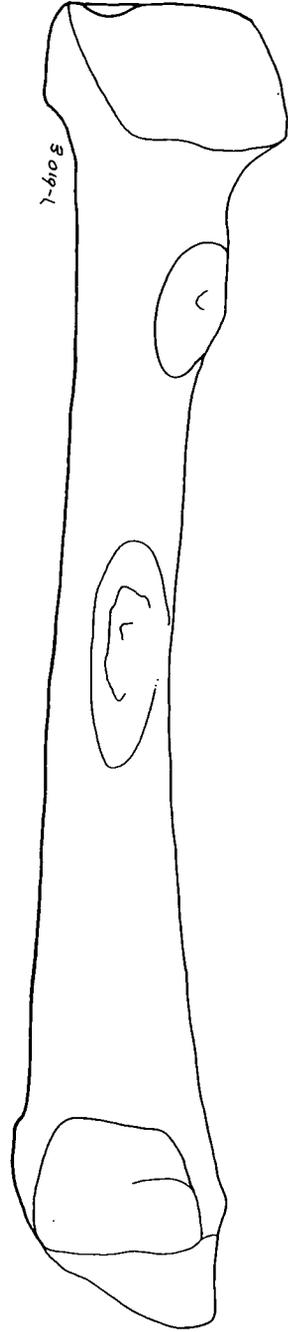
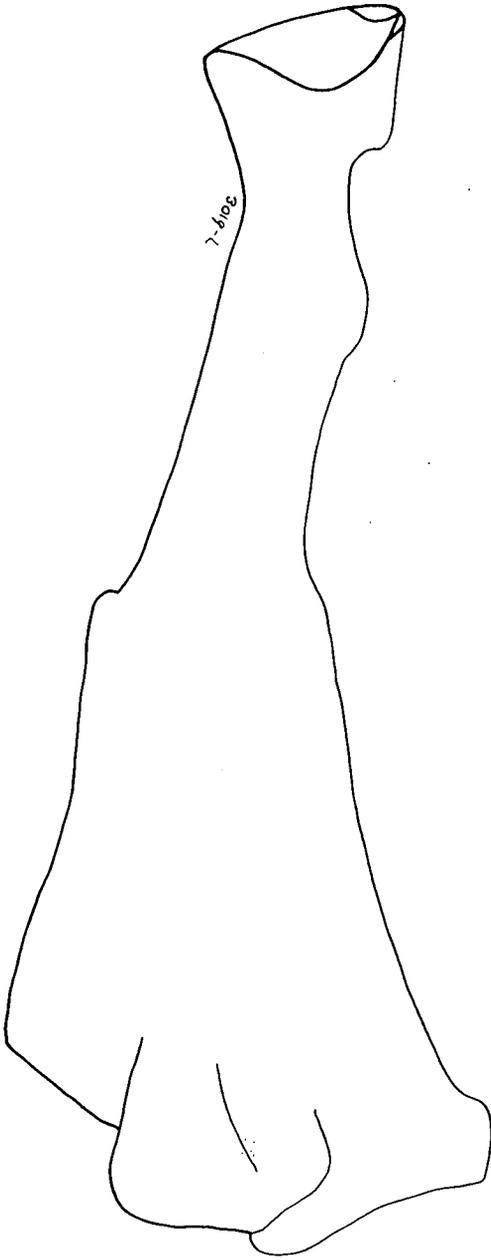
**Ringed seal—*Phoca hispida***



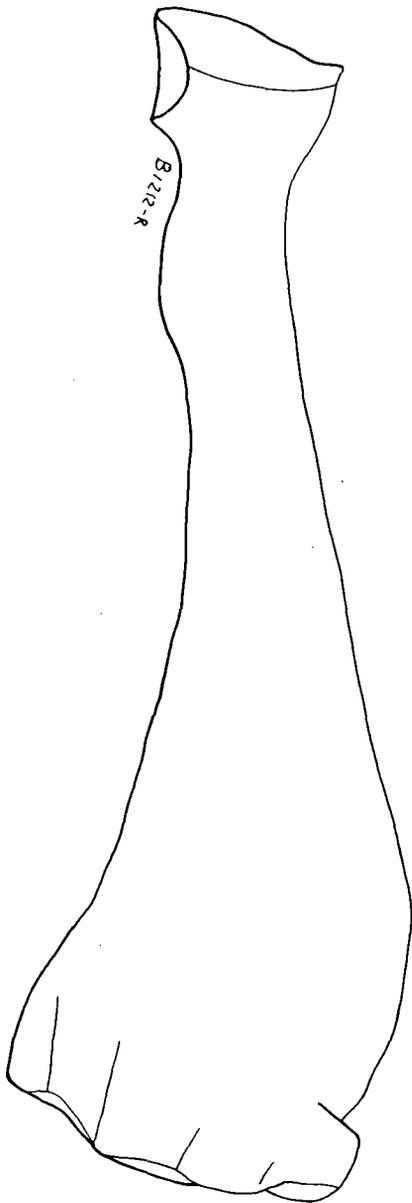
**Harbour seal—*Phoca vitulina***



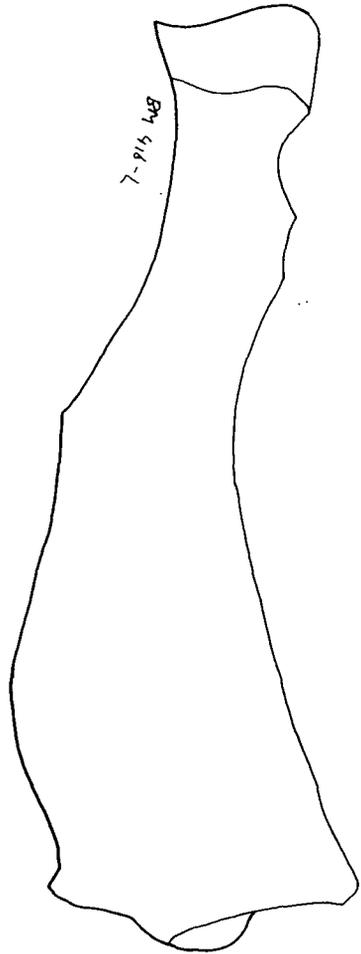
Harp seal—*Phoca groenlandica*



Grey seal—*Halichoerus grypus*



Bearded seal—*Erignathus barbatus*



Hooded seal—*Cystophora cristata*

### B.5.2 Juvenile radius

Juvenile radii are particularly difficult to identify to species. Some ringed seal radii stand out because of their extremely slender shafts. Juvenile harp seal radii tend to be particularly “chunky” in appearance.

#### **Ringed seal—*Phoca hispida***

- ⇒The shaft tends to be very slender and is long relative to its width.
- ⇒There is often more of a bend in the shaft than in *P. vitulina*.

#### **Harbour seal—*Phoca vitulina***

- ⇒The shaft tends to be thicker and straighter than in *P. hispida*.
- ⇒The angle of the distal end relative to the shaft is often flatter than in *P. groenlandica*.

#### **Harp seal—*Phoca groenlandica***

- ⇒The shaft is relatively thick.
- ⇒The distal end tends to be on a sharper angle relative to the shaft than in *P. hispida* or *P. vitulina*.

#### **Grey seal—*Halichoerus grypus***

- ⇒Very similar to *P. vitulina*, but reaches a larger size before fusing.
- ⇒The shaft tends to be somewhat longer and straighter than in *P. groenlandica*.
- ⇒As in *P. groenlandica*, the distal end tends to be on a fairly sharp angle relative to the shaft.

#### **Bearded seal—*Erignathus barbatus***

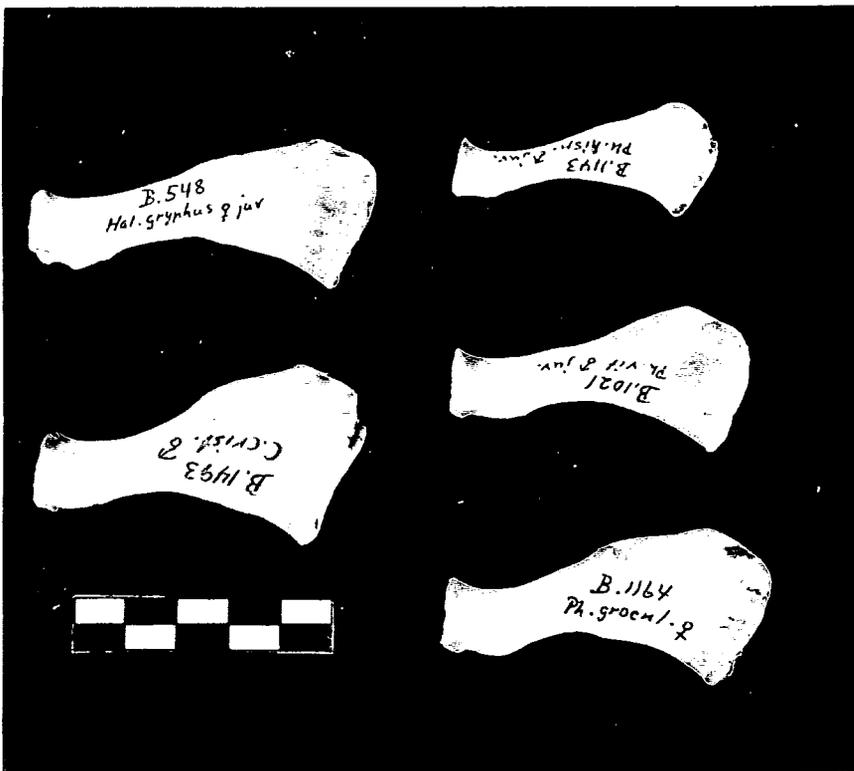
- ⇒Unfortunately, the radius is missing from the only juvenile bearded seal in the ZMB collection and it is therefore not illustrated.
- ⇒Like the adult radius, it probably has a much longer, straighter shaft than any other species.

#### **Hooded seal—*Cystophora cristata***

- ⇒The juvenile radius can be extremely wide proximally.
- ⇒The shaft is quite short and relatively thick.
- ⇒Some overlap with *P. groenlandica* in terms of size and shape.

Grey

Hooded



Ringed

Harbour

Harp

Grey

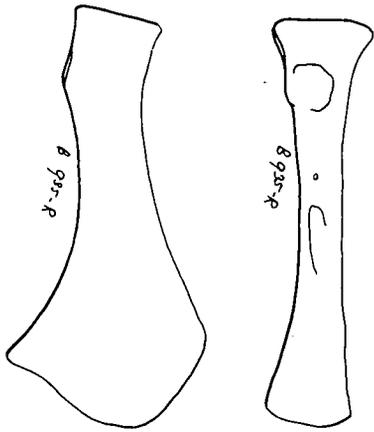
Hooded



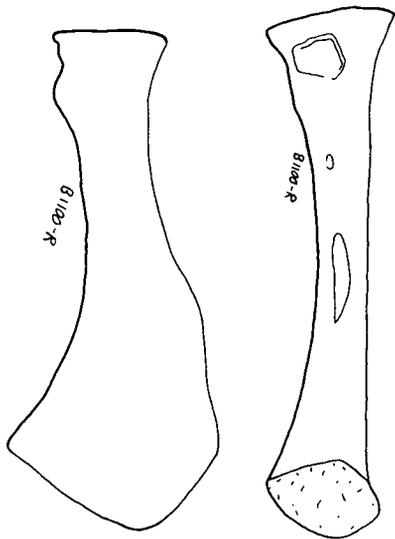
Ringed

Harbour

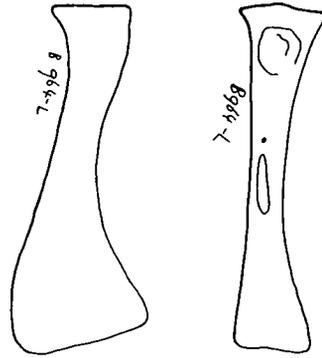
Harp



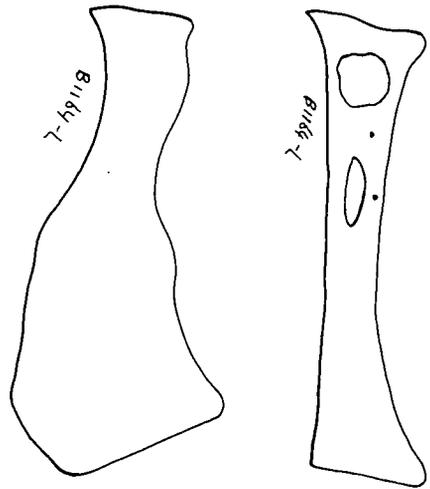
Harbour seal—*Phoca vitulina*



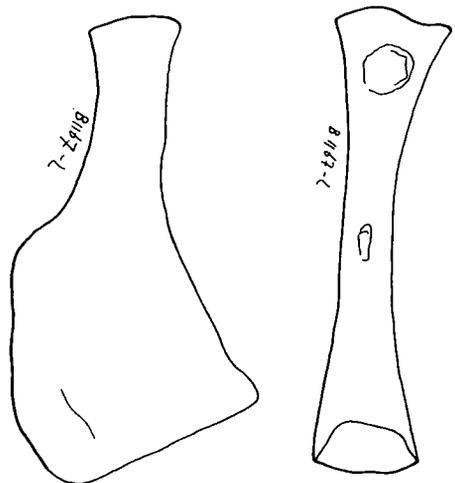
Grey seal—*Halichoerus grypus*



Ringed seal—*Phoca hispida*



Harp seal—*Phoca groenlandica*



Hooded seal—*Cystophora cristata*

## B.6 Ulna

Reliable distinctions can be made between almost all species based on the ulna. However, as for so many elements, it is difficult to separate between ringed seal and harbour seal and between harp seal and hooded seal. The number of facets in the articular notch, and the width and height of the olecranon process are important distinguishing characteristics.

### B.6.1 Adult ulna

#### Ringed seal—*Phoca hispida*

- ⇒ The articular surface of the trochlear notch has only two lobes, one proximal and one distal.
- ⇒ The trochlea is much narrower above the trochlear notch than in *P. groenlandica* and *C. Cristata*.
- ⇒ The trochlea tends to be taller than in *P. vitulina*, though the two species overlap.
- ⇒ The shaft tends to be narrower and thinner than in *P. vitulina*.

#### Harbour seal—*Phoca vitulina*

- ⇒ As in *P. hispida*, the articular surface of the trochlear notch has only two lobes.
- ⇒ The trochlea is much narrower above the trochlear notch than in *P. groenlandica* and *C. Cristata*.
- ⇒ The trochlea tends to be shorter than in *P. hispida*, though there is some overlap.
- ⇒ The shaft tends to be wider and thicker than in *P. hispida*.

#### Harp seal—*Phoca groenlandica*

- ⇒ Cannot be reliably distinguished from *C. cristata*.
- ⇒ The articular surface of the trochlear notch has three lobes, two proximal and one distal.
- ⇒ The trochlea is much wider above the trochlear notch than in *P. hispida*, *P. vitulina* or *H. grypus*.

#### Grey seal—*Halichoerus grypus*

- ⇒ The articular surface of the trochlear notch only has two lobes.
- ⇒ Attains a much larger size than in either *P. hispida* or *P. vitulina*.
- ⇒ The trochlea is relatively thin above the trochlear notch.
- ⇒ The lateral surface of the trochlea is very wide compared to *E. barbatus*.
- ⇒ The shaft is thinner and more curved, when viewed from any aspect, than in *E. barbatus*.

#### Bearded seal—*Erignathus barbatus*

- ⇒ The articular surface of the trochlear notch only has two lobes.
- ⇒ The lateral surface of the trochlea is narrow compared to *H. grypus*, *P. groenlandica* and *C. cristata*.
- ⇒ The shaft is wider and straighter, when viewed from any aspect, than in *H. grypus*.

#### Hooded seal—*Cystophora cristata*

- ⇒ Cannot be reliably distinguished from *P. groenlandica*.
- ⇒ The articular surface of trochlear notch has three lobes.
- ⇒ The trochlea is wide above the trochlear notch.

Ringed

Harbour

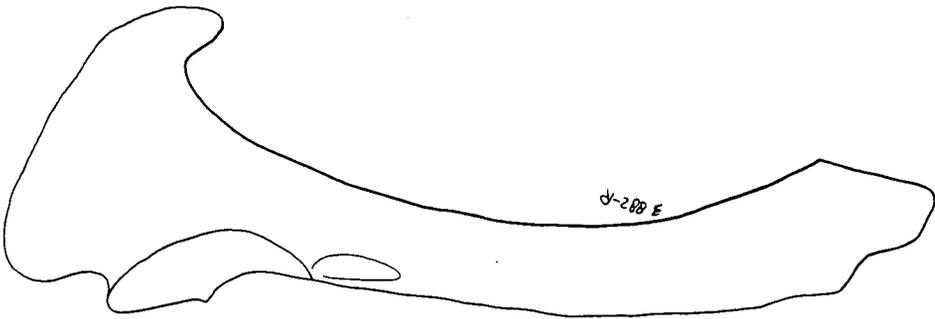
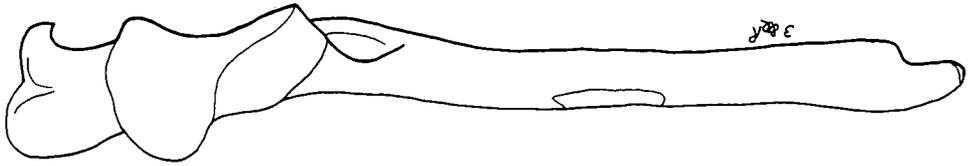
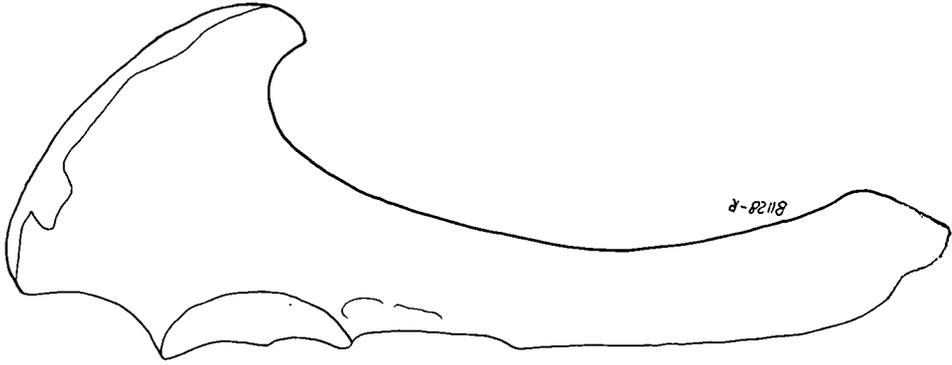
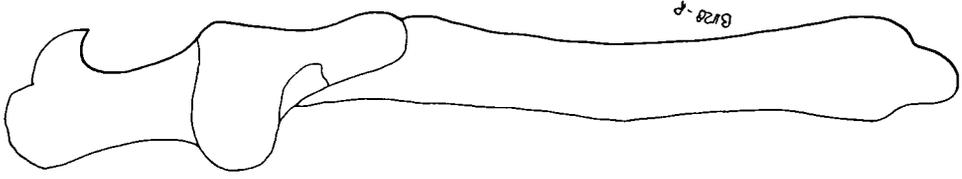
Harp



Grey

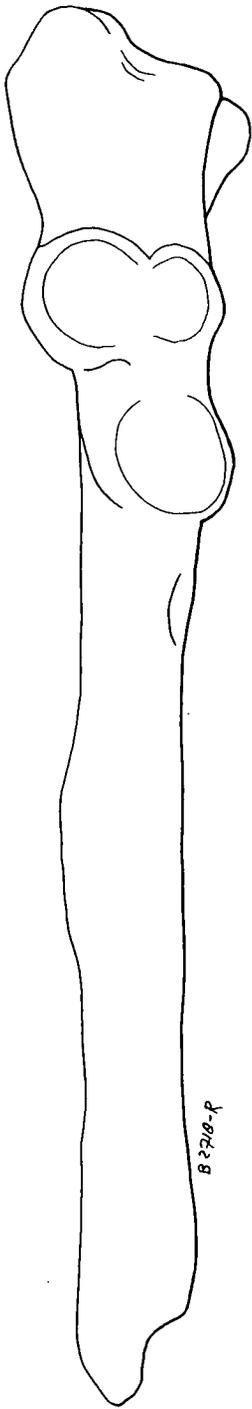
Hooded

Bearded

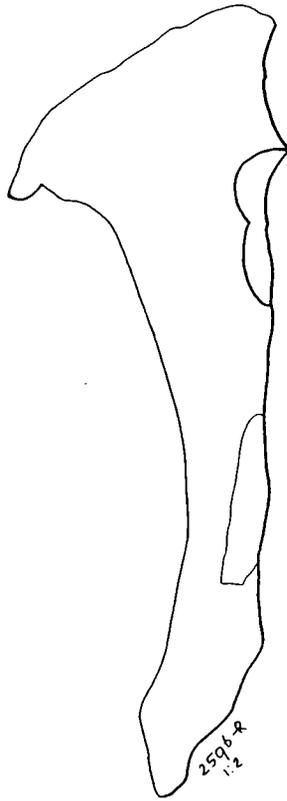


Harbour seal—*Phoca vitulina*

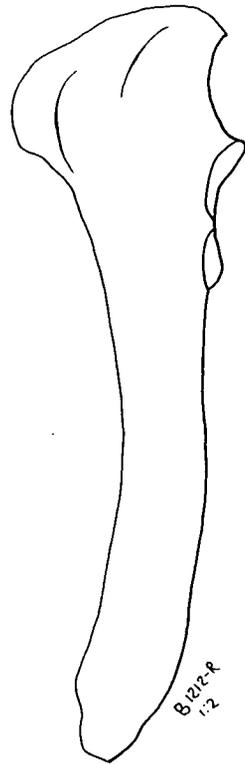
Ringed seal—*Phoca hispida*



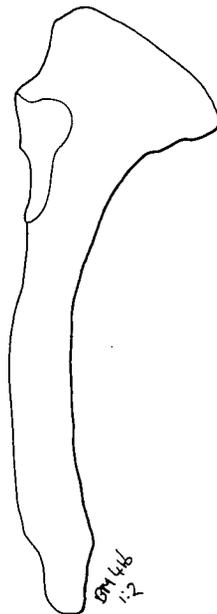
Harp seal—*Phoca groenlandica*



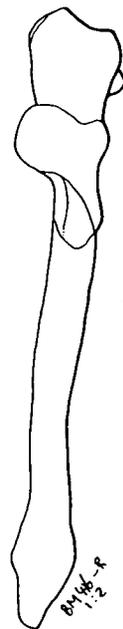
Grey seal  
*Halichoerus grypus*



Bearded seal  
*Erignathus barbatus*



Hooded seal—*Cystophora cristata*



## B.6.2 Juvenile ulna

The lobes of the articular surface of the trochlear notch tend to be less distinct than among adults. However, the width of the trochlea above the notch usually distinguishes between those species with two lobes and those with three. It is very difficult in juveniles to distinguish between *P. hispida* and *P. vitulina*. *P. groenlandica*, *H. grypus* and *C. cristata* can also be very similar to one another.

### **Ringed seal—*Phoca hispida***

- ⇒ The trochlea is narrow above the trochlear notch.
- ⇒ The shaft is very thin laterally.

### **Harbour seal—*Phoca vitulina***

- ⇒ The trochlea is narrow above the trochlear notch.
- ⇒ The shaft is usually wider laterally than in *P. hispida*, but there is some overlap.

### **Harp seal—*Phoca groenlandica***

- ⇒ The trochlear notch tends to be very wide proximally.
- ⇒ The trochlea above the notch varies in width, but is generally wider than in *H. grypus* and is always wider than in *P. hispida* and *P. vitulina*.
- ⇒ The shaft is wider laterally than in *P. hispida*.

### **Grey seal—*Halichoerus grypus***

- ⇒ Very similar to *P. vitulina*, but reaches a larger size before fusing.
- ⇒ Above the trochlear notch, the trochlea varies in width, but is generally narrower than in *P. groenlandica*.

### **Bearded seal—*Erignathus barbatus***

- ⇒ The trochlea is relatively flat on top.
- ⇒ Above the trochlear notch, the trochlea is narrower than in *P. groenlandica* or *C. cristata*.
- ⇒ The shaft is particularly straight.

### **Hooded seal—*Cystophora cristata***

- ⇒ Difficult to distinguish from both *P. groenlandica* and *H. grypus*.
- ⇒ Above the trochlear notch, the width of the trochlea is intermediate between *P. groenlandica* and *H. grypus*, overlapping with both.

Ringed

Harbour

Harp

Grey

Hooded

Bearded



Ringed

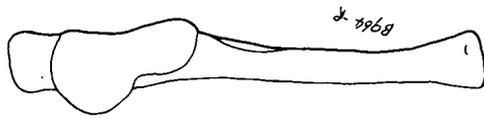
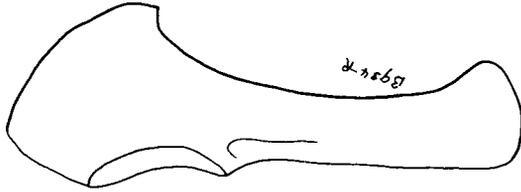
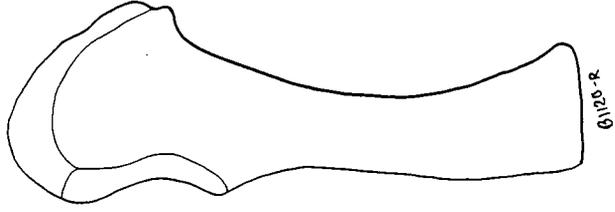
Harbour

Harp

Grey

Hooded

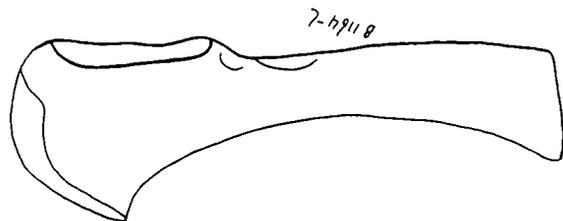
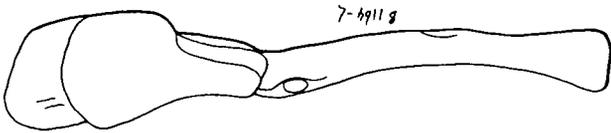
Bearded



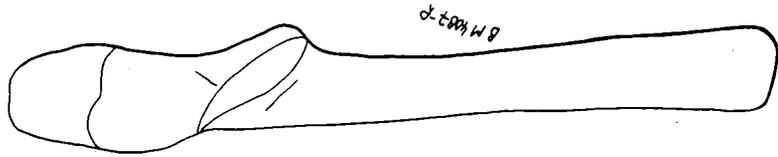
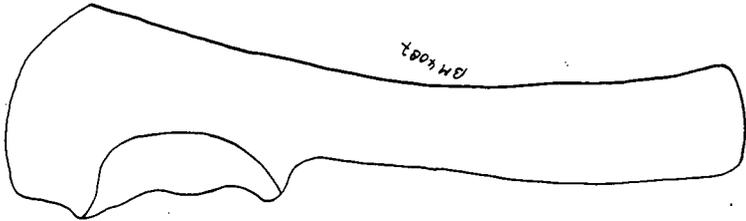
Harbour seal—*Phoca vitulina*

Ringed seal—*Phoca hispida*

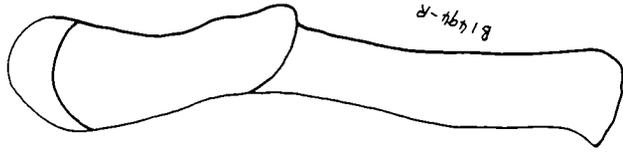
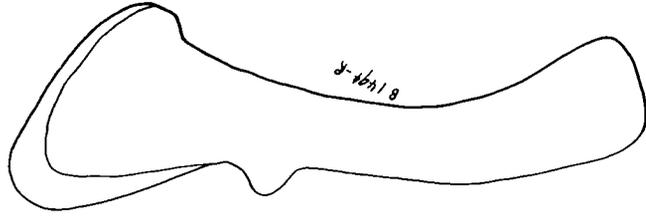
Harp seal—*Phoca groenlandica*



Grey seal—*Halichoerus grypus*



Bearded seal—*Erignathus barbatus*



Hooded seal—*Cystophora cristata*

## B.7 Innominate (Pelvis)

The innominate is better for distinguishing between some species than between others. *P. hispida* and *P. vitulina* are very difficult to separate, and could also be confused with a small *P. groenlandica* innominate.

### B.7.1 Adult innominate

#### Ringed seal—*Phoca hispida*

⇒The acetabulum is relatively small and is situated farther away from the obturator foramen than in *H. grypus*.

⇒The ischium tends to be thinner than in *P. vitulina*.

#### Harbour seal—*Phoca vitulina*

⇒The acetabulum is relatively small and is situated farther away from the obturator foramen than in *H. grypus*.

⇒The ischium tends to be wider than in *P. hispida*.

#### Harp seal—*Phoca groenlandica*

⇒Reaches a much larger size than in either *P. hispida* or *P. vitulina*, but is very similar in form to those species.

⇒The acetabulum is small relative to that in *H. grypus* and *E. barbatus*, and is situated farther from the obturator foramen.

⇒The ischium is very straight and often appears flattened in cross-section.

#### Grey seal—*Halichoerus grypus*

⇒The acetabulum is particularly large.

⇒The ischium and pubis are often more curved than in other species, so that there is a large gap underneath them if the innominate is rested on a flat surface with the acetabulum facing upwards.

⇒The acetabulum is situated quite close to the obturator foramen.

#### Bearded seal—*Erignathus barbatus*

⇒As in *H. grypus*, the acetabulum is very large.

⇒The ilium is only slightly curved and lacks the ridges which come from the edge of the ilium towards the acetabulum in all other species.

#### Hooded seal—*Cystophora cristata*

⇒The acetabulum is smaller and is located farther from the obturator foramen than in *H. grypus* or *E. barbatus*.

⇒The ilium is less curved and has smoother edges than in *P. groenlandica*.

Ringed

Harbour

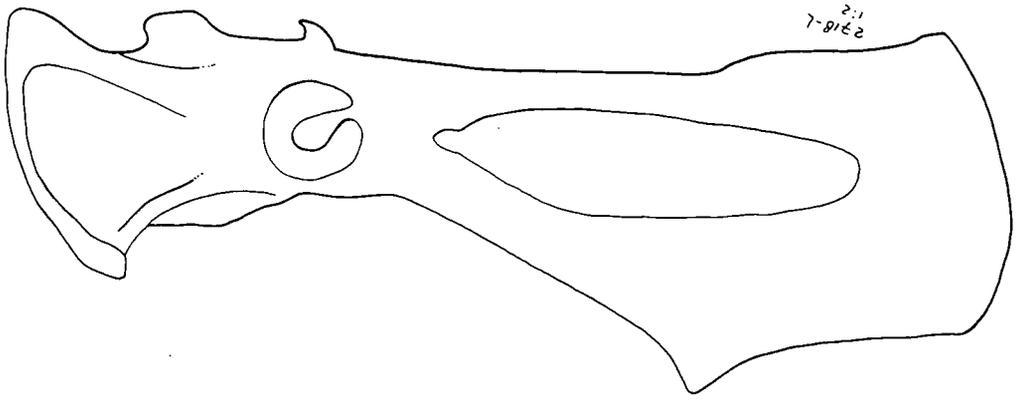
Harp



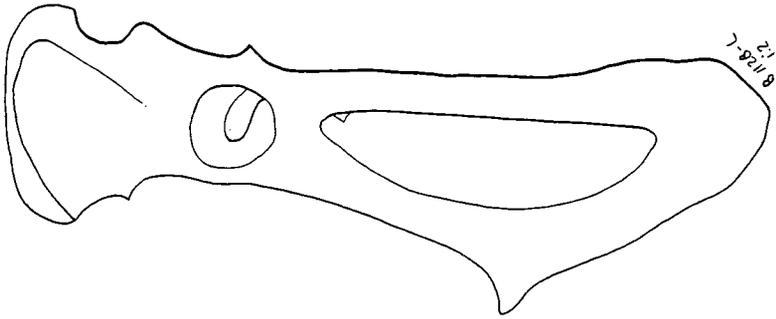
Grey

Hooded

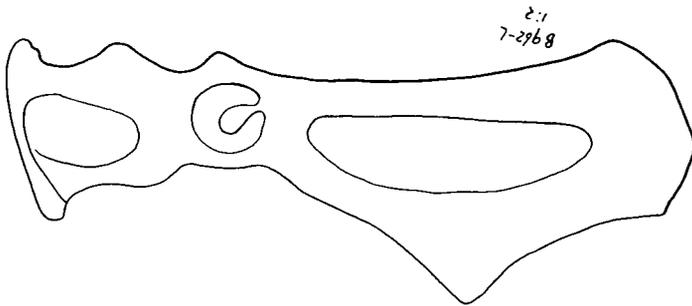
Bearded



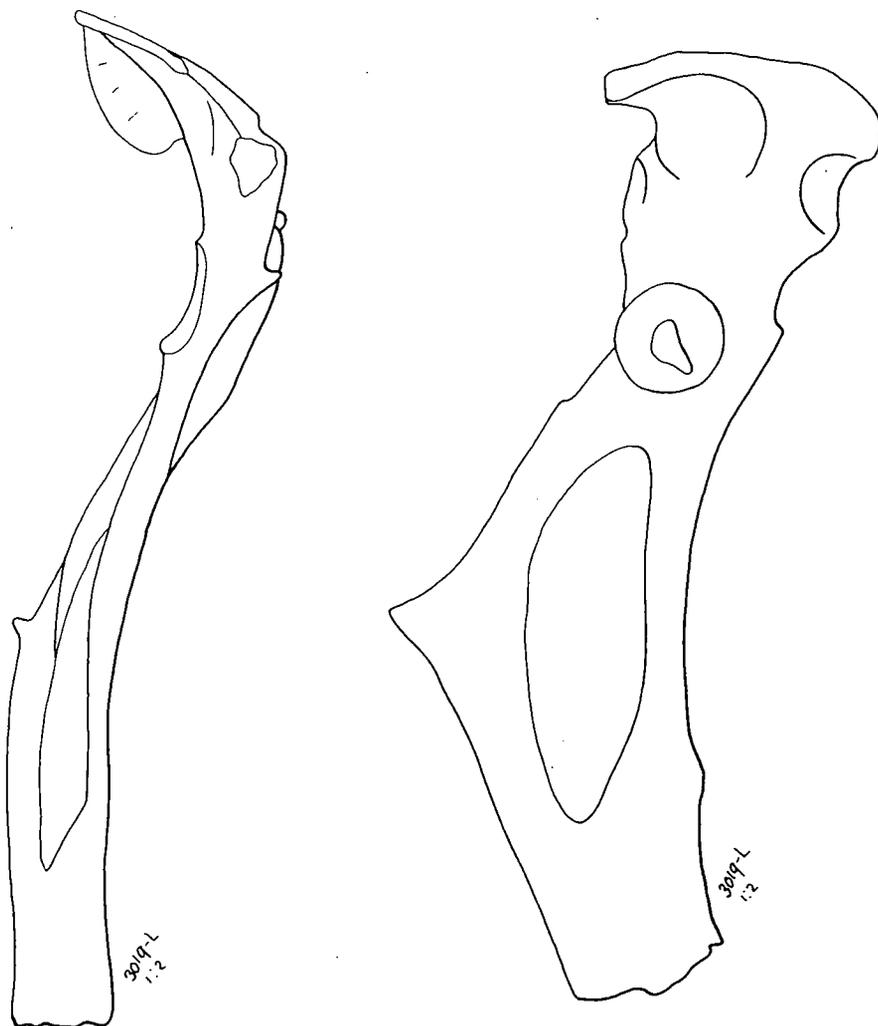
Harp seal—*Phoca groenlandica*



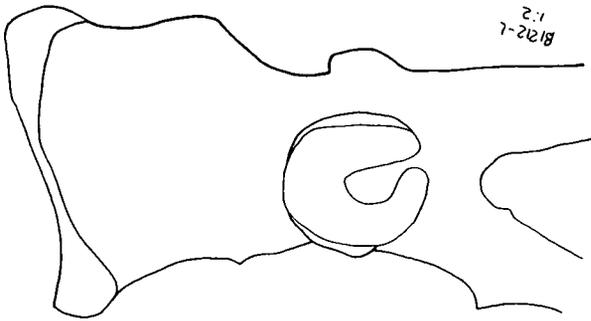
Harbour seal—*Phoca vitulina*



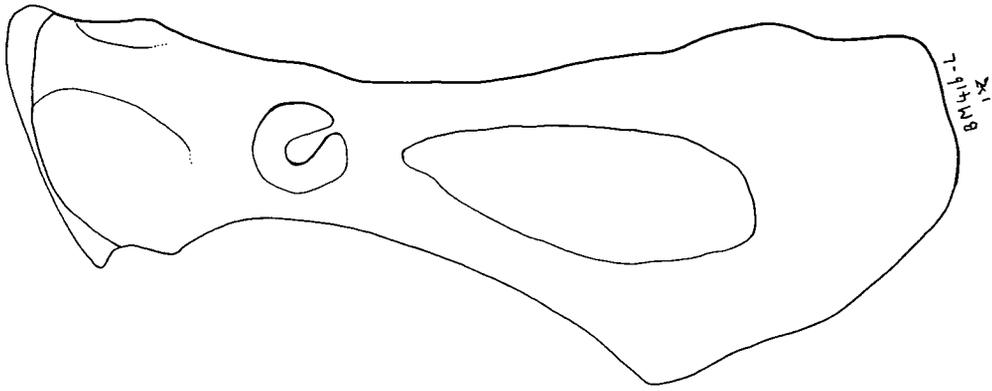
Ringed seal—*Phoca hispida*



Grey seal—*Halichoerus grypus*



**Bearded seal—*Erignathus barbatus***



**Hooded seal—*Cystophora cristata***

### B.7.2 Juvenile innominate

Juvenile innominates are extremely difficult to identify to species.

- ⇒ The acetabulum is often large in extremely young individuals, and cannot be reliably used to separate *H. grypus* from other species.
- ⇒ *P. hispida* and *P. vitulina* tend to be smaller and more gracile than the other species, but only very small innominates can be safely attributed to *P. hispida*/*P. vitulina* and very large ones to *P. groenlandica*/*H. grypus*/*C. cristata*.
- ⇒ The ischium of *P. hispida* can be smaller and thinner than in any other species, and particularly small examples can be identified to *P. hispida*.
- ⇒ Unfortunately, the single juvenile *E. barbatus* skeleton in the ZMB collections lacks an innominate, so it is not illustrated here.



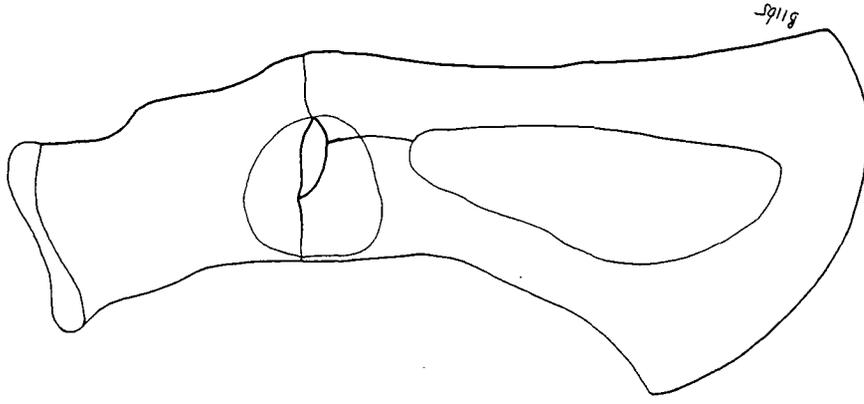
Ringed

Harbour

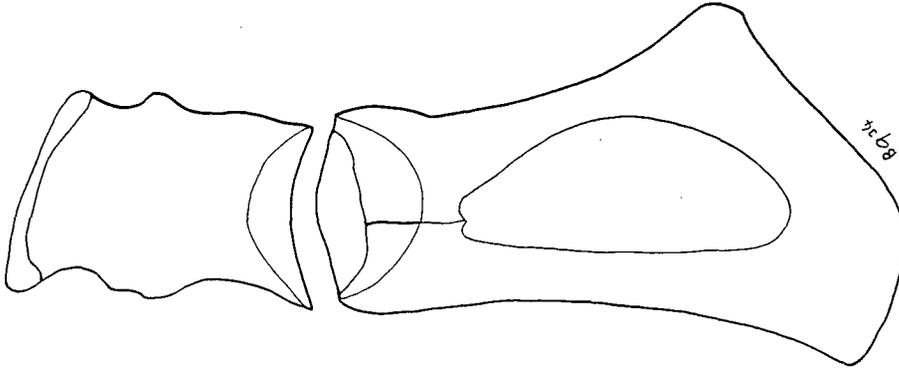
Harp

Grey

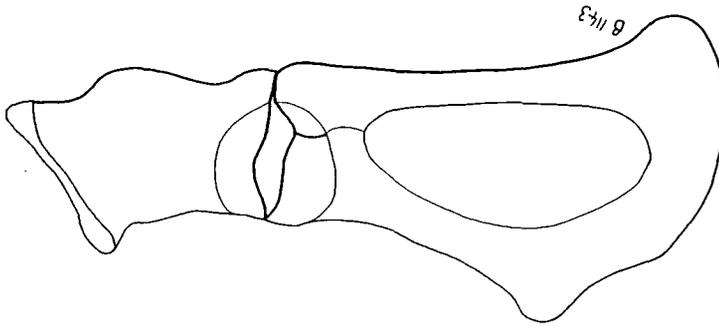
Hooded



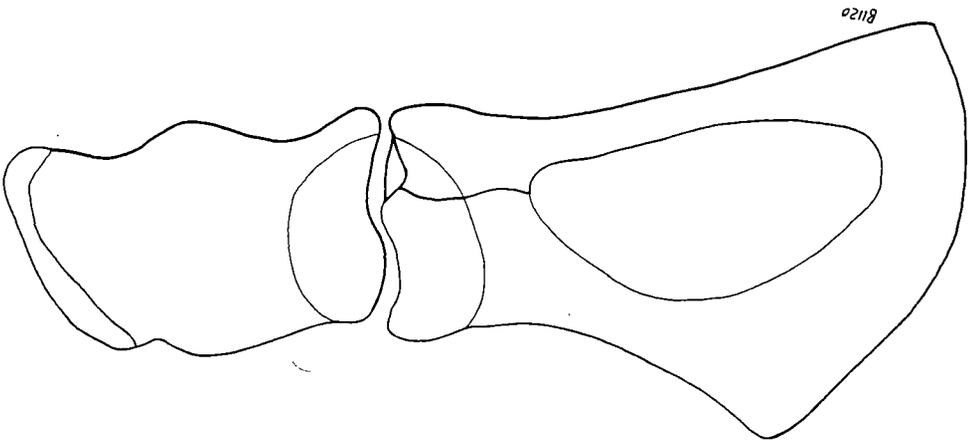
Harp seal—*Phoca groenlandica*



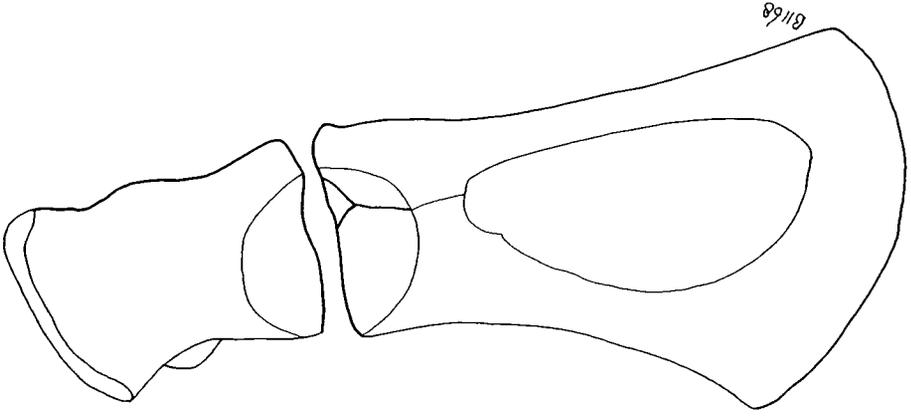
Harbour seal—*Phoca vitulina*



Ringed seal—*Phoca hispida*



Grey seal—*Halichoerus grypus*



Hooded seal—*Cystophora cristata*

## B.8 Femur

### B.8.1 Adult Femur

Femur is an extremely useful bone for making species identifications, however complete femora or large fragments of the proximal end are required. The angle of the femoral head and the width of the shaft can be used to distinguish between all species except *P. groenlandica* and *C. cristata*.

#### **Ringed seal—*Phoca hispida***

- ⇒ In anterior aspect the shaft is relatively narrow.
- ⇒ The neck is shorter than in *P. vitulina*.
- ⇒ The head tends to be slightly smaller than in *P. vitulina*.
- ⇒ The neck extends upward from the shaft less sharply than in *P. vitulina*.

#### **Harbour seal—*Phoca vitulina***

- ⇒ In anterior aspect the shaft is relatively narrow.
- ⇒ The neck is longer than in *P. hispida*.
- ⇒ The head tends to be slightly larger than in *P. hispida*.
- ⇒ The neck extends upward from the shaft on a steeper angle than in *P. hispida*.

#### **Harp seal—*Phoca groenlandica***

- ⇒ In anterior aspect the shaft is relatively wide.
- ⇒ The neck extends upward from the shaft less sharply than in *H. grypus*.
- ⇒ Cannot be reliably distinguished from *C. cristata*.

#### **Grey seal—*Halichoerus grypus***

- ⇒ In anterior aspect the shaft is narrower and longer than in *P. groenlandica* and *C. cristata*.
- ⇒ The neck is shorter than in *P. vitulina*.
- ⇒ The neck extends upward from the shaft on a sharper angle than in *P. groenlandica* and *C. cristata*.

#### **Bearded seal—*Erignathus barbatus***

- ⇒ In anterior aspect, the shaft narrow relative to the length of the femur.
- ⇒ The neck is longer than in any other species.

#### **Hooded seal—*Cystophora cristata***

- ⇒ In anterior aspect the shaft is relatively wide.
- ⇒ The neck extends upward from the shaft less sharply than in *H. grypus*.
- ⇒ Cannot be reliably distinguished from *P. groenlandica*.

Ringed

Harbour

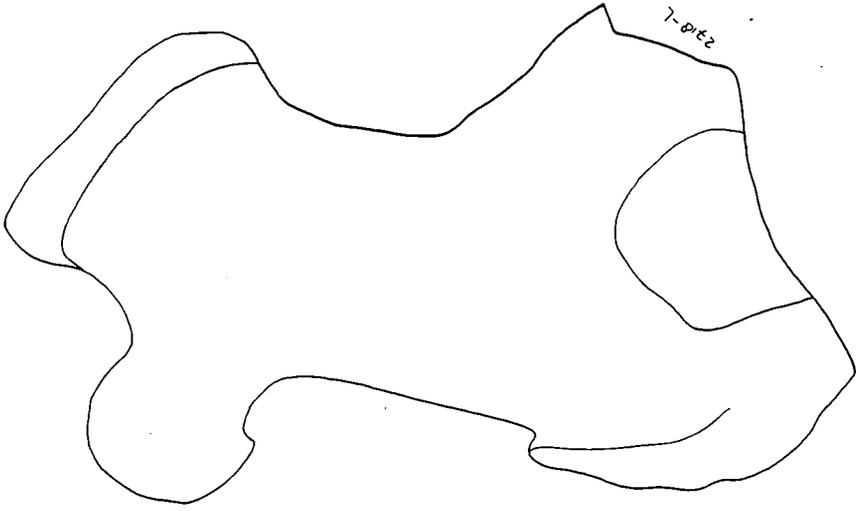
Harp



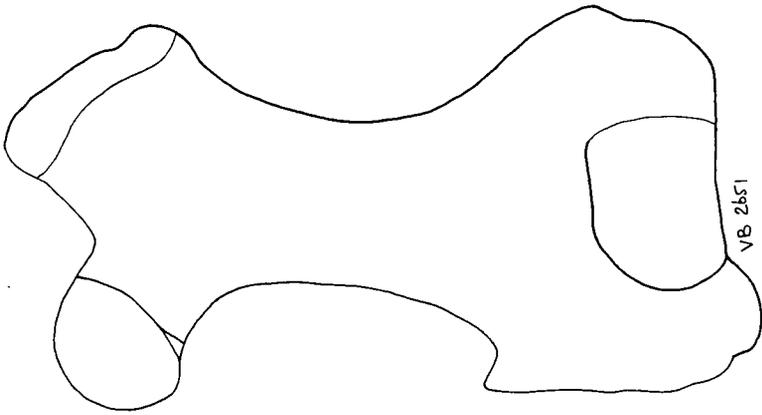
Grey

Hooded

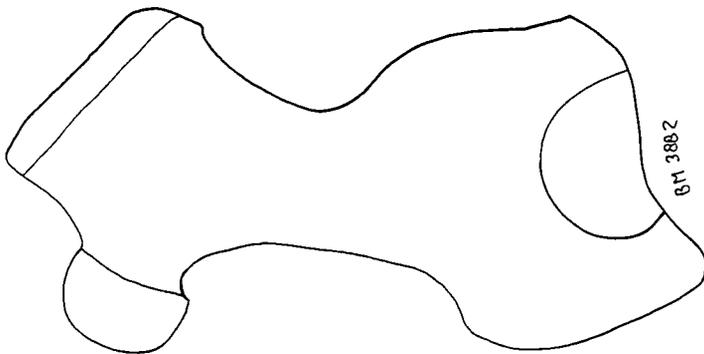
Bearded



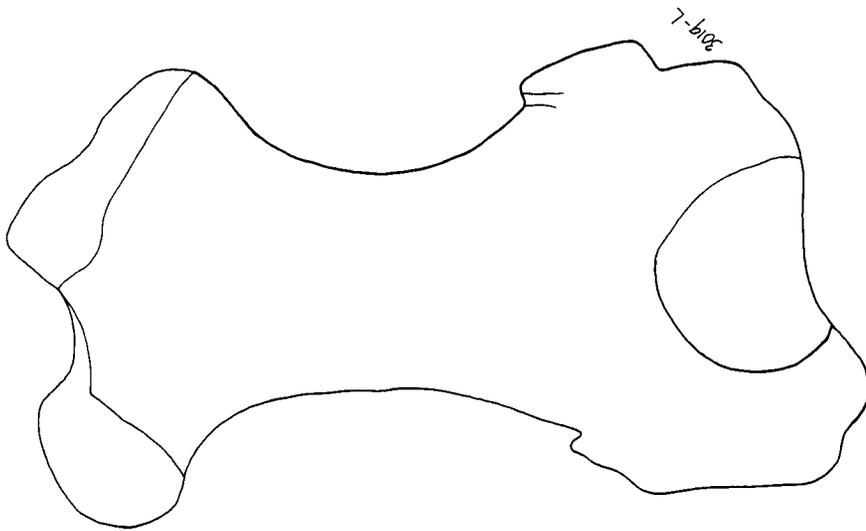
**Harp seal—*Phoca groenlandica***



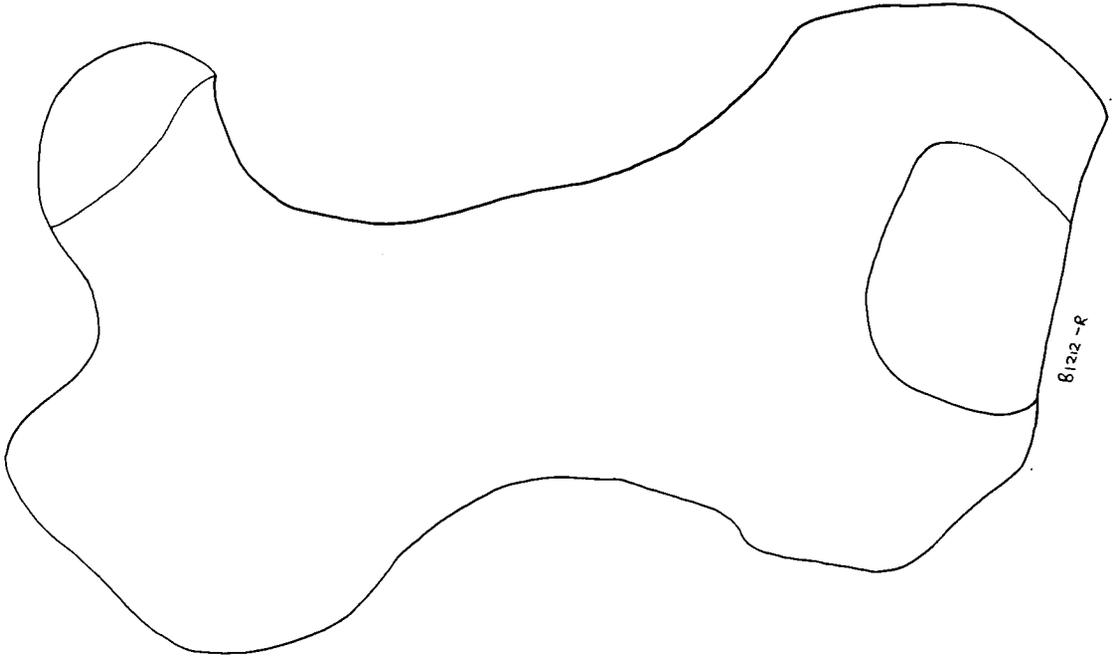
**Harbour seal—*Phoca vitulina***



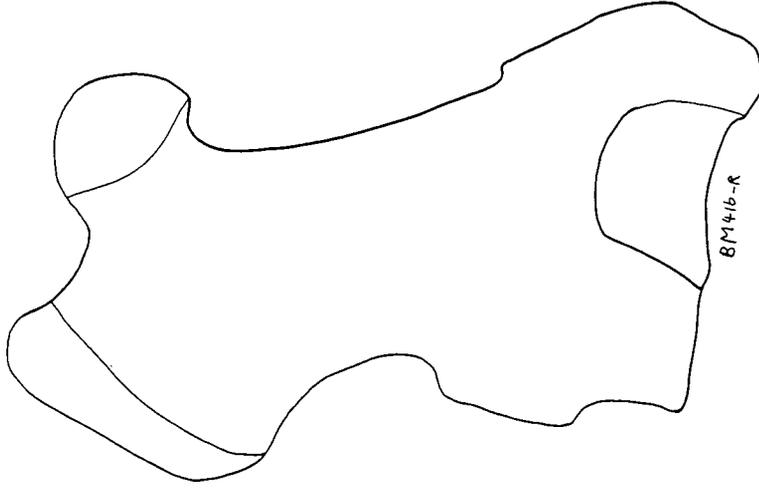
**Ringed seal—*Phoca hispida***



**Grey seal—*Halichoerus grypus***



**Bearded seal—*Erignathus barbatus***



**Hooded seal—*Cystophora cristata***

## B.8.2 Juvenile femur

### Ringed seal—*Phoca hispida*

- ⇒ Cannot be reliably distinguished from *P. vitulina* except in cases where the shaft is extremely narrow in its anterior aspect.
- ⇒ See description of *P. vitulina* above.

### Harbour seal—*Phoca vitulina*

- ⇒ Cannot be reliably distinguished from *P. hispida*.
- ⇒ The shaft is very narrow (in the anterior aspect) and longer than in *P. groenlandica* and *C. cristata*.
- ⇒ The shaft is thinner from anterior to posterior than either *P. groenlandica* or *C. cristata*.
- ⇒ The medial and lateral edges of the shaft are quite sharp rather than rounded.
- ⇒ Lacks the relatively flat bottom of *H. grypus*, so that if the femur is stood upright on its distal end the shaft will NOT be vertical.

### Harp seal—*Phoca groenlandica*

- ⇒ Cannot be reliably distinguished from *C. cristata*.
- ⇒ The shaft is relatively wide and is thicker from anterior to posterior than either *P. hispida* or *P. vitulina*.
- ⇒ The medial and lateral edges of the shaft are more rounded than in *P. hispida* and *P. vitulina*.
- ⇒ Lacks the relatively flat bottom of *H. grypus*, so that if the femur is stood upright on its distal end the shaft will NOT be vertical.

### Grey seal—*Halichoerus grypus*

- ⇒ The shaft is relatively narrow.
- ⇒ The two facets of the distal epiphysis form a line perpendicular to the mid-line of the shaft. This means that if the femur is stood upright on its distal end on a flat surface, the shaft will be oriented vertically rather than on an angle.

### Bearded seal—*Erignathus barbatus*

- ⇒ Unfortunately, the femora are missing from the single juvenile *E. barbatus* skeleton in the ZMB reference collection and juvenile femur is not illustrated here.
- ⇒ The long neck displayed by the adult femur would no doubt also serve to distinguish the juvenile femur from all other species.

### Hooded seal—*Cystophora cristata*

- ⇒ Cannot be reliably distinguished from *P. groenlandica*—see description of *P. groenlandica* above.

Ringed

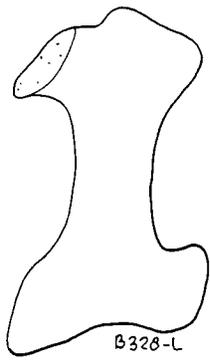
Harbour

Harp

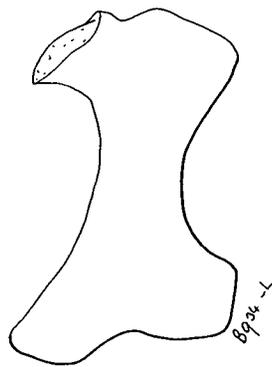


Grey

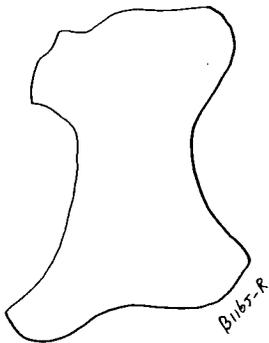
Hooded



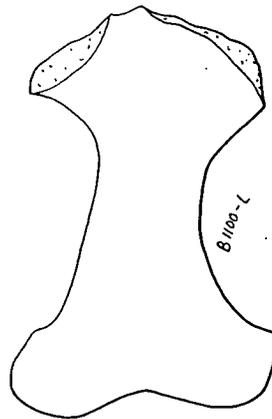
**Ringed seal**



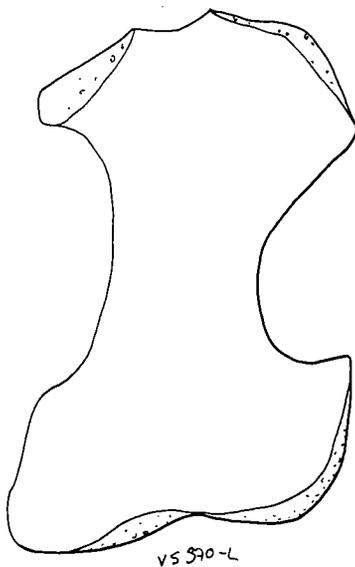
**Harbour seal**



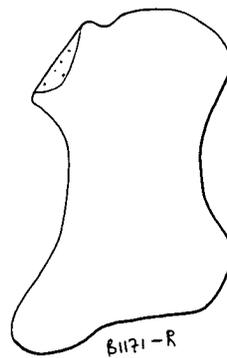
**Harp seal**



**Grey seal**



**Bearded seal**



**Hooded seal**

## B.9 Tibio-fibula (*Os cruris*)

Tibio-fibula is not a particularly reliable bone upon which to base species identifications. Except in the case of juvenile *P. hispida*, the fibula cannot be reliably identified to species. Proximal tibia allows only *E. barbatus* to be easily distinguished from all other species. The thickness and curvature of the tibia shaft permit both adults and juveniles of several species to be determined.

### B.9.1 Adult tibia

The tibio-fibula rarely preserves intact on archaeological sites. The tibia and fibula tend to become separated from each other, and often break into smaller fragments. In adults, the fibula does not permit reliable species identifications, though some examples of *P. hispida* can be identified. The shape of the distal epiphysis is particularly useful for distinguishing between species.

#### Ringed seal—*Phoca hispida*

- ⇒ *P. hispida* and *P. vitulina* tibiae can be distinguished from all other species because of their small adult size.
- ⇒ The anterior aspect of the proximal tibia has a more pronounced ridge along the medial edge than in *P. vitulina*.
- ⇒ The tibia shaft is thinner than in *P. vitulina* and has a marked curvature.
- ⇒ Viewed end-on, the distal epiphysis of the tibia can be difficult to distinguish from *P. vitulina*. The overall appearance of both is quite round, as opposed to *P. groenlandica*, *H. grypus* and *C. cristata* which are more square or rectangular.
- ⇒ The fibula can be thinner and more rounded in cross-section than in any other species.

#### Harbour seal—*Phoca vitulina*

- ⇒ *P. vitulina* and *P. hispida* tibiae can be distinguished from all other species because of their small adult size.
- ⇒ The anterior aspect of the proximal tibia is flatter than in *P. hispida*.
- ⇒ The tibia shaft is straighter and thicker than in *P. hispida*.
- ⇒ Viewed end-on, the distal epiphysis of the tibia can be difficult to distinguish from *P. hispida*. The overall appearance of both is quite round, as opposed to *P. groenlandica*, *H. grypus* and *C. cristata* which are more square or rectangular.

#### Harp seal—*Phoca groenlandica*

- ⇒ The tibia shaft tends to have a smaller minimum thickness and a more pronounced curvature than in *H. grypus*. It is easily confused with *C. cristata*.
- ⇒ The ridge on the anterior surface of the proximal tibia is more pronounced and extends farther down the shaft than in *H. grypus*.
- ⇒ The overall shape of the tibia's distal epiphysis (viewed end-on) is rectangular. It is easily confused with *C. cristata*.

#### Grey seal—*Halichoerus grypus*

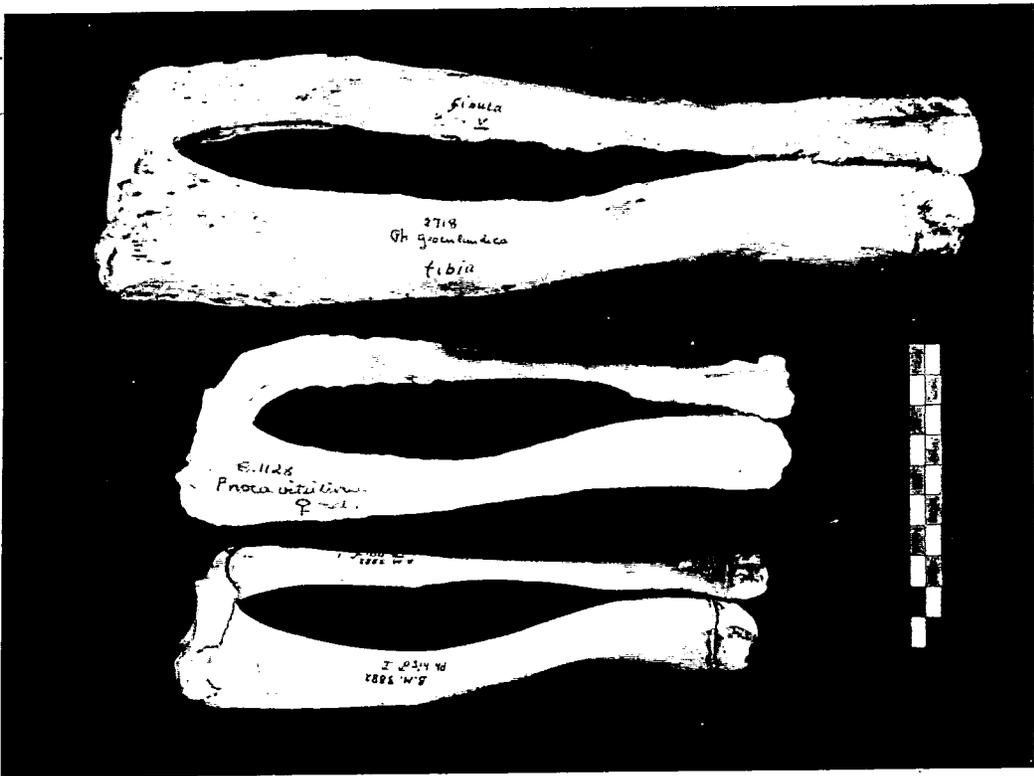
- ⇒ The shaft tends to be thicker and straighter than in *P. groenlandica* or *C. cristata*.
- ⇒ The ridge on the anterior surface of the proximal tibia is less pronounced and does not extend as far down the shaft as in *P. groenlandica*.
- ⇒ Viewed end-on, the distal epiphysis appears square. It is less flattened than either *P. groenlandica* or *C. cristata*.

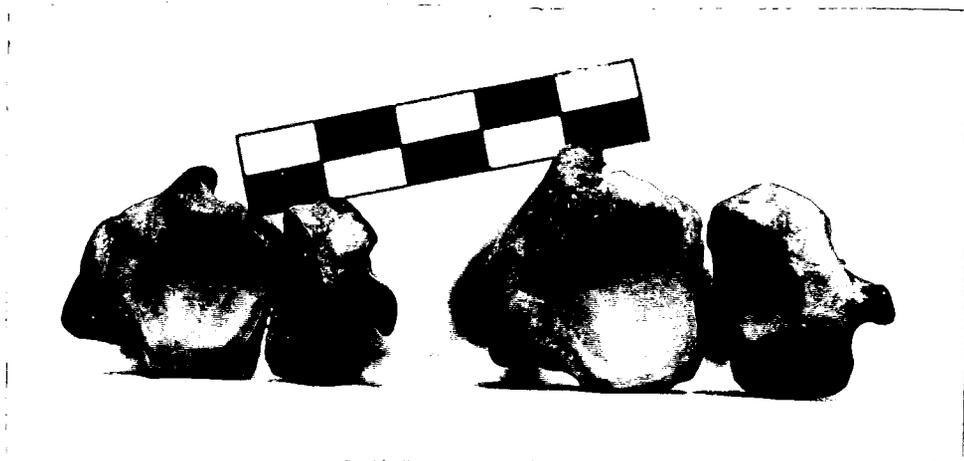
**Bearded seal—*Erignathus barbatus***

- ⇒ The ridge on the lateral surface of the proximal tibia is closer to the medial edge than in any other species.
- ⇒ Between the medial ridge and its lateral edge, the lateral surface of the proximal tibia is wider and flatter than in any other species.
- ⇒ The distal epiphysis is very rounded.
- ⇒ The bony “bulb” above the distal articular surface is skewed to the side, rather than positioned on the mid-line of the articular surface as in all other species (see the end-on illustrations of distal epiphyses). This bulb is also larger than in other species.

**Hooded seal—*Cystophora cristata***

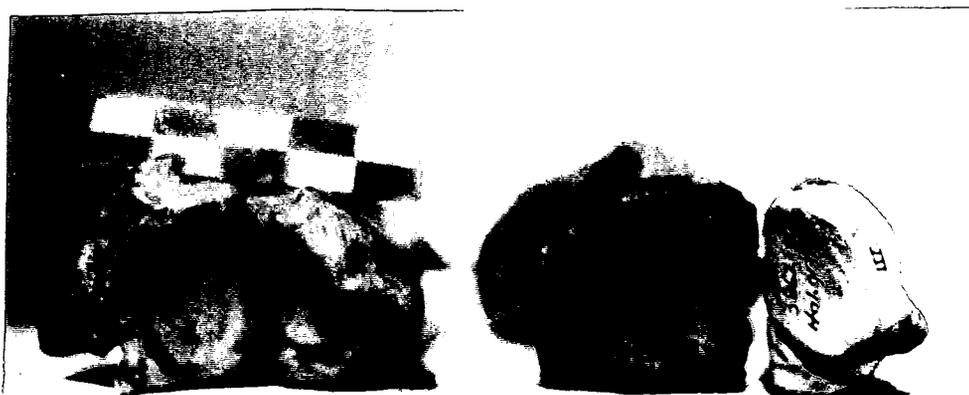
- ⇒ The tibia shaft overlaps in thickness with both *P. groenlandica* and *H. grypus*. It has a more pronounced curvature than in *H. grypus* but is easily confused with *P. groenlandica*.
- ⇒ The overall shape of the tibia’s distal epiphysis (viewed end-on) is rectangular. It is easily confused with *P. groenlandica*.





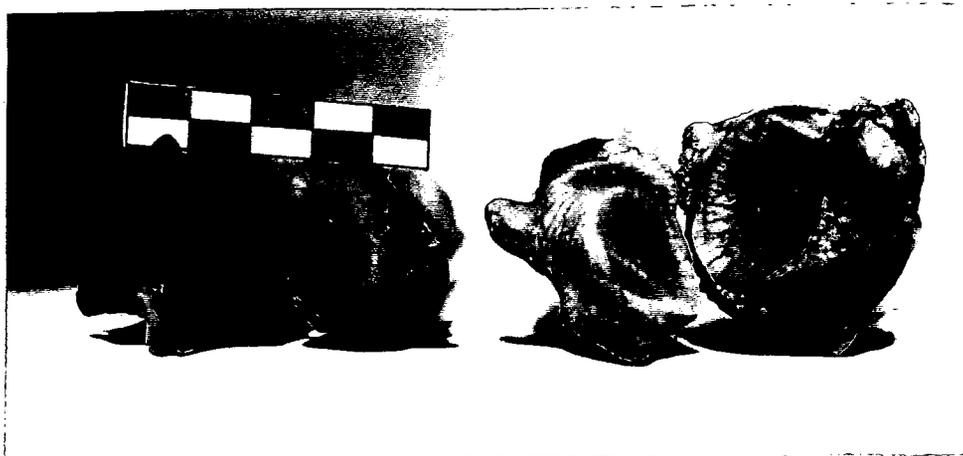
Ringed

Harbour



Harp

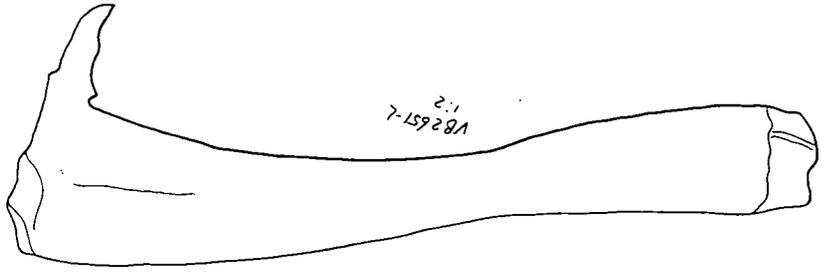
Grey



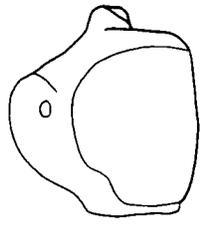
Hooded

Bearded

Harbour seal—*Phoca vitulina*

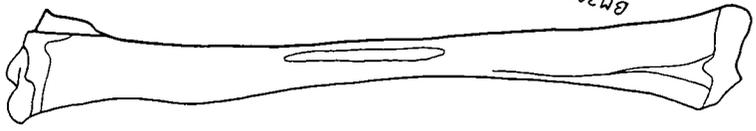


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1:2

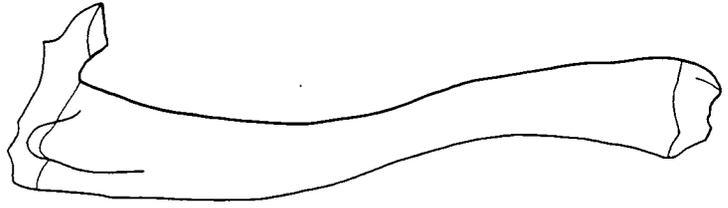


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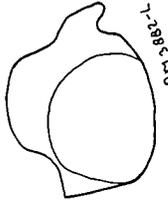
Ringed seal—*Phoca hispida*



BM 3882  
1:2

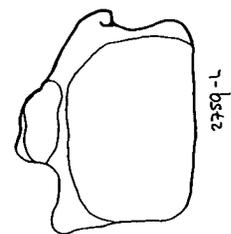
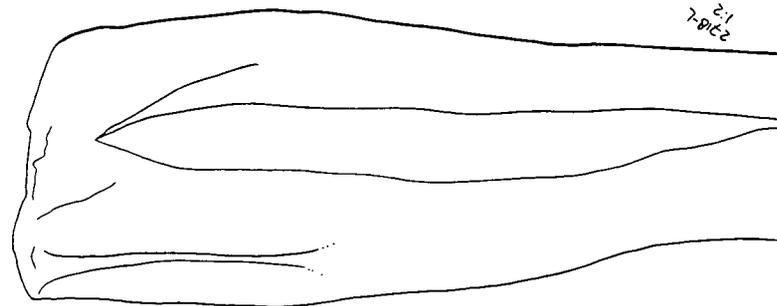


BM 1882-L  
1:2

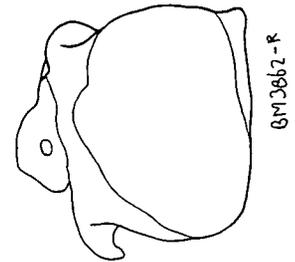
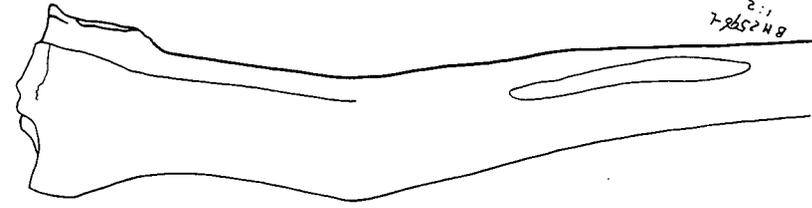
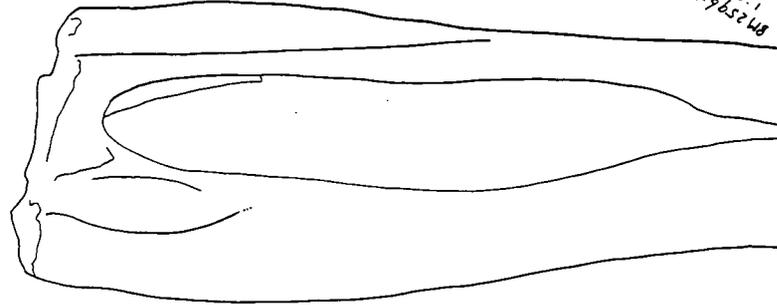


B 112882-L

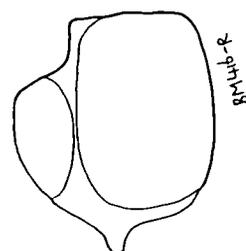
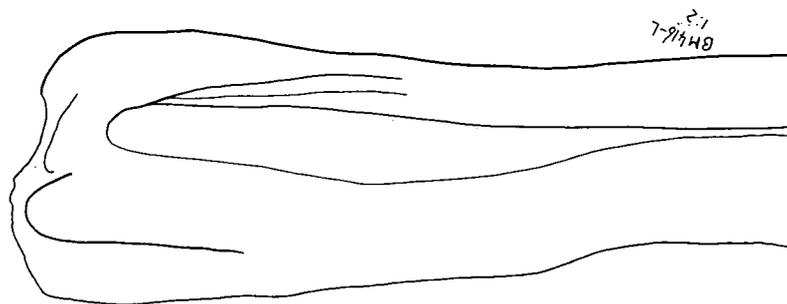
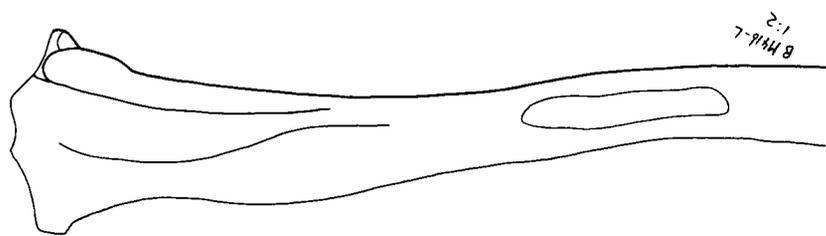
**Harp seal—*Phoca groenlandica***



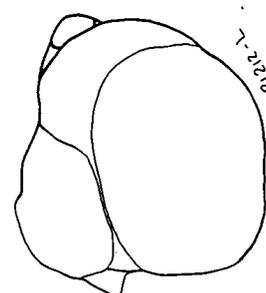
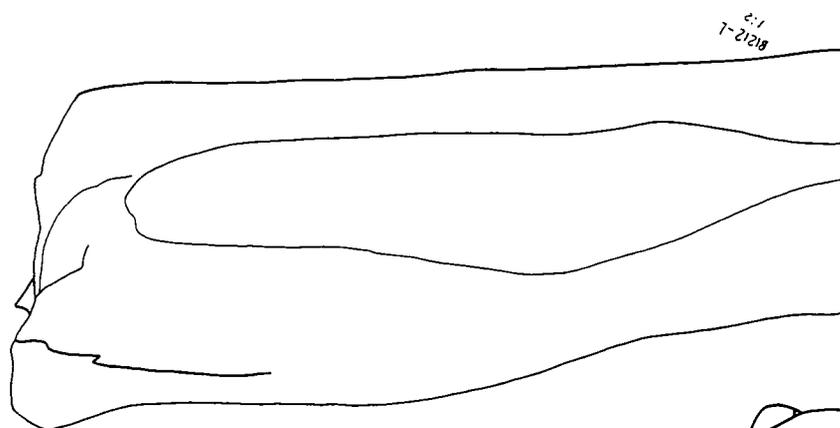
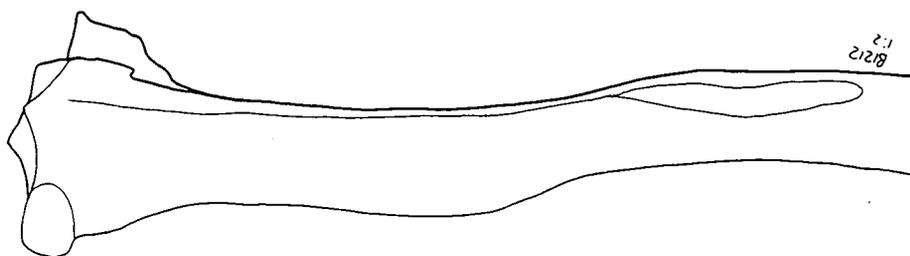
**Grey seal—*Halichoerus grypus***



Hooded seal—*Cystophora cristata*



Bearded seal—*Erignathus barbatus*



## B.9.2 Juvenile tibio-fibula

Except for *P. hispida*, the juvenile fibula is of little use in making species identifications. The overall shape of the tibia will distinguish between certain species.

### **Ringed seal—*Phoca hispida***

- ⇒As in *P. vitulina*, the tibia shaft is thin.
- ⇒The edges of the tibia shaft are sharper than in *P. vitulina*, producing a more angular cross-section, particularly at the distal end.
- ⇒The shaft of the tibia can be more curved than in *P. vitulina*.
- ⇒The fibula shaft has a rounder cross-section (it is quite flat in other species) and can have a more pronounced curvature than in any other species.
- ⇒The unfused epiphysis of the distal fibula is much taller relative to its width than in any other species.

### **Harbour seal—*Phoca vitulina***

- ⇒As in *P. hispida*, the tibia shaft is thin.
- ⇒The edges of the tibia shaft are more rounded than in *P. hispida*, producing a smoother cross-section.

### ***Phoca groenlandica*, *Halichoerus grypus* and *Cystophora cristata***

- ⇒All have thick tibia shafts relative to *P. hispida* and *P. vitulina*, but are very difficult to distinguish from one another.
- ⇒The tibia shaft of *C. cristata* tends to be straighter than in the other two species.

### **Bearded seal—*Erignathus barbatus***

- ⇒The tibia is extremely wide both proximally and distally relative to its shaft width.
- ⇒The unfused distal end of the tibia is larger and more square than in any other species.

# Tibia

Ringed

Harbour

Harp

Grey

Hooded

Bearded



# Fibula



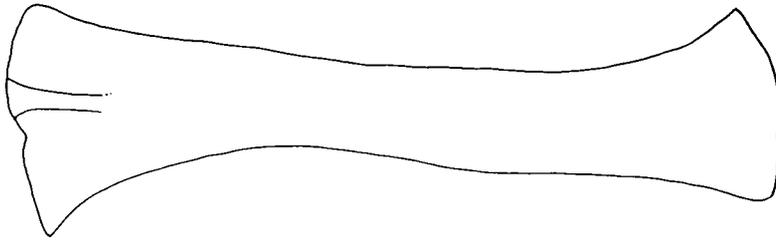
Ringed

Harbour

Harp

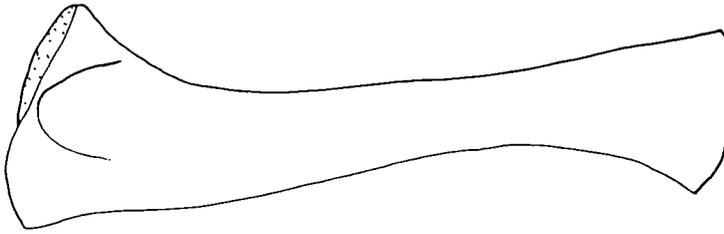
Grey

Hooded



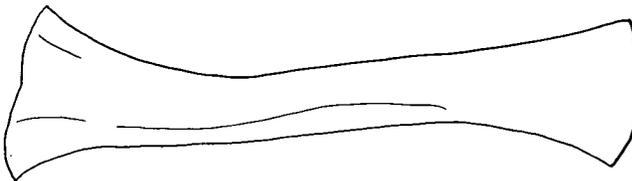
8115-R

**Harp seal—*Phoca groenlandica***



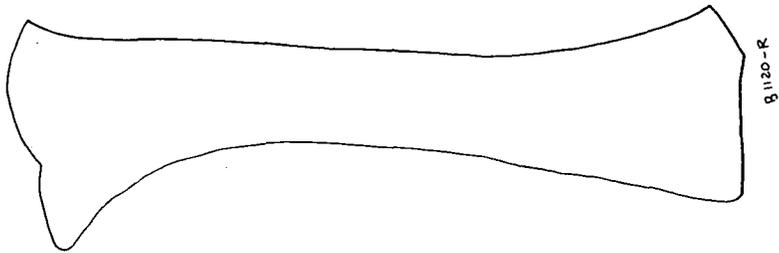
8094-L

**Harbour seal—*Phoca vitulina***



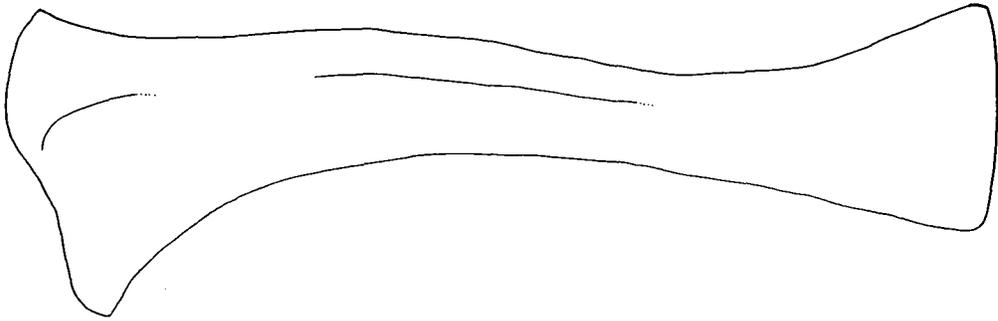
81143-L

**Ringed seal—*Phoca hispida***



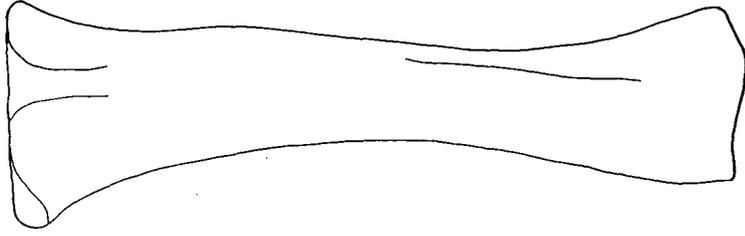
8 1120-R

**Grey seal—*Halichoerus grypus***



BM 4087-R

**Bearded seal—*Erignathus barbatus***



8 1171-R

**Hooded seal—*Cystophora cristata***

## APPENDIX C

### REINDEER TOOTH SECTIONS AND SEASON OF DEATH

The principle of determining reindeer season of death from tooth sections is the same as that for harp seal (see section 6.5.1). In the case of reindeer, both molars and premolars produce readable thin sections (Spiess 1976). As discussed in Chapter 6, seals develop a thin translucent band of dentine when they fast during the annual moult and a wider opaque band during normal feeding throughout the rest of the year. Reindeer produce a thin translucent band of dentine each winter when food is scarce, and develop an opaque band from late spring to early autumn when food is more readily available.

All loose reindeer molars and premolars from Gressbakken 3, 4 and 5 were thin-sectioned by this author. One molar or premolar from any mandible containing multiple teeth was also sectioned. Tore Fredriksen and Olaug Flatnes Bratbak assisted in preparing the teeth and mounting the sections. The teeth were decalcified in acid, frozen and sectioned longitudinally using a microtome at the Zoological Museum in Bergen. The thin-sections were then stained, mounted on slides and read under a microscope. As in the case of seal, season of death was determined by comparison with a modern reference collection of known season of death. Unfortunately, many of the teeth were in poor condition and produced sections which were difficult or impossible to read. Table C.1 therefore includes a measure of the level of confidence associated with each reading. Anne Karin Hufthammer, head of the Osteology section at the Zoological Museum, Bergen provided valuable assistance in reading the sections. All of the mounted sections are now stored at the Zoological Museum.

The tooth section data, displayed in Table C.1, suggests that the majority of reindeer hunting at Gressbakken Nedre Vest took place around the time of the spring migration. Ten out of the seventeen sectioned teeth from the site display fully developed translucent bands indicative of a late winter or early spring kill. A further four tooth sections suggest a late spring or early summer kill. Two tooth sections indicate a late summer or autumn kill and suggest that some hunting also occurred during the autumn migration. Only a single tooth section represents a mid-summer kill, and there are no indications of reindeer hunting during the height of winter.

**Table C.1** Season of death indicated by reindeer tooth sections from Gressbakken 3, 4 and 5

<b>Dentinal development</b>	<b>Corresponding season</b>	<b>House feature (at Gressbakken Nedre Vest)</b>	<b>Number of tooth sections</b>	<b>Level of confidence</b>
<b>Opaque band beginning to develop</b>	late spring or early summer	3	1	high
			1	medium
		4	2	high
<b>Medium opaque band</b>	mid-summer	4	1	high
<b>Fully-developed opaque band</b>	late summer or autumn (autumn migration)	3	1	medium
		4	1	low
<b>Translucent band beginning to develop</b>	early to mid-winter		none	
<b>Fully developed translucent band</b>	late winter or early spring (spring migration)	3	3	high
			2	medium
			1	low
		4	3	high
			1	low
		5	1	low

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