**Cut above the rest: A multi-disciplinary study of two slate knives from forager contexts in coastal Norway**

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**Summary**

Slate was a prominent tool material in the Scandinavian Stone Age. However, details of tool function have relied on morphology and has provided little to our understanding of their role in hunting and processing. Here, we demonstrate that it is possible to identify both the use-wear traces and residues from slate knives from northern Norway. By applying a multi-disciplinary approach incorporating experimentation, use-wear, and organic residue analyses, our analyses identified residues, including seal hair, and use-traces which indicate the tools were used to process fresh marine mammals.

## INTRODUCTION

Use-wear analyses of lithics are routinely performed on materials from many geographical regions and chronological periods throughout the globe. These studies are typically conducted on flint, chert, obsidian and similar microcrystalline materials. Here, we present the first such results from a pioneering study of slate knives from Stone Age northern Norway, based on a multi-disciplinary approach incorporating experimentation, use-wear and organic residue analyses.

Although we are confident that marine resources dominated the subsistence economy in the coastal region, , it is unclear for what purposes the many slate knives were used and how. Were they used for fish processing, seal butchering or hide preparation, for cutting, scraping or slicing, or as specialised or multi-use tools? Here, we demonstrate that a multidisciplinary approach can address these questions.

Two knives sharing similar blade morphology were selected for our analyses from artefactual collections held at the Arctic University Museum of Norway. They were examined microscopically for use-wear and the presence of surface residues, and the observations compared with an extensive experimental dataset. One of the knives was replicated through 3D printing and the copy was employed as an experimental tool. Lipids were extracted from the organic residues adhering to one knife and analysed using a combination of bulk carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope analysis, gas chromatography-mass spectrometry (GC-MS) and GC-combustion-isotope ratio-MS (GC-C-IRMS) to characterise the molecular and isotopic composition of the extracts. For further contextual information, subsamples of surface residues were also subjected to both radiocarbon dating and proteomic analysis. Unfortunately, both the radiocarbon dating, and proteomic analysis failed to yield diagnostic information (see Supplementary Information (SI)).

## PREVIOUS STUDIES OF SLATE KNIFE FUNCTION

For several millennia tools in coastal northern Norway were predominantly of ground slate, a sedimentary siltstone. Slate tools are also common in other circumpolar foraging contexts. Many can quite easily be identified as knives, projectiles, and other types of artefacts, but their specific function as hunting and processing tools has not been addressed in much detail.

Systematic use-wear analyses began during the 1980s, but the technique has rarely been applied to slate tools, especially ground slate knives, since it has been assumed that previous traces of use would have been destroyed in re-sharpening processes (Helskog 1983, 93). Residues have been largely disregarded for the same reason. While copies of slate knives have been used in limited experiments (e.g. Frink *et al*. 2003) and for educational purposes, we are not aware of any comprehensive published experiments, with the exception of Morin´s (2004) study comparing slate *ulus* to other types of knives for salmon processing. A few accounts show that straight single-edged knives worked well for cutting raw seal hide, whereas curved knives were superior when it came to flensing seals. Single-edged and double-edged knives both worked well for processing fish (Gustafsson 1978), however, several studies report that slate knives are not well suited to cutting through salmon skin and the backbone of larger fish (Frink *et al*. 2003; Morin 2004).

## THE KNIVES

An initial pilot study of ground slate tools from northern Norway revealed that use-wear marks and residues were preserved on their surfaces. The two knives selected for this study are both large, curved, and single-edged (Figs. 2 and 3).

One of the knives (Ts.10927) was found in a stream in Bårvik cove on Sørøya Island (Fig. 1). Although lacking precise provenance, other slate tools have been recovered from the same estate indicating the presence of a Late Stone Age site, possibly with multiple settlement phases between *c*. 5000 and 2000 cal BC. The knife is made of red-and-white banded slate. It has marked transitions between blade and shaft along both outer-edge lines and displays a low angle between blade and shaft. It is fully ground along the outer edges of the entire blade, but shaping fracture scars are retained along the medial (M) to proximal (P) part of the blade. Large fracture scars with step termination occur on the ventral (V) and dorsal (Ds) edges of the left and right edges at the distal end of the handle. The right edge of the blade has been sharpened to a fine edge and the left edge has been ground flat. The total length of the knife is 28.0 cm. The blade is 17.5 cm long and has a maximum width of 8.7 cm (Fig. 2).

The other knife (Ts.7314as) is a distal blade fragment of a green slate knife bearing strong similarities to the Bårvik knife blade. The fragment measures 10.0 cm in length and 9.1 cm in width. The right edge is heavily fractured along its entire remaining length. The left side retains an intact, ground and sharpened convex edge (Fig. 3). The knife was found during excavation at Iversfjord, Nordkyn Peninsula, 220 km northeast from Bårvik. The site consisted of three house pit clusters and a midden deposit. Associated archaeological finds included osseous remains, a high number of finished slate knives and points, fragments and preforms. Three radiocarbon dates from the Iversfjord midden fall around 4000 BP (4120 ± 50 BP (T-2485, on shell), 3910 ± 70 BP (T-2347, on shell), 4240 ± 100 BP (T-2881, on birch) (Helskog 1983, Table 3)). When calibrated, this provides a use-phase for the Iversfjord knife to *c*. 3000-2400 cal BC. Wear traces and residues were well preserved on both knives (Tab. 1).

## RESULTS

A multi-disciplinary series of analyses were performed on the Bårvik knife. The use-wear and residue traces on the Iversfjord blade fragment suggest similar overall use. Full details of the methodologies employed are outlined in the Supplementary Information (SI).

### *The Bårvik knife – Ts.10927*

*Wear traces.* Smoothing with polish is most accentuated along the right (R) edges and inner edges of the blade and is also very pronounced on the right distal (RD ) surface showing that this section of the tool was the primary focus for edge grinding and subsequent contact with the worked material (Fig. 4a). Polish and edge rounding also occur on the shaft, the most pronounced being on the right (R) and left (L) edges and R margin near the base of the blade. As well as very clear traces of linear striations from grinding on the tool surfaces, obviously stemming from tool manufacture and probably re-sharpening, there are small striations along the R inner distal (D) edge of the blade that are associated with residues (Fig. 4b). Some of these appear to be use-related, indicating that the tool had been used for cutting. The trailing edges of polish, asperities and residue on the Ds and V RD inner edges and margins are to the left (i.e. away from the cutting edge) showing that both surfaces were in contact with the worked material, the surfaces on the right side more so than the left. Such traces are suggestive of slicing and scraping. Edge bending fracture scars are most prominent along the RD-M edge (e.g. Fig. 4b). The majority have feather termination but some have slight step termination. Also most have initiation on the V side of the edge and, as shown by extensive experimentation using ground slate, this is indicative that the Ds face was in contact with the worked material more so than the V face. Several fracture scars along the V edge with initiation on the Ds side of the edge have step termination. These appear to be from crushing and may not be due to purposeful usage.

*Traces of residues*. Distinct reddish-brown deposits were observed around the Ds edges and margins of the blade, both L and R and also on the shaft (Fig. 2). Fewer residues occurred on the V surface and were concentrated around the D and RD margins. As with wear traces, the deposits were most pronounced along the DsD margin with the thickest residues on the R side of the tool. Under magnification the deposits appeared ‘greasy’ and cracked, typical of proteinaceous blood residues. Embedded within them were abundant hair fibres and animal tissue, including fat (Figs. 5a-c). Similar deposits, also embedded with hair fibres and fatty animal tissue, were distributed over much of the dorsal surface, including the shaft. The thickest residues on the shaft occurred on the base in association with polish and rounding (Figs. 5d-f) and on the LP surface. Animal tissue (cf. skin) was also compressed onto the surface and edges of the shaft. Bright metallic-like spots on the shaft associated with the M and P edge fractures are probably from contact with metal.

Analysis with transmitted light (TL) microscopy of the residue sample taken from the DsRM surface of the blade (see Fig. SI1 and Table 1) concurs with the *in situ* analyses, including the identification of hair fibres and torn animal tissue in the deposits. Particles derived from the sedimentary environment, including grass and sedge phytoliths, other non-diagnostic phytolith morphotypes and mineral particles were also identified. The other sample, taken from the central DsM surface of the shaft (see Fig. SI1), similar to that from the blade, consisted of torn animal tissue, animal fibres including hairs, although fewer than in the blade sample, and an abundance of skin cells.

*Identification of hair fibres.* One of the primary methods for identifying hair comes from the scalar pattern on their fibres. Although scales were visible with *in situ* microscopy, their morphology and patternation were not sufficiently distinctive to enable decisive identification. TL analysis offered an opportunity for better clarity, but many hair fibres were found to be degraded, having distinct tips, medullas and bulbs but less distinct scalar patternation, and therefore, insufficient morphological detail to identify them reliably. For many of the fibres, the shaft diameters were consistent with the underfur of both seal and reindeer although they were observed to be more seal-like when compared to modern hair samples. Several hair fibres, however, were well preserved. Some from the blade residue exhibited features very similar to harp seal hair (Figs. CL6a-c and CL7a-b) and others from the shaft exhibited features similar to both harp and harbour seal hair (Figs. 6d-e and 7c-d). Notably, there was no evidence in either sample for the very distinctive scalar morphology and patternation specific to reindeer hair fibres, in particular the distinctive guard hairs. Importantly, it should also be noted that as a cautionary measure, the hair identification in this study was undertaken prior to any knowledge specific to the archaeological faunal assemblages of the region.

*Experimental measuring of residue accumulation on replica knife.* An experimental plastic replica was comfortable to hold and use without any wrapping around the shaft. The highest accumulation of fat and blood residue on the blade occurred around the DsRD-M edge and margin (Fig. SI3). Hence, bearing in mind that it was held in the right hand with the Ds side downwards and in contact with the blubber, the distribution of residue deposits accords extremely well with the archaeological tool.

*Additional organic residue analysis.* Bulk $\delta^{13}C$ and $\delta^{15}N$ stable isotope data were obtained from the residues that were taken from the surface of the cutting edge of Ts.10927 (Sample 2; Lab no. Bå-2a+b; Fig. SI1). The sample yielded a $\delta^{13}C$ value of -26.0‰ implying that the residues are from an aquatic source and consistent with a marine environment. This value is similar to data obtained from carbonised surface deposits adhering to cooking vessels of the Säräisniemi 1, Sperrings 1 and Sperrings 2 Early Comb Ware pottery traditions in present day Finland (mean $\delta^{13}C$ = -27.3‰, $n$ = 20) (Mökkönen & Nordqvist 2019) – a geographical and temporal point of comparison given a lack of data from the study region. In contrast, a $\delta^{15}N$ value of 3.0‰ was obtained, which is lower than the threshold for processed aquatic organisms in cooking vessels (e.g. Craig *et al*. 2007). This may imply less protein in the residues supported by the lack of proteomic results - *contra* carbonised surface deposits formed through cooking. Despite this, the value is somewhat similar with the data obtained from the Finnish cooking vessels described above (mean $\delta^{15}N$ = 5.7‰, $n$ = 20) (Mökkönen & Nordqvist 2019). Lastly, the sample yielded a C:N atomic ratio of 20.0, which was higher than the Finnish cooking vessels (mean C:N atomic ratio = 11.1, $n$ = 20) (Mökkönen & Nordqvist

2019). This value implies a higher lipid fraction consistent with animal fats (see Heron *et al*. 2013).

Lipids were extracted (following Craig *et al*. 2013) from a second sample of residues (Sample 5; Lab no. Bå-5; Fig. SI1) located towards the centre of the blade. This extract yielded a lipid concentration of 2233.5 $\mu g\ g^{-1}$ which was above the minimum amount required for interpretation (i.e. >100 $\mu g\ g^{-1}$ for carbonised surface deposits adhering to ceramic vessels) (Evershed 2008)). In the extract, a range of unsaturated fatty acids were present ($C_{12}$-$C_{24}$), dominated by $C_{16}$ and $C_{18}$ indicating the presence of animal products in the residues (Regert 2011).

To detect compounds associated with aquatic products (e.g. Hansel *et al*. 2004; Evershed *et al*. 2008), the extract was analysed using a polar column operating in SIM mode. The extract, however, did not yield any *ω*-(*o*-alkylphenyl) alkanoic acids (APAAs) with 16, 18, 20, 22 and/or 24 carbon atoms. Since APAAs are formed during heat alteration of polyunsaturated fatty acids in the tissues of aquatic animals (Hansel *et al*. 2004; Evershed *et al*. 2008), their absence implies that the residues had not been formed through heating. Despite this, a range of isoprenoid fatty acids, including 4,8,12-trimethyltridecanoic acid, pristanic acid and phytanic acid, were identified within the extract, consistent with the presence of fats derived from aquatic resources. Further still, the extract yielded a *SRR*%, which is the ratio of the two diastereomers (SRR/RRR) of phytanic acid (Lucquin *et al*. 2016), of 83.1%, additional evidence for the presence of aquatic fats in the residues.

To distinguish the origin of the residues further, the extract was analysed by GC-C-IRMS. The extract yielded $\delta^{13}C_{16:0}$ and $\delta^{13}C_{18:0}$ values of -26.8 and -26.1‰ respectively, representing measurements made on the individual mid-chain fatty acids of palmitic ($C_{16:0}$) and stearic ($C_{18:0}$). These data are consistent with marine animal fats (Fig. 8).

Overall, the data lends weight for the presence of aquatic animal fats within the residues adhering to the slate knife. Since the composition of the residues is not consistent with prolonged heating, their presence implies that they likely formed on the slate knife during use of an uncooked aquatic animal, perhaps through skinning, flensing or butchery.

*The Iversfjord blade fragment – Ts.7314as*

*Use-wear and residue traces.* This piece exhibited traces very similar to Ts.10927, including use-related striae running parallel to the outer LD edge, rounding and smoothing of the L edge, polish and edge fractures. These concur with the tool being used for cutting/slicing and scraping fresh animal material. Deposits are mostly concentrated along the LDs margin but also occur on the middle and R margins of the Ds surface (Fig. SI2). They are sparse on the V surface. Blood, proteinaceous deposits, and fungal hyphae were observed under low magnification. Residues extracted from the LDsD margin yielded fibres, including hair fragments, torn animal tissue, including hide-like fragments and hyphae. Skin cells were also present but rare. The hair fragments exhibited similar morphology to those identified on Ts.10927, with scalar patterning aligning with seal hair, probably harp seal, but also similar to harbour seal (Figs. 6f-h).

## INTERPRETATION OF TOOL FUNCTION

Results from the optical analyses on their own provide compelling evidence that both tools were used to work soft, fresh animal material. Sufficient traces of wear on the tools' ground surfaces accord with a suite of experimental ground tools used for cutting/slicing and scraping, most likely in the process of skinning and flensing and, given the abundance of blood residue, they were likely to have also been used for butchering. The angle of use for Ts.10927 would have been primarily at *c*. 40-60$^{o}$ between the dorsal face and the worked material. This is indicated by the distribution and orientation of polish and smoothing on the distal surfaces, the distribution and initiation of edge fractures and the large accumulation of residues on the RDsD surface. Additionally, the shape of this particular piece as well as location and forming of the ground edges (i.e. sharp vs. blunt edges), imply that it was held by the right hand of the user. Notably, very strong support for this interpretation comes from the experiment with the plastic replica, which exhibited a matching pattern of residue distribution, including blood and fatty residues, indicative of the blade orientation during usage. Furthermore, the shape and large size of this piece imply it would have been well suited for working with the large, rounded body forms that typify marine mammals. The size and shape of Ts.72314as, together with similar wear traces, residue distribution and the residues themselves, indicate that this piece was likely used for a similar purpose, although details of manipulation during usage need clarification from a more detailed study of use-traces on cleaned surfaces.

Evidence for the tools being used for working with fresh (i.e., uncooked) aquatic marine mammals is strongly supported by the comprehensive suite of organic residue analyses employed in this study. Therefore, given the abundance of hair fibres, which accord with seal hair, and since there is no evidence to suggest otherwise, there is little doubt that the knives were used for processing seals, probably harp and/or harbour seals and possibly also other species of seal. It is also possible they were used to process other aquatic mammals, whales and dolphins for instance, but this has not been substantiated.

Further insight into tool handling comes from the shaft morphology of Ts.10927. The shaft, being very broad, was found to be comfortable to hold in the hand without a covering or being hafted; this was tested on the plastic replica. Most pronounced polish and edge rounding occurs on its basal R edge and margin where most pressure would have been applied under the knuckles and palm of the right hand, as well as its L basal edge where the thumb wrapped around the shaft. This also coincides with one of the thickest coatings of blood and proteinaceous deposits on the shaft. The thick coating of the same deposit on its LP surface also conforms to another pressure point from gripping while using the tool. The skin cells compressed onto the surface and edges are probably contaminated from recent handling of the tool. Notably, recent contact with a metal tool or another metallic instrument is also likely to account for the metallic traces observed on the shaft. On the other hand, the skin traces may well be intact residues from the original user's hands, which would imply that the knife was used without a haft. Notably, skin cells were not observed in the pipette sample taken from the blade and therefore the skin cell residues are unlikely to be from worked material. While blood residue might be expected to seep under haft material, it is less likely that hairs would make their way under a well-adhered haft (though further experimentation is needed to verify this). Therefore, given this assumption, it is likely that the hair fibres present in the shaft residues came from either the hide material used for wrapping or from gloves, possibly for the user's comfort or tool protection, or from worked material. Nevertheless, as they have been identified as being the same hair type as those found on the blade, the same animal source is most likely.

## GROUND SLATE AS A MARITIME SPECIALISATION?

In contrast to ethnographic evidence showing that slate *ulus* were used for processing a variety of animals, including the mass-processing of fish and for butchering both marine and terrestrial mammals (Frink *et al*. 2003), this study found no such evidence on the two knives. Instead, the analyses suggest that they were specialised tools, used for flensing and butchering marine mammals, exclusively or particularly seals. Given their large size and the time it would have taken to shape and grind them, they are likely to have been highly valued, especially since they could have been easily re-sharpened for extended usage. The visual similarities between the two large knives suggest a degree of contemporaneity based on traditional archaeological typological assumptions, and a general size reduction over time for slate implements has recently been suggested (Jørgensen 2021). However, despite the small sample size, the combination of evidence through our analyses finds strong support for the notion that slate knife morphology is related to function, and that size is more functionally than chronologically determined.

This study clearly demonstrates that seal hunting was one of the activities conducted from both Bårvik and Iversfjord. During the Stone Age, the Iversfjord dwelling site lay in a cove on an island, divided from the mainland by a narrow sound. The large knife fragment had probably originally been deposited in a midden by a house pit, together with numerous other lithic artefacts, including 29 slate knives, mostly fragmented. In addition, numerous polished or retouched fragments of unidentifiable tools, some of which are probably parts of knives, and at least eight pre-forms were recovered. A further eight knives found within the house pit could be the result of re-deposition of material from the midden into the depressed floor after the house was abandoned. The midden also contained a high number of fishing-line or net sinkers ($n$ = 53) and several slate points ($n$ = 13), providing evidence for multiple subsistence activities at the site, including marine fishing and marine and/or terrestrial hunting (Helskog 1983). Moreover, the unusually high number of knives, and especially the prevalence of pre-forms, suggests tool production was important at the site.

Some bone and shell were preserved in the Iversfjord midden core, providing us with a rare opportunity to compare our analyses results with actual faunal remains from the same context. Fish and particularly Atlantic cod (*Gadus morhua*), predominantly the stationary fjord cod, dominated the faunal assemblage, representing 96.3% of the entire sample according to the NISP data (NISP = 38,476). Mammals constituted 3.5% of NISP, of which sea mammals represented the majority, particularly seal (ringed (*Pusa hispida*), harbour (*Phoca vitulina*), harp (*Pagophilus groenlandicus*), grey (*Halichoerus grypus*) and unspecified seal). Porpoise (Phocoenidae sp.), unspecified whale (Cetacea sp.) and walrus (*Odobenus rosmarus*) were also present. Reindeer, which was probably locally available during summer and autumn before migrating inland, was relatively well represented at this outer coast site (NISP = 486) and made up the bulk of terrestrial mammals. Further, a small number of remains from other terrestrial mammals as well as a minor (0.2%) but varied bird bone component, dominated by sea diving auks, was recovered (Helskog 1983). Based on the faunal composition it has been suggested that the site could have been settled throughout the year (Helskog 1983, 82).

In line with our results, seal bones are well represented in the midden. Harbour seal, one of the possible species identified from the hair taxa analysis, was most frequent (NISP = 270) and would have been a year-round resource. Migrating harp seal, the other possible seal species, only visit the coast during winter and bones were least frequent in the seal assemblage according to species (NISP = 3). Despite the varied osseous assemblage, our results indicate species-specific seal processing for the large knife. The knife and knife fragment assemblage at Iversfjord, however, includes various shapes and sizes, something which may mirror use differentiation in accordance with the faunal variation.

Resource availability would have been similar in Bårvik where the other knife was found, although with more limited access to terrestrial mammals (Damm *et al*. 2021). The Bårvik cove is sheltered from the open sea but has short and direct access to rich and probably year-round marine resources in a wide bay. Fish, probably seals and possibly small whales could have been caught just outside the site. This combination of sheltered boat landings and short and direct access to marine resource areas represents a typical Late Stone Age settlement location in the region (Damm *et al*. 2021). As yet we have no support for specialised seasonal seal hunting at any of the sites, but seal hunting and processing was obviously one of the central activities, at least at Iversfjord.

## CONCLUSION

Results from our analyses demonstrate that use-related residues and wear traces can be well preserved on slate tools. Through a battery of different and complementary techniques it is possible to determine the function of individual artefacts. This provides hitherto unforeseen opportunities for investigating local resource use during the Late Stone Age in Fennoscandia and throughout the wider circumpolar region, where ground slate tools prevail. This also enables re-activating large collections of slate tools kept in the museums, including those with poor contextual information.

A key question related to specialisation concerns the distribution of ground slate knives versus projectile points in the larger Fennoscandian region. Both knives and projectile points are found along the northern Atlantic and western Bothnian coasts, but knives are less common in the inland and in southern regions. It has been suggested that this may reflect different economic specialisations, the knives being associated with possible extensive seal hunting and some whaling in the northern regions. This would also imply that terrestrial animal species were mainly processed using other types of tools. Our study has, for the first time, clearly demonstrated a direct link between the use of large slate knives and seal hunting, and also shows that the knives are well suited for working with seal, skinning and flensing in particular.

In our study there is close compliance between the results obtained via optical microscopy and the biomolecular analysis for the two examined slate knives. The molecular and isotopic evidence from the organic residue analysis likely indicates that the residues are derived from fresh aquatic mammal fats. This is strongly supported by the hair taxa identification to the species level (harp and possibly harbour seal). These data accord very well with the archaeological faunal assemblages, unknown to the analysts prior to both analyses. Furthermore, comparative experiments enabled the identification of wear and residue traces on the ground slate surfaces showing how the tools were held and which gestures were used. These are in accordance with skinning and flensing soft, fresh, large, rounded bodies typical of sea mammals, and given the abundance of blood residue, the knives were likely also used for butchering.

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**Supporting Information**

Additional Supporting Information on 1) optical microscope analyses of use-wear and residue traces, 2) comparative reference collections and experimentation, and 3) additional organic residue analysis of Ts.10927 can be found in the online version of this article at the publisher's website:…

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**Caption of table**

Table 1. *In situ* wear and residue traces recorded on archaeological tools Ts.10927 and Ts.7314as using low and high power reflected light microscopy. Abbreviations: ab = abundant, c = common, sa = soft animal. Ds=dorsal, V= ventral.

**Captions of figures**

**Fig. 1.** Map showing the location of the sampled slate knives, Bårvik situated at Sørøya and Iversfjord at Nordkyn. Basemap data: ESRI, Geodatastyrelsen, The Norwegian Mapping Authority, The National Land Survey of Finland and Airbus Defense and Space GmbH. (Map by J. E. Arntzen, UiT).

**Fig. 2.** Ts.10927 from Bårvik, Sørøya. The scale bar is 5.0 cm (photograph by C. Lentfer).

**Fig. 3.** Ts.7314as from Iversfjord, Nordkyn. The scale bar is 5.0 cm (photograph by C. Lentfer).

**Fig. 4.a.** Smoothing with polish and edge rounding along the RDsM edge of Ts.10927 (x10 magnification LP). **b.** Lineal striae parallel to the RDsM edge with residue and edge fracture scars (x50 magnification LP). Scale bars are 2 mm (photographs by C. Lentfer).

**Fig. 5 a – d.** Residue from the RD-M surface of the blade of Ts.10927 (x200 magnification HP). **a** shows cracked blood residue, tissue and small fibres, **b** blood, fibre and fatty tissue, **c** hair fibre with distinct bulb, embedded in cracked blood and **d** abundant tissue associated with polish. **e** – **f** shows residue from the shaft of Ts.10927: **e** fractured hair fibre embedded in residue coating (x100 magnification HP) and **f** bulb of hair showing a scalar patternation similar to seal hair (x400 magnification HP). Scale bars are 20 µm (photographs by C. Lentfer).

**Fig. 6.** Hair fibres in residue samples taken from the surfaces of Ts.10927 and Ts. 7314as (x400 magnification TL). **a – c** from Sample #1 from the blade of Ts.10927. **d – e** from Sample

#2 from the shaft. **f – h** from residue taken from the blade of Ts.7314as. Scale bars are 10 µm (photographs by C. Lentfer).

**Fig. 7** Examples of seal hair fibres (x400 magnification TL). **a** and **b** are from harp seal. **c** and **d** from harbour seal. Scale bars are 20 µm (photographs by C. Lentfer).

**Fig. 8** $\delta^{13}C$ values of the individual mid-chain length fatty acids ($C_{16:0}$ and $C_{18:0}$) obtained from Ts.10927 (Sample 5; Lab no. Bå-5). The data are compared with reference ranges, calculated at 95% confidence, from fats obtained from the tissues of modern authentic animals (Spangenberg *et al*. 2006; Craig *et al*. 2011; Craig *et al*. 2012; Lucquin *et al*. 2016; Pääkkönen *et al*. 2020; Courel *et al*. 2020) (figure by H. K. Robson).