Mesolithic Doggerland, where the points are small

A functional analysis of the small barbed bone points

Merel Spithoven

Source image on front: ‘8000 B.C.: After retreating inland from a storm, a group of hunter-gatherers in Doggerland return to find their camp flooded. Eventually there would be no dry land to come back to’ (www.nationalgeographic.com/magazine/2012/12/doggerland).

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A functional analysis of the small barbed bone points

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Preface

Over the past years I have looked at hundreds bone and antler points that were found on the beaches of Zuid-Holland in the Netherlands. In 2016 I finished my Bachelor thesis about these points and I was determined to write my Master thesis about them as well. Now, two years later, I have accomplished the latter. For this thesis I have focussed on the use-life of the small barbed bone points in order to make a reconstruction of their biographies.

I have made six experimental points, which improved my knowledge about the production process of these points. The shooting experiment conducted with these experimental points helped me understand how impact on the target influenced the wear and tear developing on these points. And finally, the use wear analysis under a stereomicroscope revealed very interesting new information about the use-life of the points.

I would like to thank everyone who helped me to finish this thesis. In particular, I would like to thank my friends and my supervisor Prof. Dr. A.L. van Gijn for all debates I could have with them about the thesis and all their feedback. Furthermore, I would like to thank the owners of the archaeological points from this research for lending me their points.

I hope you enjoy reading this thesis.

Merel Spithoven

Leiden, August 14, 2018

1. Introduction

Bone and antler points are found all over Mesolithic sites in Europe from Star Carr in England (Elliott 2009) to sites like Zvejnieki in Russia (Zhilin 2015). In the Netherlands about a thousand bone and antler points have been found, which is an exceptionally high number in comparison to other sites in Northwest Europe. All these points are being documented in one Access database made by the author (Spithoven 2016). The database now consists of 846 points made from bone or antler. The data of the first 400 points has been collected by Verhart (1986) and thereafter by the author (Spithoven 2016). The points originate from the North Sea and are mostly found on the beaches: Maasvlakte 1, Rockanje, Hoek van Holland, the Zandmotor and Maasvlakte 2. However, there are also some other find spots in the inland of Zuid-Holland, the most important of which is Pijnacker.

Finds from the coast are numerous because the beaches are being artificially maintained to preserve the Dutch coast. Therefore, a few times a year, new sand including these finds, is dropped on the beaches. This sand originates from certain sand suppletion areas in the North Sea which are appointed to a specific beach or building project on the inland. This makes it possible to track the actual find locations of the points (see Spithoven 2016).

One other find location can be found in the North Sea Basin at the Leman and Ower Bank. At the moment this is the only published artifact from the transitional period of the Last Glacial Maximum to the Mesolithic. It is a uniserially barbed antler point, also known as the Colinda point (fig. 1). In 1931 it was dredged up from the Leman and Ower Bank by a trawler ship named 'Colinda'. It has a length of 21.6cm, 18 barbs and some parallel incisions on one side of its base, which are suggested to have improved the hafting of the point to a shaft. The Colinda point was ^{14}C-dated to 11,740 ±150 BP (about 9,790 ±150 BC; Gaffney *et al.* 2009, 14-17). It was possible to dredge up this point because it was stuck in a lump of 'moorlog', otherwise it would have probably slipped through the fishing nets, like many other points.

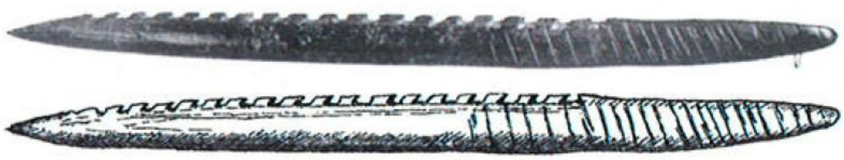


Figure 1: The Colinda point from the Leman and Ower Bank in the North Sea (Gaffney *et al*. 2009, 15).

Additionally, a lot of other interesting finds from the North Sea have been done as well, including other artefacts made from bone and antler, such as awls and axes. Furthermore, flint is also well represented although the amount in comparison to the artefacts of bone and antler differs per site. Flint artefacts mainly consist of flakes and blades but also scrapers, axes and even some flint points are represented (pers. comm. Niekus 2018). Additionally, some human remains from the Mesolithic period have been found and studied, which provide a lot of important information relevant for this research as well. However, most finds from the North Sea are fossils mainly from the Pleistocene era, such as mammoth, woolly rhinoceros, steppe wisent, deer, hyena and wolf. Smaller animal fossils are also being found more frequently like birds, rodents and fish. The archaeological context of this research will be discussed in chapter 3.

This thesis aims to answer the research question '*What was the function of the Mesolithic small (<88,5mm) barbed bone points from the North Sea and what does this contribute to our understanding of subsistence strategies of the inhabitants of the North Sea Basin?*' This introduction chapter will build up to the reason why this research question was chosen. Firsty, in section 1.1, the terminology concerning bone points will be discussed followed by section 1.2 which discusses the biography of bone points. Thereafter, there will be a short explanation of the stakeholders of these finds, in section 1.3. This chapter will conclude with the aim of this research and the further outline of the thesis, in section 1.4.

1.1 Terminology

In the literature of bone points different terms are being used for the entire point and for the different parts of the point. Therefore it is important to determine which terms will be used in this thesis. When talking about the entire point it will not be further specified to a projectile point, arrowhead, spearhead, etc. unless it is certain that it is this type of point. For example, in the next chapter the 'arrowheads' used for the experiments will be discussed. These experimental points were specifically made as arrowheads and thus can be called arrowheads instead of points. The inferred function of archaeological points could lead to a more specific term being used for certain points.

For the different parts of the point it is generally agreed upon calling the uppermost part the tip and the lowermost part (that was hafted) the base (fig. 2). Furthermore, the inner and outer surface of the point is being defined according to the inner or outer surface of the bone it was made from. For example, the inner surface can be recognized by the spongy tissue. Concerning the terms of orientation there are different opinions. For this thesis the most recent consensus of terminology will be used. The tip is called the distal end of the point and the base the proximal end. The part in between is called the mesial part. For this research only unilateral points will be discussed, meaning the barbs are only present on one side of the point. A barb can be defined as a 'laterally positioned piece'(Rots and Plisson 2014, 155).

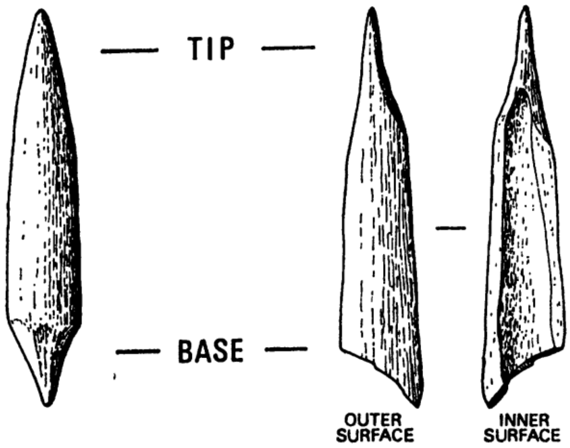


Figure 2: Terminology of bone points (Newcomer 1974, 141).

1.2 Biography of Small Barbed Bone Points from the North Sea

Objects have lives which can be reconstructed as biographies outlining different parts of their live, from raw material to deposition (Kopytoff 1986, 66). Reconstructed object biographies can be used to describe objects and thus determine how it was produced, what the object was used for, etc. Objects are constantly being transformed due to shifts of context, perspectives and use. However, they do not need to be physically modified or exchanged to acquire these new meanings (Gosden and Marshall 1999, 174). Objects also have a strong cultural and thus social component as well, which can also give new meaning (Kopytoff 1986, 89). The social component will only be briefly discussed in the discussion chapter of this thesis since it is not the focus of this research.

When studying bone artefacts it is important to keep in mind that it was once part of an animal. This means that it has gone through a lot of transformations before it became the raw material used by humans. The biography of artefacts made from bone begins long before humans become involved. Therefore the following sub-section will discuss bone as a raw material before going into the parts of the biography of the points when humans become involved: production, use-life and deposition.

1.2.1 Bone as Raw Material

The most important aspects of raw material are the properties and the availability. For bone the availability depends on the available animals in the environment. The bones used for the production of the points will (mainly) be from the hunted animals taken to the sites for food. However, different bones have different properties depending on their role in the animal's skeleton, which differ for each animal as well. Concerning the latter, the age and size of the animal are important factors. Bones from younger animals are generally more porous and thus weaker, which makes them less suitable for point production. Furthermore, the size of the animal also determines the length, thickness, etc. of the bones, which is interwoven with the design of the point. Bones can have different densities depending on the stress which the bone has to endure. Because the anatomy of animal species differs the density of the same sort of bone may be different as well. Moreover, there are different shapes of bones. Long bones – especially metapodials – are mainly preferred for the production of points because of the length of the bones and the fact that they can sustain impact along their long axis. However, these bones will break more easily when pressure is put in a transverse manner. Furthermore, metapodials have a suitable cross-section (rounded, square-shaped or D-shaped) and a groove down in the middle of the bone, which makes it easier to split the bone. Moreover, these bones are hollow inside and bone can be soaked in water to make it easier to work with (Hurcombe 2007, 124). These properties make metapodials well suited for point production. Verhart (1988) has suggested that these metapodials belonged to aurochs, horse, elk, red deer and roe deer.

It should be noted that the factors discussed above are not always seen as the most important factors for choosing a raw material. For example, the reason people chose a certain raw material also depends on their cultural traditions (Hurcombe 2007, 111; Ingold 2007, 12).

1.2.2 Production: Morphological and Technological Variation

The previous section presented the first step of the *chaîne opératoire* of the bone points. The second step is the production of the points which will be divided into different steps. In 2010, Tsiopelas presented his results concerning the points from the North Sea (Tsiopelas 2010). He studied the production traces through microwear analysis and experimental archaeology. For his study he looked at fifteen bone and antler points from the collection of the National Museum of Antiquity in Leiden. Eight of these points were made from bone, probably metapodium (Tsiopelas 2010, 23). According to

Tsiopelas there were not many traces visible on these points, but he managed to identify the different production steps which were carried out in order to make the bone points. He suggested that as a first step the 'metapodial technique' was used, one of the most common production techniques of the Mesolithic period. This technique was also used to produce awls. The natural groove in the centre of the metapodium was used to make an incision and split the bone. Thereafter the epiphyses were cut off. However, he also suggested that sometimes more opportunistic techniques might have been used, such as pounding on a bone with a hammer stone in order to break it into useful fragments (Tsiopelas 2010, 17).

As the following step in the *chaîne opératoire* Tsiopelas suggested that the points were ground into shape on a stone and that the barbs were cut with a flint blade. The manufacturing traces are present on the archaeological points in the form of striations which are directed parallel vertical, diagonal and horizontal (Tsiopelas 2010, 24, 47).

The eventual shape of the point and barbs differs and these different types of points from the research area are classified by Verhart (1986; 1988) and the author (Spithoven 2016). For this research the focus will be on the 'small barbed bone points' of which three types are identified (Spithoven 2016, 67). The small points have a length of <88,5mm as inferred from morphometrical analysis (Spithoven 2016, 43). At this time there are 787 small barbed points documented in the database of which most are made of bone. The smallest complete small barbed bone point found so far has a length of 28,9mm and was found at the beach of Rockanje (find number 14.56 in appendix A). Of all these small barbed points none has been dated with ^{14}C so far. There have only been six ^{14}C-dating of North Sea bone and antler points in total. Out of the six points that have been dated two are not further defined than 'point' and one is a small simple point (without barbs) which was much younger than the other points (Verhart 1988, 178; Hedges *et al.* 1990, 104-105; pers. comm. Van der Plicht 2016):

- Small simple point 6160 ± 135 BP; 5096 ± 165 cal. BC (CalPal) (Ua-643)
- Large barbed point 9945 ± 115 BP; 9539 ± 195 cal. BC (CalPal) (Ua-642)
- Bi-serially barbed point 9690 ± 125 BP; 9061 ± 184 cal. BC (CalPal) (Ua-644)
- Large barbed point, Maasvlakte 2, 8860 ± 55 BP; 8023 ± 184 cal. BC (CalPal) (GrA 59743)
- Unknown, Europoort, M-64, bone 8060 ± 250 BP (?) (OxA-1944)
- Unknown, Europoort, M-167, bone 8180 ± 100 BP (?) (OxA-1945)

On the basis of the results of typochronological research and the few available C^{14}-dates, it was suggested that the points date to the Early Mesolithic period. The dating of the only small point is regarded as contaminated (Verhart 1988, 178).

The three types of small barbed points defined by Spithoven (2016, 67) are points with an oval base, with long barbs, and with a square base. The oval base and square base types differ only in base morphology and the barbs were mainly cut with oblique incisions (see figure 3, shape type 2). The points with long barbs are oval in shape like the points with an oval base but the barbs were cut much deeper and with incisions in the shape of crosses (see figure 3, shape 5 and 6).

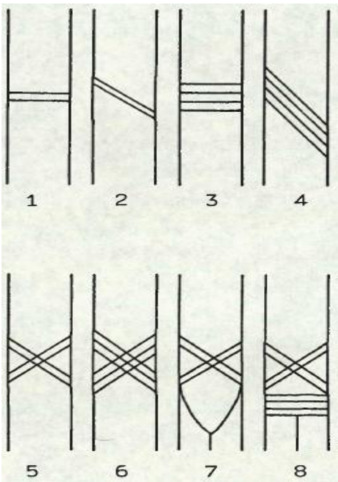
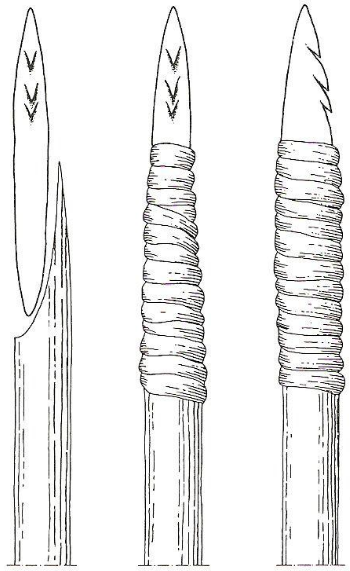


Figure 3: Shapes of incisions in order to make barbs, according to Verhart (1986, 167).

The shape of the points is important for the next step in the *chaîne opératoire*: hafting. The base of the points with an oval base as well as the points with long barbs were narrowed which created the oval form. This is common for projectile points and was done in order to reduce the thickness of the joint between the point and the shaft (Guthrie 1983). This led to the mesial part of the point having the maximum width and thickness of the point. This shape was meant to maximise the penetration of the point and avoid drag. The depth of the incisions to make the barbs plays a significant role as well.

After the production of the points they were hafted on wooden shafts. Verhart documented 434 points from the North Sea macroscopically and found impressions of bindings on nine complete points. Eight of them have impressions on the outer surface of the bone and one of them all round. For the points on which the impressions are located only on the outer surface of the bone, it is suggested that they were affixed to a bevelled shaft (fig. 4). This hafting method has been found at a number of other sites, such as Friesack in East Germany (Gramsch 1985, 62 in Verhart 1988, 183) and

Ulkestrup-Lyng in Denmark (Andersen 1951 in Verhart 1988, 183) (fig. 5). At the latter site no resin was used for extra fixation in contrast to the former (Verhart 1988, 183). At the time of writing this thesis four North Sea points with (possible) lumps of tar residue have been found and documented in the author's database.



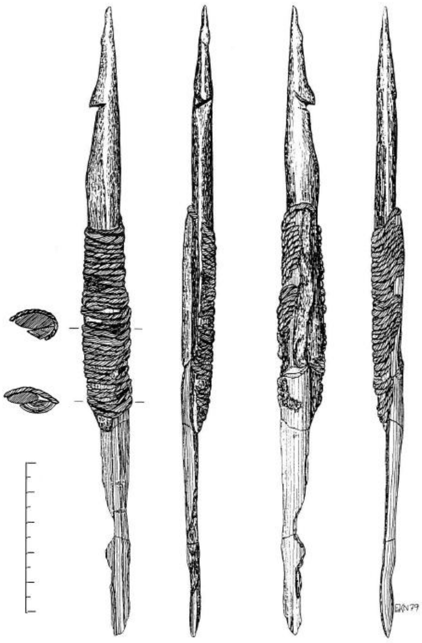


Figure 4: (left) A reconstruction of the hafting method by Verhart (1988, 183).

Figure 5: (right) A bone point with partly preserved shaft from Ulkestrup Lyng in Denmark (after Andersen *et al.*, 1982: fig. 58 in Verhart 2000, 120).

1.2.3 Use-Life: Function

After the production the use-life of the point starts which means it was going to be used for its intended function. Function is one of the possible explanations for the variety seen in the different types of points. This research aims to better understand the function of the small barbed bone points from the drowned Mesolithic North Sea area. However, the term 'function' requires some further explanation. It can be understood by studying the use-life of the point. Function depends on many different factors, such as the properties of the raw material, the efficiency of the shape and barbs, etc. Furthermore, it should be kept in mind that social interactions between people and objects can also create meaning (Gosden and Marshall 1999, 169). For example, the craftspeople of these points require certain knowledge about bone as a raw material in order be able to produce a point from it. This knowledge can be obtained by observing and experiencing how the material behaves (Hurcombe 2007, 105). There are many possibilities for the function of these points. In order to infer the function they should be compared to other points from the archaeological as well as the ethnographic record.

1.2.3.1 Arrowheads

Verhart (1987; 1988; 2000) reflected on the function of Mesolithic bone and antler points. For the hunting strategies he suggested that the animals could have been hunted in groups, but solo operations might have occurred as well. Evidence for hunting in groups consists of some archaeological finds of wounded aurochs in Danish bogs and Germany Vig, Denmark (Noe-Nygaard 1974), Prejlerup in Denmark (Aaris-Sorensery 1954 in Verhart 2000, 121) and Schlaatz in Germany (Gramsch 1987c in Verhart 2000, 121). For example, at the site of Prejlerup aurochs were found with many arrowheads still inside (Aaris Sorensery 1984 in Verhart 2000, 121).

Verhart narrowed the function of the points down to three categories. They were probably used as arrowheads, spearheads and on some occasions, harpoon heads. He suggested that the bow and arrow was used on big terrestrial animals, small terrestrial animals, birds and big fish. Spears were suggested to be used to hunt big terrestrial animals and big fish as well (Verhart 2000, 119-121). Harpoons could also have been used to hunt big fish. Furthermore, small terrestrial animals were probably hunted as well with the use of snares and small fish with the help of nets and traps (Verhart 2000, 121).

Additionally, Langley (2014) has speculated that a long tip on the point, which she calls the distal extremity or '*taille exceptionnelle*', could have been made for a specific function of the point. She suggests that the raw material might have been bigger than usual which made it possible to create a longer tip. This distal extremity might have served to penetrate the animal deeper in order to damage a vital organ (Langley 2014, 106). The longer tip could also have been made in order to prolong the use-life of the point. When the tip of the point gets damaged it needs to be repaired which decreases the length of the tip. When the tip is longer, it can be repaired more often.

For the North Sea points Verhart compared other Mesolithic sites around Europe with a similar landscape to the drowned Mesolithic Europoort area. This led him to conclude that the small barbed points were probably used as arrowheads and the bigger ones as spearheads which was later confirmed by Tsiopelas (2010). Tsiopelas performed shooting experiments with small barbed points as arrowheads and large barbed points as spearheads. The results of these experiments proved that the points could have been used in this way (Tsiopelas 2010, 37). However, it is also possible that the small barbed points were used as spearheads and vice versa (Bergman and Newcomer 1983). Tsiopelas (2010, 37) concluded from the results of his experiments – with replicas of North Sea points – that both small and large barbed points could have lethally wounded big sized animals. Verhart (1988, 185) suggested that the bow and arrow in the Mesolithic Europoort area would have been used to hunt small and fast animals. Especially the hunt of birds is suggested to have been important in this area (Verhart 1988, 189). The specific animals which could have been hunted will be discussed in chapter 3.

1.2.3.2 Other Interpretations

Besides the function of small points as weapon tips they are sometimes interpreted as child's toys (Politis 1998 in Langley 2014, 113; see Stapert 2007 for a discussion of miniature (flint) tools functioning as children's toys). Langley studied 732 Late Magdalenian barbed points from 18 different sites through France and Germany. She identified three small points as 'miniature points' (fig. 6) and stated: 'Only around 40 of the miniature points have thus far been recovered from Magdalenian sites and these artefacts appear to have a restricted geographic distribution, being found only in southern France and Cantabrian Spain (Gonzalez-Sainz 1989; Julien and Orliac 2003; Lefebvre 2011 in Langley 2014, 113).' These 'miniature points' seem similar to the small barbed points from the North Sea Basin, especially the type with long barbs. However, these points from the North Sea have been assumed to be from the Mesolithic period.

Langley also suggested that besides the interpretations of weapon tips and child's toys another function is possible. She suggested that the 'miniature points' could also have been examples of 'artisan virtuoso' by which she means that they were made in order to demonstrate the superior skills of the craftsperson (Langley 2014, 113).

Figure 6: 'Miniature points' from La Madeleine (left) and La Vache (middle and right) (edited figure from Langley 2014, 114, fig. 11).

1.2.4 Re-use: Curation versus Expediency

It is assumed that when the craftspeople made these points they had at least some thoughts about the anticipated use-life of the point in question. When studying the re-use of points the theory which Binford (1973) coined about the difference between curated and expedient tools is a useful one. The difference between curated tools and expedient tools is said to be the 'estimated utility for future use' (Binford 1973, 143). Expedient tools are anticipated to only be used for a short period of time whereas curated tools are anticipated to be used longer and are being kept and transported for future use (Binford 1973, 143). Binford observed the production and discarding of tools by the Nunamiut of Alaska (Binford 1979) and noted that the degree of the conscious stylistic variation is related to how expendable the tool in question is considered to be (Binford 1973, 144). An expedient tool, used and discarded at the same place, was produced with less investment of the craftspeople. This led to expedient tools representing less of the identity of the craftsperson and thus less conscious 'stylistic' characteristics of the craftsperson and group. For curated tools this works the other way around which leads Binford to the following statement: 'Thus I would anticipate that the best material markers of ethnic identity might well be found in items curated and preserved for relatively long periods of utilitarian life within the technological system.' (Binford 1973, 144). However, because curated tools are mainly used for a longer period of time, they will be less frequently represented in the archaeological record (Binford 1973, 144).

The distinction between expedient and curated tools cannot be made solely on the basis of a difference in technological complexity. Curated tools might as well be made with only a minimum amount of effort but will be maintained for a longer period of time and might even been recycled into a new tool (Binford 1976, 338). After Binford coined the terms in 1973 they have been used in many different interpretations of the terms. Shott (1996) redefined the term 'curation' by looking at these different uses. She stated that curation is 'the degree of use or utility extracted, expressed as a relationship between how much utility a tool starts with – its maxiumum utility – and how much of that utility is realized before discard' (Shott 1989, 24). This definition implies that the utility of a tool declines when it is used, which results in a certain degree of curation. According to Shott, every used tool is curated but the degree of curation differs. For example, an expedient tool can be seen as a tool with a low curation. Moreover, different contact-materials can result in a different degree of decrease of utility. For example, shooting a bone point in a fish or shooting it in a deer might result in a different degree of wear and thus a different degree of curation as well. This will be tested by conducting a shooting experiment (chapter 4).

In order to further clarify these terms some relevant examples will be provided. As a first example, some bone points might have been produced or finished at a hunting stand while watching for game. This practice used to be common among the Inuit (Binford 1979, 268). The second example derives from common practices of the Inuit as well. Binford noted that their personal gear was heavily curated (Binford 1977, 33). The personal gear was inspected before leaving camp, which resulted in repairing or replacing tools if needed. Bone points tend to break more easily when not repaired in time, which makes this case-study a good example of how these North Sea points might have been treated by their owners. When the tip of these points were repaired their length would decrease, which means a decrease in utility as well. The reparation of points might at times have resulted in big barbed points – which are assumed to be spearheads – being re-used as small barbed points – which are assumed to be arrowheads, when the utility of the point was at his end (Tsiopelas 2010, 46). As a last example, Zhilin mentions arrows from a Siberian ethnographic context gaining a higher value after they were used to kill an animal (Teploukhov 1880; Serikov 2009 in Zhilin 2015, 50). According to Zhilin these practices are probably applicable to the Early Mesolithic arrowheads as well. The arrows were treated with special care, which can result in better inspection of the arrow in order to repair it in time when needed. As a result, the arrow will gain a higher curation.

In the end it all depends on how people used curated and expedient tools in a specific situation, which is strongly influenced by cultural practices. This will also influence the discarding behaviours, which will be discussed in the following section.

1.2.5 Deposition

Which points will eventually end up in the archaeological record depends on many different factors. First of all, points were discarded intentionally. For example, when they were considered no longer usable. However, as discussed in the previous section the remaining utility of a point depends on the perception of the owner in question. This means that the archaeological record of these points might consist of points curated to a different degree. This results in an assemblage where the most heavily curated points are the least represented and the least curated points are overrepresented. Furthermore, as discussed earlier a big barbed point could be re-used to create a small barbed point. This way, the big barbed point will not enter the archaeological record, which might be an explanation for the overrepresentation of small points being found on the beaches of Zuid-Holland.

It should be noted that if points needed to be repaired this could take place in camp, but also in the field. Even points which were damaged beyond repair could have been taken back to the site for recycling purposes. This means that an assemblage of unusable points does not necessarily correlate to a site or hunting field (Binford 1977b in Torrence 1983, 12-13). These damaged or even unusable points might have been stacked at the camp or at locations in the field.

Groups of points have also been found in water, such as at Friesack in East Germany (Gramsch, 1987a, 1987b in Tsiopelas 2010, 38), in Horne Terp (Mathiassen 1937, 116 in Tsiopelas 2010, 38) and in Loejesmoelle in Denmark (Clark 1936, 114). It has been suggested that this was done in order to protect the points from the gnawing of dogs (Tsiopelas 2010, 38-39). However, the deposition of groups of points in water could also have been unintentional. They might simply be lost during the hunt when the arrow missed the target or the animal fled.

The assemblage of points which were lost in this way can be biased as well because of different functions of points and different values. The latter was explained in the previous section with a case-study about Siberian arrows that killed an animal. The influence of different functions of points is demonstrated by ethnographic research of the Agta of Northeastern Luzon by Griffin (1997, 281-282). He mentions that different types of arrows were meant for different prey species, prey sizes and the condition of the prey. This means that the arrows shot will be related to the hunted game. Furthermore, a distinction is made between the relative qualities of arrows, which influences the choice of the archer to take a shot at the prey or not. For example, a barbed point will not be shot when the chances are low of not being able to retrieve the arrow. This will result in the higher quality arrowhead being underrepresented in the archaeological record.

The length, thickness and number of barbs can influence the fragility of each point. When points are broken they will be less likely to be found on the beaches of Zuid-Holland, because they will be smaller and less recognizable for the collectors. This results in points which are more fragile to be underrepresented in the archaeological record. These broken pieces can be deposited in the field because they had been broken due to impact but could have been deposited at the camp as well. The pieces of the point which are being scattered on the ground after impact might have been collected and taken back to the camp by the owner. The part of the point which is still attached to the shaft after breakage could have been carried back to the camp still attached to the shaft or thrown away in the field. If only the distal part of the point remains, it will often not be usable anymore. Fragments of the point might also get stuck in the carcass of the killed animal. These pieces – mainly the distal or distal-mesial part – can be retrieved when the carcass is being processed, which occurred in the field or at camp. Afterwards, these pieces could sometimes be used to make a new point if the length of the fragment was deemed long enough. These fragments would then receive a new base produced from its proximal extremity (Langley 2015, 348-349). The breakages described above have been supported by experiments conducted by multiple authors, which will be further discussed in chapter 2.

As a final note on the deposition of points, it should be kept in mind that when points are being deposited they probably look different then when they were produced. The deposition of the points might not have been the fully intended use-life, which the craftsperson had in mind. Thus, the way points look when found 'only reflect state of abandonment rather than state of design' (Langley 2014, 110). Furthermore, post-depositional processes have also altered the points over a long period of time, which will be further discussed in chapter 2 and 5.

1.3 Stakeholders

Nowadays, these North Sea points are being found on the beaches of Zuid-Holland by private collectors, which mainly do not have any background in history or archaeology. They like to know what they have found and what value the artefact has, both in the sense of economical value, symbolic value and archaeological value. It is important that people know the archaeological value of the points they find and that archaeologists are interested in their finds. A research group has recently been set up to keep track of all these finds and to publish results of research done in association with these private collectors. The research group has been called 'Dutch Doggerland Research Group' (DDR) or in Dutch '*Werkgroep Steentijd Noordzee*'. This group consists of different institutions (Office of Antiquarian Research of Municipal Works Rotterdam (BOOR), National Museum of Antiquity in Leiden, The Cultural Heritage Agency in Amersfoort, foundation Stone) and volunteers, including the author. In order to come into contact with these private collectors the members of this research group visit the collectors at home or organize 'determination days'. These days are organized in cooperation with museums, such as Futureland (Maasvlakte 2) and Historyland (Hellevoetsluis). This way, the public is receiving 'edutainment' (education and entertainment combined) in the form of lectures and explanations of their finds. Papers like this contribute to the stories archaeologists are able to tell the public about their own archaeological collections.

1.4 Research Questions and Thesis Outline

The previous sections have been used to describe the method of reconstructing the biographies of the small barbed bone points, which is necessary to understand the research material. Even though the points have been studied by multiple authors (Verhart 1986; 1988; 2000; Tsiopelas 2010; Spithoven 2016) a lot of information is still missing. It is not clear yet why the points are morphologically and technologically different from Mesolithic points in the rest of Europe. This could relate to a difference in function, a cultural choice or a combination of both. The aim of this thesis is to research the function. With this research it is intended to contribute to a better understanding of hunting technology and subsistence strategies of the drowned Mesolithic North Sea Basin. This is important because it will not only give insight into their diet but also into development of social, organizational, planning skills, etc. (Brooks *et al.* 2006 in O'Driscoll and Thompson 2014, 399). The research question of this thesis is stated as follows: '*What was the function of the Mesolithic small (<88,5mm) barbed bone points from the North Sea and what does this contribute to our understanding of subsistence strategies of the inhabitants of the North Sea Basin?*'

This will be studied through use wear analysis – also referred to as microwear analysis or traceology – in combination with experimental archaeology. With this method it is possible to infer the function of the points based on the use wear present on the archaeological points in comparison to experimental counterparts. Although the Laboratory for Artefact Studies already had several experimentally made points (Tsiopelas 2010), six additional experimental points were made for this research to enlarge the experimental reference base.

In chapter 2 applied the method and how it can be used to study use wear on bone points will be further discussed. In chapter 3, the archaeological context – in particular the landscape, flora and fauna of Mesolithic Doggerland – will be further elaborated. In chapter 4 the shooting experiment which was conducted for this research will be discussed. The experiments will be described in detail followed by the results of the use wear analysis of the experimental points. For the experiments three different targets were used in an attempt to answer the following question: '*Is it possible to distinguish wear traces from shooting fish from those that develop due to hunting land mammals? If so, is it possible to distinguish these two types of traces on the archaeological small barbed bone points?*' For each target there was an experimental point which was intended to be shot only four times at maximum and one which was intended to be shot as many times as possible. With the results an attempt will be made to answer the following question: '*Is there a relationship between the number of times that the small barbed bone points were used as projectiles and the degree to which wear traces developed?*'

In chapter 5 the wear on a sample of archaeological points will be discussed. The use wear of the archaeological points will be compared to the use wear on the experimental points of chapter 4. Before the concluding chapter there will be a discussion in chapter 6 about the intended use-life of the points, the function of the points, the influence of social factors on the deposition, and the representativeness of this research. In the final chapter (7) an attempt will be made to answer the thesis's research question, the used methods will be reviewed and some suggestions will be made for future research.

2. Methodology

For the further study of the small barbed bone points a functional analysis has been conducted. Microwear analysis as well as experiments have been carried out. In this chapter the method of microwear analysis will be discussed, followed by an explanation why experimental archaeology is an essential component for answering the main research question.

Microwear analysis is a tool which can be used to answer research questions of archaeologists about form and function of implements, and the activities and tasks which have taken place on sites (Van Gijn 1990, 143). This functional data can help identify activity areas and highlight functional differentiation between sites (Van Gijn 1990, 143).

Archaeological experiments are necessary in order to conduct microwear analysis. Firstly, the experiments provide reference material or data in order to test hypotheses. Secondly, the execution of experiments will assist the archaeologist to become acquainted with the traces which occur during the process (Van Gijn 1990, 23). The archaeologist might start thinking of the artefacts in a different way and find new meanings of objects, which results in the archaeologist looking for other signs in the archaeological record. This way, the performing of experiments creates a link between evidence and interpretation (Hurcombe 2007, 65).

2.1 Microwear Analysis

Microwear analysis is the study of microscopic traces such as fractures, pitting, striations and polish. Residue analysis is often incorporated into the study because residue often occurs in association with wear traces (Hurcombe 2007, 87). Most often a stereomicroscope is used in combination with a metallographic microscope. A stereomicroscope uses reflected light with magnifications ranging between 10–160x and a metallographic microscope uses incident light, which allows magnifications of up to 1000x (Van Gijn 2005, 49; 2014, 166). However, most often magnifications of 200-300x at maximum are used. For the comparability of microwear studies it is essential to mention the specific microscope and magnifications that were used (Van Gijn 1990, 12).

Cleaning procedures are also an important factor in the study of microwear. Cleaning is mainly conducted by soaking the object in (warm) water (and a detergent). Additionally, finger grease is removed with alcohol (Keeley 1980, 181; Van Gijn 1990, 11).

Furthermore, the registration of the wear traces should be documented in a universal way. The use of symbols, terms and abbreviations should be comparable to other microwear studies.

2.1.1 History of Microwear Analysis

Microwear analysis is a relatively new method within the discipline of archaeology. In 1964 Semenov's book '*Prehistoric Technology*' – which was originally written in 1957 in Russian – appeared in English. Semenov was the first researcher to systematically execute experiments and regularly employ a microscope. The first publications outside the former USSR took place in the mid-1970s by Tringham and Keeley (Tringham *et al.* 1974; Keeley 1974). Tringham mostly studied edge-damage in the form of micro-retouch. This study was done with magnifications of up to 100x and is now commonly referred to as the 'low-power approach'. Keeley on the other hand, was focussed on other aspects of use-damage, such as polish. For this study magnifications of 100-400x were being used. In the following two decades the first use wear studies on bone tools were conducted (Campana 1980; LeMoine 1994; 1997), and from the second half of the nineties onwards high power approaches were used as well (Griffitts 2001; Griffitts and Bonsall 2001). It had become clear that due to experiments certain traces of wear (polish, rounding, striations, abrasive features and chipping) would appear rapidly on bone and antler tools. However, these traces could be confused with manufacture traces which are very visible as well. Additionally, taphonomic processes could also create or transform traces (Van Gijn 2005, 49).

Microwear analysis has had its ups and downs in archaeology. In the period from 1975 until 1985 microwear analysis was used with still little knowledge and expectations were unrealistic. This period was followed by a period of rejection and pessimism from 1985 to 1990 when the limitations of the method became clear. Presently, these limitations – which will be discussed in the last section of this chapter – are gradually accepted and microwear analysis is becoming increasingly important in archaeological research projects. However, there is still some scepticism about the validity, trustworthiness of observations and conclusions resulting from this method because it can still not fully be explained how wear traces develop. There is too much variability in human behaviour to always allow specific functional inferences (Van Gijn 2014, 168).

2.1.2 Reference Collections

The study of microwear requires proper reference collections. There are many variables that are of influence on the development of wear traces, such as the characteristics of the raw material, contact-material, motion and skill. These factors all determine the appearance of wear traces. Ideally, the raw material used for the experimental artefacts should come from the same source as the archaeological raw material itself (Van Gijn 1990, 14). The source of the raw material can be determined by the means of reference collections. Reference collections can be published work or physical reference collections (Hurcombe 2007, 76). Use wear analysis mainly makes use of experimental artefacts as a reference.

Generalized experiments – in which variables such as raw material, form of the tools, type and state of the contact-material, intensity and direction of motion are controlled – form the basic reference collection (Van Gijn 1990, 24). For example, when looking at craft activities the motion of a tool is regular, which results in a certain type of use wear. The variation of this use wear can be an indication of intensity of use, which could be used to infer the function of a tool and the contact-material. However, it is possible that the combination of features observed on the artefact is not present on an experimental tool from the reference collection. In this case, new experiments need to be carried out.

In order to come to solid interpretations of the use of an artefact the archaeological context is crucial (Van Gijn 1990, 25). Ethnographic sources can provide a source of inspiration for the possible function of the artefact (Van Gijn 1990, 24). Furthermore, the reference collection needs to include natural samples of the material as well, because of the taphonomic processes which may have affected the tool (Van Gijn 2005, 49).

2.1.3 Features of Microwear

With these reference collections at hand, the archaeological artefacts can be studied under a microscope. When objects are used they can become damaged and develop characteristic features. The object's biography can then be reconstructed by observing these features and linking them to manufacture, hafting, use, re-use, and post-depositional factors. Sometimes the intensity of use can be inferred as well.

The worked material is often graded in categories of hardness: soft, medium, hard and some categories in between. It should be noted that these features are never presenting a certain use and do not always develop on the object when it was being used (Van Gijn 1990, 3). It is hard to infer whether a tool was unused because if the tool was only used for a short period of time or worked with very soft materials this might not leave any (recognizable) traces on the tool (Hurcombe 2007, 87). Furthermore, the surface can be affected post-depositional by natural as well as human factors.

When bone points were used for hunting, most use wear can be found on the tip of the point (Frison 1989; Bradfield 2012a; b). These traces include edge-removals (or use-retouch), breakage, fractures, edge-rounding, striations, polish and residue, which will be further discussed below. There are use wear traces which can be used to infer maintenance work as well, which can be associated with the tool being curated. Maintenance traces will be discussed below as well.

2.1.3.1 Edge-removals

Edge-removals are features which are hard to distinguish from damage caused by usage and damage caused by other factors. There are various ways in which this type of fracturing can occur. For example, the usage of the object and retouching of the edge of the object can lead to (unintentional) edge-removals. The micro-chipping of the object is in this case a by-product of the retouching. Furthermore, micro-chipping can also occur when the object is being excavated, sieved, transported or bagged together with other artefacts. Finally, the object can also be fractured by non-intentional factors such as trampling, falling on a hard surface, transport and soil compaction (Olsen and Shipman 1988; Pargeter and Bradfield 2012; Bradfield and Brand 2015). These different factors often result in different types of edge-removals on the object. Bone can also be flaked when the density is sufficient (Hurcombe 2007, 134). Furthermore, as illustrated with flint tools, there is a lot of variability in flake-scar morphology, location and distribution as well, which makes interpretation even more difficult (Van Gijn 1990, 4).

2.1.3.2 Breakage and fractures

As discussed above, breakage and fractures on bone can have many natural causes, which makes it more difficult to interpret use wear. However, by looking at edge-rounding and the preservation state of the surface it is possible to infer if the breakage or fracture occurred pre- or post-depositional (trampling, accidental dropping, etc.) (Pargeter and Bradfield 2012; Bradfield and Brand 2015).

Use wear fractures on projectile points are mainly caused due to the impact on a hard material. The raw material (bone) from which the point is made will have some parts where it is weaker which causes the fractures to form along already existing fissures (Lawn and Marshall 1979). The impact on a hard material can cause chipping on the dorsal and ventral surface of the tip of the point, which may eventually lead to the breakage of the tip or the upper barbs.

The type of fractures depends for an important part on the morphology of the point, especially the relative length and shape of the cross section, as was demonstrated for flint points (Bergman and Newcomer 1983, 243) as well as bone points (Bradfield 2016, 74). The type, position and grouping of fractures can be used to infer the function of the point, as was demonstrated for stone points (Bergman and Newcomer 1983; Fischer *et al*. 1984; Lombard 2005). For example, at the rock-shelter site Ksar Akil in Lebanon 79 bone points have been found where use wear consists solely of breakage and fractures. The use wear on these points consists of traces of splintering on the tips and/or bases (Newcomer 1974, 147). Tyzzer (1936) inferred the function of these traces by conducting a shooting experiment with bone points as arrowheads, which were shot into gravel. At another site, in central Russia, bone arrowheads were found at the Early Mesolithic sites of the Volga-Oka interfluve from the layers Ivanovskoye 7 (layer IV) and Stanovoye 4 (layer IV and layer III, trench 3). The use wear on these points is mainly present on the tips in the form of smashing or chipping and small or larger flat or semi-flat facets running down one or more sides of the point. These traces were also present on the experimental points created for this research, which were shot at a target of peat covered with fresh wild boar skin (Zhilin 2015, 44).

Additional to the minor damage caused by splintering or chipping, breakage of the point into two pieces is possible as well. Recently, Langley (2014) posted a doctoral study of 732 'intact' antler barbed points and fragments of antler barbed points – intact meaning the distal, medial and proximal part were all present – from 18 sites located in France and Germany. The wear on antler points is quite similar to that on bone points, which makes it an important research to mention in this thesis. Langley noticed that most of the bilaterally barbed points had their distal part broken off due to use. This was inferred from the presence of impact fractures on the distal and proximal ends of the points (see fig. 7). The types of fractures consisted of bevel, splinter and cleavage fractures which on some points were combined with wear such as mushrooming, chipping, crushing and rounding. Some points show fractures due to post-depositional processes (Langley 2014, 108). These examples are also applicable to bone points similar to the points used in this thesis and therefore make a good reference study.

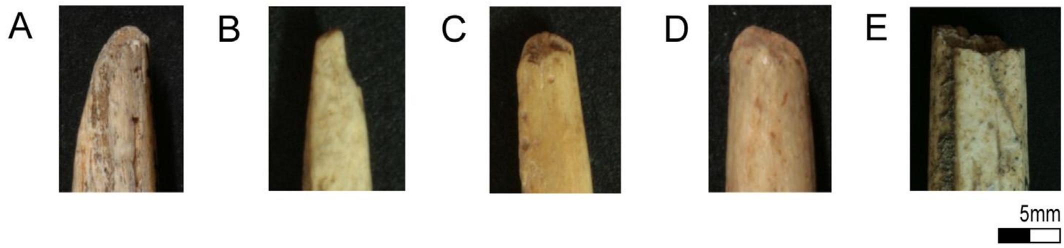


Figure 7: Examples of impact and post-depositional fractures to the distal tip of antler projectile points according to Langley: (A) Mushrooming; (B) Chipping; (C) Crushing; (D) Rounding; and (E) Post-depositional fracture (Langley 2014, 108).

2.1.3.3 Edge-rounding

Another feature which develops on the edge of objects due to use is rounding. Edge-rounding is caused by contact-materials with different degrees of wear. The degree of edge-rounding can thus provide an indication of the kind of contact-material on which the object was used. When identifying edge-rounding, hardness categories of contact-material are useful. For example, soft contact-material such as leather causes extensive edge-rounding on bone tools. As illustrated with flint tools, the different degrees of rounding can also indicate which area was the contact surface (Van Gijn 1990, 8). For example, from the previously discussed sites in central Russia – the Volga-Oka interfluve – the majority of bone points with use wear from the layers Ivanovskoye 7 and Stanovoye 4 showed rounding. These traces were also present on the experimental points from Zhilin's research (Zhilin 2015, 44). Furthermore, it should also be noted that edge-rounding, just like edge-removals, is not always due to use. As illustrated with flint tools, edge-rounding can develop when the object is embedded in a sandy matrix (Van Gijn 1990, 8), which is also the case for the points of this research. Therefore, most of the points from the North Sea are very rounded. Edge-rounding also makes it possible to infer if breaks are pre- or post-depositional, such as the breakage of the tip or barbs.

2.1.3.4 Striations

It is generally assumed that striations are the result of the use of an object when abrasive particles between tool and contact-material are present. As illustrated with stone tools, the distribution and orientation of striations which appear on the object provide an indication of the kinematics involved (Vaughan 1985, 12). For example, at the sites of the Volga-Oka interfluve in central Russia, two types of striations were observed on the bone arrowheads that were found. These striations were mainly fine and sometimes coarse and can be used to infer if the arrow was fletched (Zhilin 2015, 44). For example, when the arrow was fletched it rotated when it hit its target, which resulted in screw-like traces. On the contrary, when the arrow was not fletched and thus was not rotating when it hit the target, the use wear appeared as straight striations on the point. Nevertheless, there was also a point found with both types of striations present. Screwlike striations overlap straight striations, which was seen by Zhilin as an indication of re-use. He suggests that the point was first used on an unfletched arrow and re-used on a fletched arrow after repair (Zhilin 2015, 49-50). The different types of striations were also present on the experimental points of his research (Zhilin 2015, 44).

Furthermore, on the North Sea points randomly oriented striations are present, which are probably caused by depositional modifications after they had been discarded (Tsiopelas 2010, 24).

2.1.3.5 Polish and Residue

Polish is one of the features which has been the subject of many discussions about its origin. An aspect of polish which everyone seems to agree on is that polish on bone can be recognized as a surface which reflects light. For example, bone can have dense areas which can be polished with a grinding stone, to create a lustrous surface (Hurcombe 2007, 134).

On the bone arrowheads from the sites of the Volga-Oka interfluve in central Russia, use wear was present in the form of 'hide polish' on the tip, running down the point and gradually disappearing. This was also replicated on the experimental points, which were shot at a target made of peat covered with fresh wild boar skin (Zhilin 2015, 44). For example, at Ivanovskoye 7 (layer IV) a fragment of a long, needle shaped arrowhead was found with a bright polish, which gradually becomes duller when running down from the tip to the stem of the point. Two types of use wear are visible in the polish: fine striations and coarse grooves. These traces run down at an acute angle from the tip of the point to the axis. It is inferred that the fine striations are the result of multiple hits on soft material covered by fine mineral particles, such as animal skin or clothing. The coarse grooves are inferred to be the result of the point hitting the ground (Zhilin 2015, 44-45). This is indicated by the location of these grooves. To illustrate this, at another point from this layer these grooves did not appear further than two centimeters from the tip. This also means that the point did not penetrate the ground very deeply (Zhilin 2015, 46).

At the site of Ksar Akil in Lebanon, five bone points with blackened tips or bases – interpreted by Newcomer as a result of intentional fire-hardening – were found (Newcomer 1974, 147). From Zuid-Holland five points have been found with macroscopically visible residue. Three of the points have a lump of black residue on the base of the point. The lumps of residue are only present at the inside of the bone. Two of the points with the black residue have been found on the beach of Rockanje and one has been found further inland in Pijnacker where sand from the North Sea was used for construction work. The black residue was assumed to be tar or pitch, which was being used to fasten points to shafts (O'Connor *et al*. 2014, 115). However, it is also possible that the residue is post-depositional. There is also a point found at the Maasvlakte 2 beach with still cordage and black residue left on the base of the point. These residues have been studied for this research. The results are discussed in section 5.3.

2.1.3.6 Maintenance

The last type of traces of importance when looking at use wear traces on bone points are traces left by retrieval, re-sharpening and rejuvenation of the point. Sometimes points will get stuck in the bones of the animal, which results in accidental 'nicking' of the point. This nicking can create short, oblique and isolated incisions which are located on the surfaces of the distal-mesial section of the point. These traces are called 'retrieval marks'. 'Haft retrieval marks' are created in the same way and are created during the process of repairing or retooling when the point is being cut away from the haft (Langley 2015, 346-347).

In order to infer the maintenance of a point different traces can be used. The most important ones for barbed points are traces as a result of re-sharpening or rejuvenation. Re-sharpening of the point means that a (dull) part was being retouched in order to create a fresh, sharp cutting edge at the tip or barbs (Hayden 1987; Towner and Warburton 1990). Rejuvenation on the other hand, means that the (broken) point was reworked into a new point with the same function. Most of the maintenance traces of barbed points are located at the tip of the point. Additionally, maintenance sometimes took place on the mesial part of the point (Langley 2015, 350).

Maintenance of a point could create striations. These striations may be difficult to distinguish from manufacture traces caused by shaping the point because the striations share many characteristics. What makes them distinguishable from manufacture traces is the fact that they overlap the manufacture striations and that they are not – as manufacture traces – present over the entire surface of the point. The maintenance striations can vary from faint and thin to deep and coarse. The former is usually associated with better quality repair, which – in contrast to the poorer quality repair – results in a symmetrical tip with a smooth surface (Langley 2015, 347). The less expertly repaired points were suggested to be rejuvenated. Additionally, maintenance traces consist of localised facets, uneven surfaces, and a significant axis change (Langley 2015, 350).

Experimental work has shown that even little damage on a bone point can lead to breakage of the entire point. The most dangerous damage on a bone point is impact damage to the tip and fractures on the base section where it is hafted (Tyzzer 1936; Arndt and Newcomer 1986; Bergman 1987; Knecht 1997; Langley 2015). Since the damage to the point makes it more likely to break, it is likely that the users of points would have repaired damaged points in order to decrease the chance of failure (Langley 2015, 346).

Furthermore, barbs were sometimes repaired as well or (partially) removed, sometimes leaving a slightly raised scar. If barbs are repaired more expertly, they remain finely shaped with only a few and/or fine striations. On the contrary, poorer quality repairs will result in coarse and roughly made barbs (Langley 2015, 346-347). It is suggested that damaged barbs were (partially) being removed because of the increased chance of failure of the point. This was inferred from damaged tips of points which caused the point to break more easily, as demonstrated with experiments. However, it was not tested whether damaged barbs have the same effect (Langley 2015, 352).

2.1.4 Sampling

In order to come to proper conclusions about the function of the small barbed bone points from the North Sea Basin, an assemblage of these points was selected. It was not possible to study all small barbed bone points because microwear analysis is a very time consuming method. Time and money restrictions will influence how many objects can be studied. This means that the sampling of the research collection and the sampling of the objects themselves should be done with utmost care (Van Gijn 1990, 10). If the sampling of objects is mainly focused on the expected function of the tool these expectations influence which objects are chosen for the research and sometimes even which areas will be looked at. Because of this it is essential that the researcher mentions why they have chosen for a certain sampling method and what this is based on (Van Gijn 1990, 11). The sampling will take place on a macroscopic level or with the help of a stereomicroscope. A stereomicroscope can be used to observe the macroscopic traces of use and manufacture and the identification of residue (Van Gijn 2005, 49). Because of the large visible area of the object, a stereomicroscope can be used to relatively rapidly conduct microwear analysis on the objects and determine which areas show the most wear and if there are any residues present. Therefore, washing and cleaning of the objects with alcohol should take place after the sampling of the objects with the stereomicroscope. Sampling with a stereomicroscope forces the researcher to observe the entire object, which makes it less likely to miss traces. Afterwards, the sampling could continue under higher magnifications for the areas where wear and/or residue is present (Van Gijn 2014, 167). A metallographic microscope can be used to examine polish and microscopic striations (Van Gijn 2005, 49). This high power approach requires a lot of time because the metallographic microscope commonly uses magnifications of up to 300x. In order to examine the entire surface of the object it needs to be positioned exactly at a 90º angle to the source of light for the traces to be visible (Van Gijn 1990, 10).

For the sampling of the assemblage of this research, a first selection was made of small (<88,5mm; Spithoven 2016, 43) barbed bone points that are complete (the distal, mesial and proximal parts are present). Thereafter, the assemblage was filtered on points which have not been treated with any chemical preservative. Finally, the assemblage was filtered on the degree of weathering: deselecting the ones which seemed too weathered for microwear analysis were filtered out. The final assemblage for microwear analysis for this research came down to 29 points.

2.2 Experimental Archaeology

Experimental archaeology is inevitably linked with microwear studies and is a method which tests hypotheses related to specific archaeological problems. If the hypothesis is falsified the hypothesis must be discarded and replaced by a new hypothesis, which will then need to be tested. If the hypothesis turns out to be valid this does not make the hypothesis 'true'. It means 'that the principles behind the hypothesis can continue to be used until falsified and replaced by a better set of principles' (Popper 1959 in Outram 2008, 1). However, experiments can exclude certain possibilities, which will result in less possible interpretations (Van Gijn 1990, 24).

There are laboratory experiments and actualistic experiments. The former are experiments within a controlled area in order to better understand scientific principles. Actualistic experiments make use of potentially authentic materials and conditions in order to test hypothetical scenarios (Outram 2008, 2-3). This way, actualistic experiments are able to give tangible data on practical matters (Hurcombe 2007, 65). Reynolds (1999, 158-162) defined experimental archaeology in five major classes:

construct; processes and function experiment; simulation; eventuality trial; and technological innovation.

For this research an actualistic experiment into the function of the small barbed bone points from the North Sea was carried out, which will be further discussed in the following subsections. The documentation of the experiment is of crucial importance because the experiments must be replicable by the researcher and others as well. Furthermore, the experiment needs to be performed in such a way that the results may be assessed statistically (Reynolds 1999, 158).

2.2.1 Hypotheses

This research started out with three hypotheses, which needed to be studied before the final research question could be answered. The first hypothesis is: Shooting small barbed bone points in fish creates different wear traces than shooting these points into land mammals. This hypothesis will be tested by shooting experimental points at three different targets: salmon, meat covered with deer skin, and meat with fresh bones covered with deer skin. Afterwards, the following question will be answered: '*Can we distinguish wear traces from shooting fish from those that develop due to hunting land mammals? If so, can we distinguish these two types of traces on the archaeological small barbed bone points?*'

The second hypothesis is stated as follows: On the Mesolithic small barbed bone points from the North Sea Basin there is a difference in degree of wear traces. It is expected that points can be assigned to different categories based on the degree of use wear traces. Five categories can be made according to degree of use wear. Category A consists of no use wear, category B and C of little wear. The wear traces mainly include edge-removals, breakage, fractures, edge-rounding and striations. In category B, the point is still considered usable, meaning that there is no damage which will likely cause the point to break. In category C, the point is no longer considered usable because of breakage and/or damage that will cause the point to break when used again. Category D consists of points which are still considered usable but with a lot of wear, and category E consists of points which are no longer considered usable and show a lot of wear. The difference between 'little wear' and 'lot of wear' will depend on the differences of wear developing on the experimental points. In this research these five categories of degree of wear will be defined as follows:

A. No wear

B. Little wear but still usable

C. Little wear and unusable

D. Lot of wear but still usable

E. Lot of wear and unusable

The third hypothesis states: Mesolithic small barbed bone points from the North Sea Basin can be divided in expedient and curated points based on these five categories of degree of wear. If there are groups of points belonging to a certain category (or multiple categories) then these points can be inferred to be expedient or curated. As a result of testing hypotheses 2 and 3 the following question will be answered: '*Is there a relationship between the number of times that the small barbed bone points were used as projectiles and the degree to which wear traces developed?*'

2.2.2 Outline of the Experiment

In order to test the hypotheses and answer the questions stated above, a shooting experiment was set up. Bone was chosen as type of material for this research because of the larger amount of archaeological points made of bone from the research area. For the experiments one small barbed bone point of the most common type of small points was chosen: small barbed bone point with an oval base (Spithoven 2016, 67). One point of this type was chosen as an example to make the experimental points. The point was found at the beach of Rockanje by Peter Soeters (find number 14.4 in appendix A). The point is 53,1 mm in length, 9,5 mm in width and 4,7 mm in thickness. It has a narrowed barbstrip and the barbs have been made by oblique incisions (the most common shape of incisions (type 2 in fig. 3)). The point was desalted by lying into clean water and not treated with any chemical preservatives. Six experimental replicas – as similar to archaeological poin 14.4 as possible – were made.

In order to answer the question about degree of wear at least two points were necessary per contact-material (fish, meat or meat with bones) resulting in a minimum of six experimental points. The experimental points were made from a metatarsus of a red deer because in Mesolithic Northwest Europe most bone points were made from deer metapodia (Bailey and Spikins 2008, 112, 163; Dickson 2001, 436-437). From the deer metatarsus six pieces had been sawn with a modern metal saw, as close to the actual size of the original point as possible. The six pieces of bone were ground on a modern brick with sand. Different parts of the brick were used depending on the roughness needed. The smoother sides made it easier to hold the piece of bone, which was necessary at the start of the grinding. The rougher parts of brick made the grinding process quicker and were mostly used. Furthermore, it was necessary to differentiate between the different ways of grinding and holding the point to make it possible to grind for a longer period of time. The thinning of the blank took most of the time. During the shaping some issues occurred. Some points have bone splinters in their structure and not all of them could be ground to a smooth surface. Furthermore, during the shaping process the tip of experimental point 3644 chipped. This was corrected by grinding a new tip.

After the shaping of the points, the part of the point where the barbs were going to be cut was narrowed by grinding it. This was done on the front and back of the point. The grinding of the points required some experience to become more efficient. The first point took about one and a half day to grind and the last one took about four hours. Therefore, it can be inferred that the production speed increases when the person becomes more experienced. Unfortunately, the tips of experimental points 3642-3645 needed to be further sharpened than initially thought – which extended the grinding process – in order to be able to penetrate meat and bone. The tip of experimental point 3642 chipped multiple times resulting in a relatively large loss of length in comparison to the other points (appendix B).

After the shaping of the blanks the barbs were cut with flint flakes and blades. The flint became blunt quite fast but remained sharp enough to continue cutting. It was difficult to keep cutting in precisely the same place, which resulted in damage around the incision in the form of manufacture striations. Another issue was the distance between the barbs. It was hard to locate where to cut the barbs in order to make it the same as the original point, a process which improves when the craftsperson becomes more experiences. Mainly due to the problems discussed above, the experimental points are not all as good a replica of the original point as was hoped.

Before the experimental points were hafted they were photographed to document the production wear, and to create 'before-use' photos. Photos have been taken of the four sides of the point with a Nikon D5100 camera. A metallographic microscope and stereomicroscope were used to make photos of the manufacture traces and of locations where use wear was expected. The manufacture traces were quite similar on all the experimental points. Divergent wear was photographed as well, such as bone splinters or accidental incisions. When taking photos with a stereomicroscope and using light from one direction, the wear became much more visible. The photographing of the tips was the most difficult because of the roundness and therefore the difficulty of getting the point in a 90 degrees angle with the light from the microscope. This could sometimes be improved by using the program 'Helicon Focus' to build an image out of multiple photos.

After the documentation was completed, the experimental points were hafted as suggested by Verhart (fig. 4) as tips on pine fletched arrows and shot with a Polderweg-model flatbow (Louwe Kooijmans *et al.* 2001, 385). Some measurement equipment was necessary for the documentation, including: a thermometer, a ruler for measuring the distance between the target and the archer and the depth of penetration of the arrow into the target, and a geo-triangle to measure the angle of impact. Photos and videos were made of the arrow hitting the target and of the arrow inside the target. Furthermore, a pocket microscope with a magnification of 60x was used to observe use wear traces during the experiment.

Two types of experiments were conducted on three different types of contact-material. The targets were a complete salmon of about 4,5kg, an artificial target made of pork chops (without bones) covered with deer skin, and an artificial target made of pork chops with fresh cow bones covered with deer skin. For each contact-material, the first experimental point was shot only four times at maximum in contrast to the second experimental point, which was shot as many times as possible. This way, it was attempted to create an expedient point and a curated point.

2.3 Use Wear Analysis

After conducting the shooting experiment, 29 archaeological points were taken to the Laboratory for Artefact Studies of the Faculty of Archaeology in Leiden. All points had already been desalted after they had been found at the beaches of Zuid-Holland. These points have not been treated with any chemicals. Before the use wear analysis, the assemblage was further sampled on the weathering state of each point, as explained in section 2.1.4. Furthermore, some points had to be observed more closely to determine if the raw material was bone or antler. Only the bone points were selected for the final assemblage.

The use wear analysis started with the documentation of the macroscopic traces, followed by the wear analysis under the stereomicroscope. For the least weathered points it was also possible to use the metallographic microscope. The experimental points from this research as well as the existing reference collection of bone points from the Laboratory for Artefact Studies were used for the comparison of the wear traces.

The experimental points were also used to infer the degree of wear according to the categories stated in section 2.2.1.

2.4 Limitations

When conducting microwear analysis and experimental archaeology it is important to know the methods their limitations. First of all, as explained in this chapter, both microwear analysis and experimental archaeology are very time consuming methods. With microwear analysis this could result in traces being missed because of the lack of time and because of pre-conceived ideas of where wear will be present.

Secondly, there are many uncertainties in the interpretation of wear traces, which is also limited by the available experimental collection. For example, polish and residue are sometimes difficult to distinguish and post-depositional processes can produce the same wear traces on objects as usage, as was illustrated by experiments conducted with flint tools (Van Gijn 1990, 20; Rots and Plisson 2014, 158).

Thirdly, usage sometimes does not produce (sufficient) wear traces. For example, on bone points spin-off fractures provide an indication of longitudinal impact. This wear can infer the function of the point being used for the hunt. However, this type of wear does not always develop on bone points even though they were used for the hunt. Therefore, it is important to use multiple criteria for inferring the function of an artefact (Bradfield 2016, 76). For example, ethnographic and ethno-historical research can support interpretations and provide new views on possible functions (Van Gijn 2014, 166).

Fourthly, the experimental collection may not be large enough to encompass the variability of wear. The experimental basis could be too weak to support the wear analysis, which could result in false interpretations. Furthermore, within the studied assemblages there are often only a few examples of characteristic impact features even though there are many implications based upon these. Additionally, methods which have not yet been tested are often suggested (Rots and Plisson 2014, 154).

Fifthly, the lack of expertise of the researcher might result in unrealistic traces (Van Gijn 1990, 26).

Sixthly, most experimental tools will only be used on one contact-material and a certain mechanical motion. In the past these artefacts might have been used for a variety of activities and might also have been re-used, re-sharpened, stored, transported, intentionally destroyed, etc. (Van Gijn 2014, 167). Maintenance traces on bone points, for example, strongly resemble manufacture traces because these activities are carried out with the same tools (Langley 2015, 345).

And finally, the compatibility of microwear analyses also causes limitations. For example, because there is no consensus between microwear analysts on how to clean the experimental tools (Van Gijn 2014, 167).

For projectile points in particular there are some additional problems. There is a great variability of extrinsic and intrinsic techno-functional parameters. The latter is related to the design of the projectile, such as shape, hafting, and weight. Extrinsic parameters are related to the conditions of use, such as projecting mode, target material, target distance and the environment. Furthermore, it is often not possible to create a repetitive motion for a certain amount of time because the projectile can become unusable after only a few shots, as was demonstrated by experiments with stone points (Rots and Plisson 2014, 155-156). This also results in a great variability of wear traces on the point, namely different types, dimensions and combinations of wear (Rots and Plisson 2014, 156). This also means that a series of identical points hafted and shot in the same way show great variation between the individual points. Thus, it is not possible to infer the function of a point from certain wear traces on an individual point (Rots and Plisson 2014, 155). Some bone points may have rounded tips and edges which make it difficult to infer a function (Arndt and Newcomer 1986; Buc 2011). A series of points needs to be studied in order to make proper conclusions about their use (Rots and Plisson 2014, 156). Another important problem concerning use wear analysis on projectile points is the fact that the contact-material and the incidence of the contact are very variable. The contact-material can be soil, rocks, trees, flat bone, curved bone, hide, flesh, etc. and the incidence of the contact can be perpendicular, under an angle or tangential. These factors may all create different wear on the point (Rots and Plisson 2014, 155-156).

Microwear analysis in combination with experimental archaeology is a very useful method for the study of archaeological problems. Some questions about function can only be answered by using this method. Microwear analysis is less of a 'hard science' than most people think. When considering all the uncertainties and limitations discussed above, microwear analysis can be seen as an interpretive archaeological method (Van Gijn 2014). Microwear analysts should be clear about this in their correspondence with other archaeologists and in their final reports. Most of these uncertainties will probably never be fully resolved because they derive from human activities, which can be carried out in an infinite number of ways. The artefacts can be re-used and this might never be discovered as part of the object's biography by the means of microwear analysis because those traces are not visible (anymore) on the archaeological artefact. Presently all efforts which have been made at quantification and standardization have not been able to acknowledge the complexity and diversity of human behaviour (Van Gijn 2014, 168). However, the observation of traces results in interpretations of use, which can answer broader questions about the site from which the artefact originates. The results of microwear analyses also provide the information needed to compare different sites with each other. Finally, the study of microwear is an ideal method for the reconstruction of *chaîne opératoires* and object's biographies.

3. Mesolithic Doggerland

The North Sea Basin was part of Europe in the Mesolithic period and this part of Europe was named Doggerland by Coles (1998 in Coles 2000). This chapter contains background information on Mesolithic Doggerland because the points originate from the North Sea Basin along the coast of Zuid-Holland (fig. 8). Firstly, section 3.1 will discuss the evidence and theories which can generally be applied to the Mesolithic of Northwest Europe. Thereafter, in section 3.2, the focus will be on Doggerland specifically which will start with a section about the preservation of the Mesolithic layer. Thirdly, in section 3.3, the changing landscape during the Mesolithic and how people might have responded to sea level rises will be discussed. Fourthly, in section 3.4, the flora and fauna of the landscape – including the people's diet – will be outlined. Finally, in section 3.5, the non-homogenous responses of the inhabitants of Mesolithic Doggerland will conclude this chapter.

3.1 The Mesolithic Period in Northwest Europe

The Mesolithic period in Northwest Europe is generally assumed to have taken place from the beginning of the Holocene about 9,600 BC until about 4,000 BC when the Neolithic period starts with the introduction of farming (Milner 2012, 223). At the beginning of the Mesolithic period, humidity and temperatures rose rapidly marking the end of the Last Glacial Maximum. The open grass steppe of the Late Paleolithic changed into an open birch and pine forest with lakes and marshes. The fauna changed as well and a community of warmer temperature species appeared (Amkreutz *et al.* 2018, 23). The Mesolithic period is characterized by a broad-spectrum exploitation of animal- and vegetable resources, which will be further discussed in section 3.4. There is a great variability in settlement location and site types and a repeated use of specific places (Peeters and Momber 2014, 57). For example, locations next to large lakes and dunes are assumed to have been preferred as either "central places" or "persistent places" (Barton *et al*. 1995; Crombé *et al*. 2011, 466). During the Mesolithic period the mobility decreased and the populations seem to have increased because of the improvement of the climate and landscape (Peeters and Momber 2014, 58).

The changing landscape and climate probably affected people differently at different locations within Doggerland. Therefore, homogeneity of human behavior should not be assumed (Lovis *et al.* 2006, 175). For example, the material culture – such as points – can be influenced by a change of flora and fauna, because other type of points might have been needed for the hunt. Furthermore, the changing landscape might also create new barriers resulting in the loss of contact with other groups, which might have resulted in different material cultures as well (Ballin 2017, 329).

Figure 8: Doggerland Reconstruction with the red dot marking the find location of the points from this research. After map by William E. McNulty and Jerome N. Cookson, National Geographic Magazine december 2012 (www.nationalgeographic.org/maps/doggerland).

The Mesolithic period is seen as a transitional period from the cold Paleolithic period to the warm Neolithic period. Additionally, there is a transition from hunter-gatherers to farmers. The changing climate and landscape forced people to adapt during the Mesolithic period (Kitagawa *et al*. 2018, 193). Some strategies might have changed and others might have continued, such as settlement locations and hunting strategies (Kitagawa 2018, 206).

People living in Mesolithic Doggerland adapted to these changes, which resulted in a change in behavior and material culture. It has been proposed by Clark (1936) that Doggerland might have been the core of the Northwest European Mesolithic and that it probably contains one of the most complete records of the Holocene. In the remaining sections of this chapter theories about the responses of people to the changing landscape are discussed and how this might have resulted in a different hunting strategy. However, the state of preservation of Mesolithic Doggerland will be discussed first, in order to clarify the archaeological value of the research area.

3.2 The Preservation of the Mesolithic Layer of Doggerland

The taphonomical processes which influence the points are still not well understood (Peeters and Cohen 2014, 4). It has long been thought that the finds from Doggerland were all out-of-context finds and thus had a low archaeological value. The reason for this is that the entire North Sea is still being used today and is thus being anthropogenically disturbed, by for example mineral exploitation, infrastructural developments, fishing and the construction of wind farms (Fitch *et al.* 2007b). However, not all of these disturbances will significantly impact the Mesolithic layer of Doggerland (Ward and Larcombe 2008, 78), which has been proven by Fitch *et al.* in their research (2007b).

Fitch *et al.* (2007b) suggested that 'a large part of the Southern North Sea contains an in-situ prehistoric landscape which never suffered the effects of later agricultural and anthropogenic practices.' Furthermore, studies along the coastlines of England, Denmark and the Netherlands have shown that prehistoric sites can still be preserved after thousands of years underwater. For example, at the Bouldnor Cliff in England (Peeters and Momber 2014, 66) and at the Yangtze Harbor in the Netherlands (Moree and Sier 2015) well-preserved Mesolithic sites are found in situ.

However, the preservation of the Mesolithic layer will probably differ at different locations in Doggerland, the topography of the location being the most important factor. In the best case the layer will be covered with sediments, which protects it from the forces of the sea. These sediments form silt which can encapsulate and preserve artefacts in an anaerobic environment. Sedimentation will mainly occur in sheltered, deltaic estuarine environments, such as fluvial channels and coastal lakes. As mentioned in section 3.1, these locations are often preferred site locations (Peeters and Mombers 2014, 61).

For the Dutch part of Doggerland there is a lot of evidence for human presence in the Mesolithic, such as bone, antler and flint tools and even human remains (van der Plicht *et al.* 2016). These finds are mainly collected at the beaches of Zuid-Holland due to the reinforcement of the Dutch coast, which means that sand from suppletion areas in the North Sea will be deposited at the beaches.

In the remaining sections of this chapter, what is known or assumed about the Mesolithic period in Doggerland will be further discussed.

3.3 A Changing Landscape: Rising Sea Level

The Mesolithic period in Doggerland is characterized by an ever-changing landscape due to the rise of the sea level. There is still discussion about the extent of Doggerland when it was still fully 'intact' at the beginning of the Mesolithic period. It is generally agreed upon that Doggerland connected Britain with the European continent and southern Scandinavia (Ballin 2017, 329). A complete reconstruction of the palaeolandscape of Doggerland was made with 3D seismic technology (fig. 9). The use of 3D seismic scans revealed evidence of meandering river systems with major and secondary channel belts, tunnel valleys, sand banks, mud flats, salt marshes, estuaries and lakes (Van Heteren 2014, 38). Moreover, evidence from 2D data revealed many different landscape features, including deltas, rivers, dunes, coastal barriers, estuaries and freshwater marshes (Van Heteren 2014, 38).

The sea began to rise rapidly at the end of the last glaciation, at about 10,000 years cal. BC. However, the rise of the sea level was not a continuous process. Periods of rapid flooding were being alternated by periods of relative calmness of the sea (Leary 2009, 228). Low-lying areas would have flooded first, resulting in higher lands becoming islands (fig. 9). Some islands might have been isolated where other islands might have been connected to each other at low tide. All these islands would have shrunk over time until they were completely submerged (Leary 2009, 227).

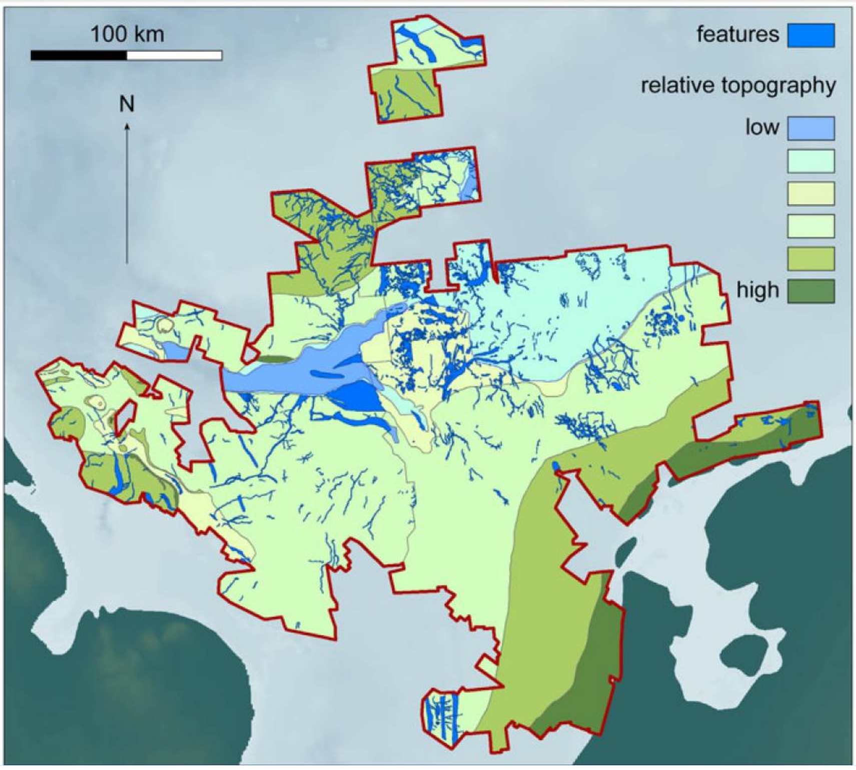


Figure 9: 'Palaeolandscape reconstruction for part of the British and Dutch Continental Shelf on the basis of 3D seismics. Depositional features and relative topography were reconstructed' (Van Heteren 2014, 39).

The rise of the sea level resulted in a challenge for human occupation in Doggerland. Firstly, the rise of the sea level caused the erosion and submersion of land along the coasts – such as protective sand beaches – which in turn resulted in more floods and increased exposure to storm surges. Secondly, land started to subside and cliffs started to erode more rapidly. Thirdly, groundwater rose which resulted in freshwater aquifers getting contaminated with salt water, which was especially problematic for inhabitants of islands. Fourthly, the rise of the groundwater level caused forests close to the coast to drown, resulting in swathes of dead woodland. It would not have taken long for the sea to completely reclaim these woodlands (Leary 2009, 230).

The first land to flood was the low-lying plain in the south of Doggerland. The Atlantic coastline started to shift east along the Channel River – which is known today as the English Channel – submerging more and more of Doggerland (Leary 2009, 227). Around 8,000 cal. BP (about 6,050 BC) England was completely disconnected from the European continent (Gaffney *et al*. 2007). It is possible that some islands were not completely 'lost' when they were submerged. After their submergence some islands might have been above sea level during low-tide. Furthermore, these islands affected the behavior of currents, collected drifting material and provided different sorts of fishing grounds. These new resources might have caused people to return to these islands on occasions (Sturt 2015, 20).

Around 8,200 BP (about 6,250 BC) the so called 'cooling event' started due to the meltwater release from Lake Agassiz in North America. As a result, there was an abrupt 0.25-0.5m sea level jump in Doggerland at around 8,300 cal. BP (about 6,350 BC), which may have a caused an unusually cold and windy period on the remaining coasts of Doggerland (Weniger 2008, 16). It is estimated that this event lasted for 220 ± 2 years with a four-year long peak at 8,222 cal. BP (Weniger 2008, 9). Between 6,500 and 6,300 BC the last land to submerge were the upland areas, such as Dogger Bank and Brown Bank, which were turned into islands (Van der Plicht 2016, 112-113). 'Dogger Hills' was the highest part of the Dogger Bank. In the beginning of the Mesolithic period Dogger Hills was a fluvially dominated area with lakes and at the end – about 8,500 years ago (about 6,550 BC) – the last remaining island of Doggerland. Around 8,000 BP (about 6,050 BC) it became completely submerged (Heteren 2014, 38). It is suggested that this final flooding of Doggerland has been accelerated by the 8,200 BP (about 6,250 BC) meltwater pulse mentioned above and by a tsunami (Sturt 2015, 20). This tsunami – called the Storegga Slide Tsunami – took place at 7300 ± 30 C^{14}-BP (95%-confidence; about 5,350 ± 30 BC), or 8100 ± 100 cal. BP (95%-confidence; about 6,150 ± 100 BC; Weniger 2008, 6). The Storegga tsunami was caused by a slide, which according to Bryn *et al.* (2005) was caused by an earthquake in the North Atlantic. At that moment the sea level of the southern North Sea stood about 17 meter higher than today. It has been suggested that when the tsunami hit Doggerland its run-up was about three meters (pers. comm. Bondevik 2007 in Weniger 2008, 2).

3.3.1 Human Responses to the Submerging Landscape

The rapid submergence of Doggerland is expected to have had a great impact on its inhabitants. Firstly, humans preferred site locations in close proximity of waterways or coastlines and were therefore facing river floods, storm surges and a coastline that would be getting closer and closer due to the rising sea level (Van Heteren 2014, 39). Groups probably moved away when the coastline reached their dwellings (Coles 2000, 398). This meant leaving behind the landscape that they knew, including its resources and sentimental value, such as ancestral lands (Ingold 2000). 'The landscape was something that provided identity to a society or individual and *vice versa'* (Leary 2009, 231). When sites were abandoned they might have been re-visited, as discussed above.

However, other groups stayed at their dwellings. For example, at the Bouldnor Cliff site in England the coastline reached the site at 8,000 cal. BP (about 6,050 BC). The inhabitants of this site chose to stay and adjust, instead of moving away (Peeters and Momber 2014, 58-59). This might be explained by the fact that the effects of the sea did not really change for the inhabitants of Doggerland. The sea was flooding the land and getting closer for generations long during the Mesolithic. People might have gotten used to it because flooding happened regularly. They would have had strategies to deal with these hazards. However, this attitude towards the sea might have had some dangerous consequences, such as staying on shrinking islands or on land which became inhabitable (Leary 2009, 234).

The biggest danger for inhabitants of Mesolithic Doggerland was probably the Storegga Slide Tsunami that was mentioned above. It is estimated that 700-3000 individuals of its population were affected when the tsunami hit Doggerland. This amount is large enough to have resulted in several local bands getting extinct. The tsunami undoubtedly killed a significant number of individuals by drowning them and many others would have been displaced. Furthermore, the coastal survivors of the tsunami would have to deal with destroyed camps, including food resources, such as fixed fishing facilities and shellfish beds. Moreover, the food storage might also have been destroyed or displaced (Weniger 2008, 16). The tsunami probably hit during late autumn, as shown by macrofossil analysis of fish bones and twigs from deposits in Norway (Bondevik *et al*. 1997, 50). There might not have been enough time to restore the food supply for the winter, resulting in starvation.

Secondly, it is suggested that the loss of land – and thus territory – led to more competition among Mesolithic hunter-gatherer groups (Waddington 2007; Gaffney *et al.* 2009; Momber 2011).

Thirdly, the climate was changing to a warmer climate, which changed the flora and fauna and thus the available food resources. The inhabitants of Doggerland needed to adapt to this new landscape, partly by changing their diet. This will be discussed in the next section.

3.4 Flora and Fauna

As discussed in section 3.1, the Mesolithic period was a transitional period with a climate that was becoming warmer. Temperature and humidity rose and with it the flora and fauna. The landscape in Doggerland changed from a steppe-tundra into a boreal area. Forested environments increased, especially tree species, such as pine, hazel and birch. Doggerland consisted of different kinds of landscapes, which probably consisted of valleys, with plains, low hills, wetlands, lakes and draining rivers (Deeben and Arts 2005, 141; Fitch *et al.* 2007a, 106-107; Gibbard 2007).

Frequent forest fires occurred throughout the Mesolithic. They occurred mainly during the colder and drier period around 8,400/8,200 BP (about 6,450/6,250 BC) as a result of the 'cooling event', as mentioned in section 3.3 (Crombé 2016, 316). Additionally, it is suggested that forest fires were sometimes deliberately caused by humans in order to create open hunting areas (Mol *et al.* 2006, 183; Gaffney *et al.* 2009, 54-56; Crombé 2016, 318).

Mesolithic people shared this new Doggerland with new animals as well. The fauna can only be directly inferred from a few finds of the Boreal period. The following terrestrial mammal species have been ^{14}C-dated to the Early Holocene (7,780-8,780 BP; about 5,830-6,830 BC): *Castor fiber* (beaver), *Cervus elaphus* (red deer), *Alces alces* (elk), *Capreolus capreolus* (roe deer), *Canis familiaris* (dog), *Lutra lutra* (otter), *Sus scrofa* (wild boar) (Linnaeus 1758 in Mol 2016, 132), *Equus sp.* (horse) and *Bos primigenius*(aurochs)(Glimmerveen *et al.* 2006, 245; Mol *et al.* 2006, 184; Mol *et al.* 2008, 135). It is argued that game consisted mainly of red deer, elk, wild boar, horse and aurochs (Lauwerier *et al.* 2005, 46; Mol *et al.* 2008, 165; Kitagawa *et al*. 2018, 204). Furthermore, it was suggested that birds were attracted by the open vegetation and new freshwater expanses, and were probably an important game as well (Verhart 1988, 185; Coles 2000, 396). The dog was also present in the Mesolithic and lived amongst the people (Lauwerier *et al.* 2005, 46; Mol *et al.* 2008, 165). Additionally, some marine mammal species have been identified and ^{14}C-dated to the Holocene as well (8,135-11,550 BP; about 6,185-9,550 BC): *Phocoena phocoena* (porpoise), *Eschrichtius robustus* (grey whale), *Halichoerus grypus* (grey seal) *Orcinus orca* (orca) and *Tursiops truncatus* (bottlenose dolphin)(Linnaeus 1758; Fabricius 1791; Lilljeborg 1861; Montagu 1821 in Mol 2016, 132). These sea mammals could have been hunted as well (Mol *et al.* 2008, 165, 202) but no evidence of this has been found yet.

Rivers and lakes could have been exploited for resources, such as fish, shellfish and birds. Not much is known about the consumption of fish in the Mesolithic because fish remains are rarely found on archaeological sites due to degradation and their small size. However, there is a lot of evidence from Mesolithic sites in Denmark where fish and shellfish remains were found. The remains included marine fish (e.g. cod), freshwater fish (e.g. pike and tench) and catadrome fish (eel)(Fischer *et al.* 2007). Catadrome fish are fish that grow up in salt water and then switch to living in freshwater. At other sites (Final Mesolithic) in the Scheldt in Belgian numerous fish remains were found, belonging mainly to freshwater species (Van Neer *et al*. 2005). Shellfish are found more frequently due to better preservation and were mainly marine (Hebels 2014, 15-16).

3.4.1 The Mesolithic Diet in Doggerland

Isotope analyses from human bones originating from the North Sea can assist in reconstructing the Mesolithic diet in Doggerland. Human remains originating from the North Sea were ^{14}C-dated and their isotopes were analyzed. For the isotope study 32 samples of Early Mesolithic human remains – from the same research area in Doggerland as the points from this research (fig. 8) – were analyzed and compared with the stable isotope values of Fischer *et al.* (2007; Hebels 2014; Van der Plicht *et al.* 2016). It is possible to identify different dietary groups based on these samples. It must be noted, however, that the freshwater component in the diets might be overrepresented because of taphonomical issues and that 'the conditions for preservation may have been more favourable in energetically less intense wetland settings in contrast to transgressive coastal settings, or unsheltered upland locations' (Van der Plicht *et al.* 2016, 116).

The results of the isotope study show a mainly (61%) freshwater diet for the majority of the human bone samples (fig. 10). Additional food resources for these humans might have included terrestrial plants and animals. These people probably inhabited inland aquatic environments (river valleys, lakes). Examples of Mesolithic exploitation of freshwater resources can be seen on several inland sites of Northwest Europe in the proximity of the North Sea, such as Zutphen-Ooijerhoek in the Netherlands (Peeters and Niekus 2005), Star Carr in England (Milner *et al*. 2018a; Milner *et al*. 2018b), Duvensee in Germany (Holst 2010) and the sites Holmegård and Mullerup in Denmark (Fischer *et al*. 2007).

Another assemblage of six samples shows a mixed diet consisting of freshwater and marine resources (Hebels 2014, 37; Van der Plicht *et al.* 2016, 115). It was suggested that these humans were 'coastal dwellers' living in environments with lagoons, tidal inlets and/or salt marshes (Van der Plicht *et al.* 2016, 115). A good example of this dietary focus can be found on the site of Star Carr. The Early Mesolithic site of Star Carr is located in the Vale of Pickering in Northeast England. It was situated in the proximity of a freshwater lake and only about 9-10km from the coast. They consumed freshwater and marine fish and birds. Furthermore, the boreal landscape provided the terrestrial component of the diet consisting mainly of red deer and roe deer. Elk and aurochs were also present and some smaller amount of wild boar (Gaffney *et al.* 2009, 49; Milner *et al.* 2018a; Milner *et al.* 2018b).

Additionally, there are some other samples that did not show a particular diet. These samples seem to show a mixed diet of an equal amount of freshwater and terrestrial resources (Hebels 2014, 37 and 51). These people probably lived on the dryland (Van der Plicht *et al.* 2016, 115). An example of this dietary focus can be found on the Early Mesolithic site of Zutphen-Ooijerhoek in the east of the Netherlands. The site was situated on an old river dune in the valley of the IJssel river. Evidence for the diet of the inhabitants consists of remains of terrestrial mammals, freshwater fish and birds. Furthermore, evidence in the form of burned shells for the consummation of hazelnuts was found here as well. Moreover, fragments of a bone point – suggested to be a harpoon – were also found (Peeters and Niekus 2005, 218-219).

The diet of the inhabitants of Mesolithic Doggerland is comparable with the dogs that lived among them. Dog remains originating from the North Sea show signs of a significant freshwater food component in their diet as well. This is to be expected, because the dogs probably ate left-overs of the people's meals (Van der Plicht *et al*. 2016, 114).

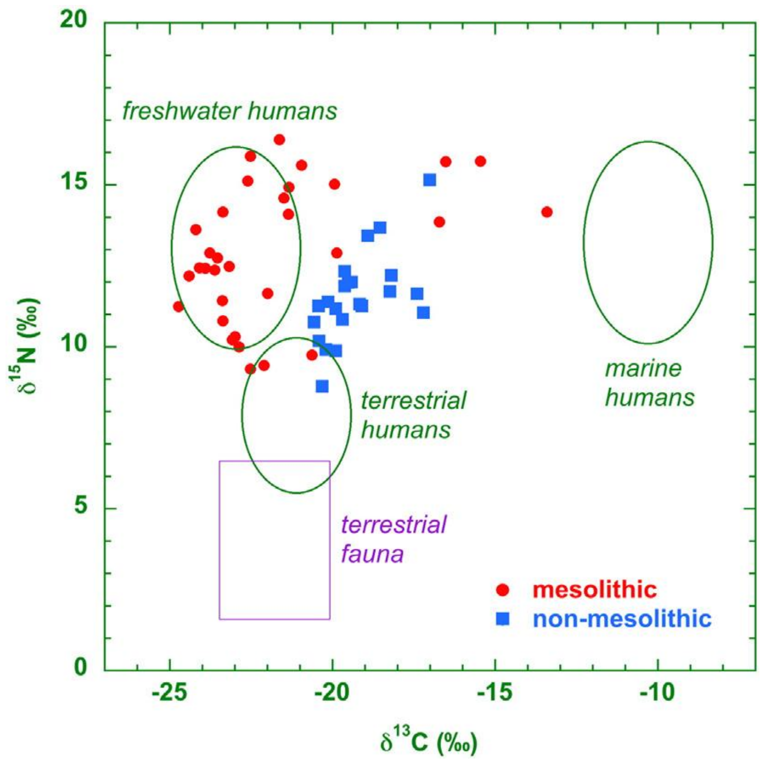


Figure 10: Stable isotope values (δ13C, δ15N) for 14C-dated human remains from the North Sea (Van der Plicht *et al*. 2016, 114).

It seems that most of the inhabitants of Mesolithic Doggerland did not abandon the changing submerging landscape, but adjusted to it (Van der Plicht *et al.* 2016, 116). Van der Plicht *et al.* compared the δ15N values with the (uncalibrated) ^{14}C-dates of the human remains from the North Sea. They observed a correlation, which suggests a chronological development of a terrestrial diet in the Late Paleolithic to an increasing aquatic diet in the Mesolithic (fig. 11). They were able to change their terrestrial diet as a response to the changing landscape, which provided more aquatic resources, resulting in a mixed – mainly freshwater – diet. This corresponds well with the information from other Mesolithic and Neolithic inland sites (Van der Plicht *et al.* 2016, 117). For example, in the Rhine-Meuse delta area there was a long-term focus on wetland resources (Louwe Kooijmans 2007; 2009; Smits and van der Plicht 2009; Amkreutz 2013).

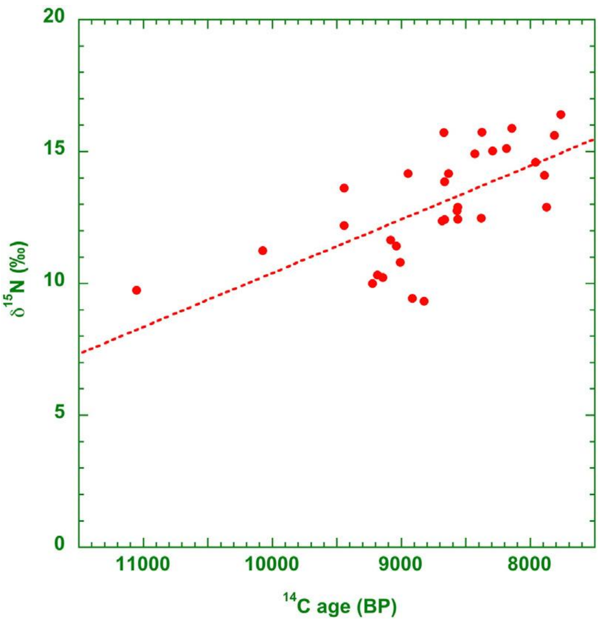


Figure 11: 'Stable isotope δ15N values for Mesolithic human remains from the North Sea, plotted as a function of (uncalibrated) 14C age. The dashed line is a linear fit through the data points' (Van der Plicht *et al*. 2016, 116).

3.5 Non-homogenous Responses to the Changing Landscape

The different hunter-gatherer groups of Mesolithic Doggerland probably responded in different ways to the environmental change. It is unclear if this correlates to different hunter-gatherer groups or that the same group had different strategies for different parts of the landscape (Crombé *et al*. 2011, 469). Their responses could relate to differences in exposure to hazards, available resources and people's resilience strategies (Leary 2009, 232).

The difference in exposure to hazards depends for a major part on the settlement location. For example, inhabitants of small islands are more susceptible to damage from the rising sea-level and wave damage because of the high ratio of shoreline to land area. Furthermore, this vulnerability due to a close proximity to the coastline would have increased over time when the land became smaller and the coastline came further inland. As a result of this constant stress of loss of resources due to land loss, people might have been more vulnerable for other hazards as well, such as hurricanes, storm surges and the Storegga tsunami (Leary 2009, 232).

How and to what extent people cope with and recover from changing conditions is called 'resilience'. People can use certain strategies to enhance resilience by learning from past changes and to adapt to them. Resilience strategies are stated by Leary as 'being flexible and able to move quickly to exploit any positive opportunities that might arise, as well as to monitor ecosystems and resource stocks. Other strategies include mobility, including the ability to relocate temporarily and permanently.' (Leary 2009, 232). For example, resilience can be enhanced by broadening their diet, as seems to have occurred in Doggerland as a response to the changing landscape.

If people possessed enough resilience they were capable of benefitting from the changed landscape. The new landscape offered an increased diversity of resources to exploit, which seems to have resulted in a mixed diet for most inhabitants of Mesolithic Doggerland. As stated by Leary 'environmental change can benefit individuals as much as disadvantage them' (Leary 2009, 235).

4. The Shooting Experiment

In section 2.2 it was discussed that an experiment was set up in order to answer the research question of this thesis. In this chapter firstly the link of this experiment with the archaeological context (chapter 3) will be discussed in section 4.1. In section 4.2, the hypotheses which were stated in section 2.2.1 for the shooting experiment will be discussed. Thereafter, in section 4.3, the set-up and conduction of the experiment will be outlined. Finally, in section 4.4, there will be a summary of the results of the use wear analysis on the experimental points, which will be used as a reference collection for use wear on the archaeological points.

4.1 Hunting from a Distance

In order to hunt the game which was suggested to have been hunted in Mesolithic Doggerland – terrestrial animals, birds and fish – people made hunting weapons. The possible function of the small barbed bone points from Doggerland as weapon tips will be discussed in this section. Furthermore, the associated hunting strategies and techniques which could have been used in the Mesolithic Doggerland landscape will be discussed as well.

The preference for a certain type of hunting weapon is influenced by the available fauna and the landscape in which the hunting takes place (Knecht 1997, 266). Preferred performance characteristics influence the design of the weapon, such as accuracy, penetration, haft security, durability, wound size, projection distance, projection speed, ease of transport, and ease of recovery, which will lead to a certain form of the weapon tip. The size of the weapon tip is positively related with wound size, resistance to breakage and penetration. Furthermore, the size of the tip also influences the distance the projectile will travel and with which speed. Moreover, the potential for a longer use-life of the weapon tip depends on the size as well. A larger bone point means it can generally be re-sharpened and reworked more often, prolonging its use-life. Furthermore, the width of the weapon tip decreases its sharpness and penetration but increases its wound size. The size of the cross-section is positively related to the wound size as well and increases the weapon tips' resistance to breakage (Nelson 1997, 377). Adding barbs to a weapon tip increases the bleeding and thus lethality of the wound. Furthermore, barbs will improve the embedding of the projectile in the target (Pokines and Krupa 1997, 256). For hunting fish this is suggested to be especially important because the fish might otherwise float away or sink (Julien 1982; Mason 1900; Rostlund 1952; Von Brandt 1984 in Pokines and Krupa 1997, 256). Finally, the form of the base influences the haft security and the chance of breakage (Nelson 1997, 377).

As mentioned in section 1.2.3.1, it has been suggested that small barbed points were most likely used as weapon tips, arrowheads in particular. The variety in types of small barbed bone points can be explained by a variety of functions and/or methods of hafting, because different characteristics make a point suitable for different purposes. It is generally assumed that bone points were hafted on the tips of shafts – instead of just sharpening the wooden tip – in order to increase the penetration and cutting ability of the weapon, which increases the weapon's killing power (Churchill 2008, 12).

4.1.1 The Bow as Hunting Weapon

Since it is assumed that the small barbed bone points are used as arrowheads the bow will be discussed in this section as the assumed hunting weapon. However, it should be noted that other possible hunting weapons of which these points could have been the weapon tips are: atlatl, lance, leister (fish spear) and/or harpoons. For example, at the Star Carr site a point was found with a hole in its base, which indicated its use as a harpoon head. Furthermore, from this same site two other points were found in an arrangement indicating use as a leister (Clark 1954). However, no holes or arrangements of points have been found for the small barbed bone points from the North Sea.

The use of the bow for the hunt was an important innovation in human behavioral evolution. Being able to shoot animals from a safe distance made hunting less dangerous and gave them the opportunity to hunt larger and/or more dangerous prey (Knecht 1997; Crosby 2002; Faith 2008; Dusseldorp 2010; Weaver *et al*. 2011).

Ethnographic information shows hunters frequently carry more than one type of arrow. The different types have different performance ratings relating to range, accuracy, killing and wounding power (Griffin 1997, 281-282). In general, arrows are intended to kill the animal by piercing an internal organ or by causing severe bleeding (Miller *et al*. 1986; Friis-Hansen 1990). As mentioned in section 1.2.3, it was proven by Tsiopelas that small barbed points from the North Sea could have lethally wounded small as well as big sized animals (Tsiopelas 2010, 37).

Furthermore, the arrow types differ in ease of manufacture and ease of re-use as well (Christenson 1997, 138). Ethnographic information has shown that simple types of arrows which are quickly manufactured are often used to compensate for the numerous arrows which break or get lost during the hunt. The adding of barbs to points is an extra step in manufacturing and thus takes more time. These barbs attach in the wound of the target which make the wound deep and complex and thereby more susceptible for infection. However, this takes time to develop and thus the wounded animal would need to be followed, which could have been done with the help of dogs.

Bow hunting is possible in all types of environments on all types of game (Hardy 1976, 24-26; Pétrequin and Pétrequin 1990, 487, 498-499 in Cattelain 1997, 228). The hunting strategies which could have been used are inferred from ethnographic information and are stated by Cattelain (1997, 228) as follows: 'stalking, individually or in small group; individual tracking or approach hunting with or without a screen, with or without a decoy system; and game drives with beaters, generally in small groups, but in certain cases with much larger groups'. Furthermore, Cattelain mentions the use of various types of traps in combination with bow hunting (Cattelain 1997, 228). These hunting strategies will be further discussed in the next sub-section.

4.1.2 Hunting Techniques

For the hunting strategies discussed above, several hunting techniques can be used. Churchill (2008) looked at primary ethnographic and ethnohistoric literature from 96 human groups in order to study hunting behavior among hunter-gatherers. He observed five hunting techniques, which can all be used with bow hunting: approach, ambush, pursuit, encounter and disadvantage (Churchill 2008, 16).

The 'approach' technique means that hunters will stalk the prey until they can come within effective range. In contrary, the 'ambush' technique means that the hunters are hiding while waiting for game to come within effective range of their weapon. Both these techniques focus on taking out the prey while it is unaware of it being hunted.

The 'encounter' technique focuses more on a direct attack when an animal is encountered. A deer might jump out of the bushes and will be shot at immediately. If the animal flees and gets out of effective shooting range, the animal will often not be pursued (Churchill 2008, 16). On the contrary, the technique of 'pursuit' means the hunter's intent is to overtake the animal by chasing it. The animal will already be fleeing and will be shot at while on the run when the hunter comes within effective range. The prey can also be run to exhaustion by chasing it. This may involve dogs that keep the animal running until it is exhausted and can easily be shot.

The hunting technique 'disadvantage' focuses on the decrease of the chance that the prey escapes or the increase of time to use the hunting weapon. For example, the hunting strategy of game drives can be employed with this technique. The intention of the game drive is to force the animal(s) into a position of disadvantage to make the kill easier, for example driving the animal(s) into water, mud or into a tree. For this technique dogs could have been used as well (Churchill 2008, 16).

Since all hunting techniques can be used when hunting with bow and arrow, the hunters can chose their techniques based on the specific game that they are going to hunt. When the hunting technique disadvantage, approach or pursuit is used, the arrow is supposed to hit a vital organ and induce death by hemorrhage. The shot needs to be accurate in order to reach the vital organs between the ribs or behind the shoulder blades. By using these hunting techniques the bow and arrow can even effectively be used against large game, because then game can be shot from a closer distance or multiple times. When the arrow does not hit a vital organ multiple shots will be taken at the animal. However, from archaeological evidence from Mesolithic sites it can be inferred that theses shots will increase the chance of medium- to large game escaping. The evidence consists of a large number of cervid, bovid and suid bones with healed arrow wounds (Noe-Nygaard 1974). For small game the shots do not need to hit vital organs in order to bring down the animal. Therefore, the encounter technique is mainly used on small game instead of medium to large game (Churchill 2008, 18).

4.1.3 Hunting Grounds

It is commonly accepted that because of the changed landscape – as a result of climate change – forests had become denser due to deciduous tree species. As a result, the forests became darker and more closed environments. It is generally assumed that these new forests were unfavourable for large game, which made them forced to move towards open zones, such as forest edges and wetlands/floodplains (Waterbolk 1968; Iversen 1973; Paludan-Müller 1987; Spikins 1999 in Crombé *et al*. 2011, 467). Furthermore, large herds were replaced by relatively small groups. For example, it is suggested that large herds of bison were replaced by small groups of herbivores, such as aurochs (Kitagawa *et al*. 2018, 204). These changes in herd structures and probably migration patterns as well, could have resulted in changing hunting strategies for the tracking and pursuit of game (Bibikov 1975; Dolukhanov 2008; Smyntyna 2014; Stanko 2007 in Kitagawa *et al*. 2018, 204). For example, in section 3.4 it was mentioned that some forest fires might have been deliberately caused by humans to create open hunting grounds.

Furthermore, freshwater lakes and rivers were hunting grounds for bow hunting as well. Evidence has been found on the site of Ivanovskoye 7 (layer IV) (Zhilin 2015). At this site a barbed bone point was found stuck in the bottom of a lake, which used to be near the shoreline. The point stuck in the ground with an angle of about 70° and had a small tang as base that is identical to tangs of other small arrowheads. It is suggested that the arrow was shot into the water from a very close distance. The use-wear on the point consists of rounding of the tip, a dull matt polishing running from the tip towards the shaft while gradually disappearing. Furthermore, within the polish multiple long fine striations are present running from the tip up to the first barb and some beyond. This use-wear is interpreted by Zhilin as characteristic of bone leisters and fishing spearheads. He further elaborated this by explaining that these traces indicate multiple hits of the point against a silty and sandy lake bottom while stabbing or shooting fish (Zhilin 2015, 45). At this layer of the site the habitation of humans took place during the warm season (Zhilin *et al.* 2002 in Zhilin 2015, 45). The most present fish species is Pike (*Esox lucius*). It is generally known that pikes need to warm themselves, which they do in shallow water. This makes pike an easy target for humans to shoot. Zhilin suggest that the point that was found stuck in the lake bottom represents a missed arrow, targeted at a pike (Zhilin 2015, 45).

4.2 Hypotheses

The large amount of (very) small bone barbed points (<88,5mm; Spithoven 2016, 43) is unique for Mesolithic Europe. This thesis aims to study the function of these points in order to come to preliminary conclusions about the reason why these points from Mesolithic Doggerland are that small. As discussed in the previous section and chapter 3, the reason could be that they were an adaptation to the changed landscape. The changed landscape resulted in the loss of old food resources and provided new food resources, such as different fauna. People were able to exploit more aquatic resources and might have adapted their hunting gear for this. Therefore, an experiment was set up to test if it is possible to distinguish wear traces from shooting fish from those that develop due to shooting land mammals (first hypothesis in section 2.2.1). If this is possible, it should be tested if it is possible to distinguish these two types of traces on the archaeological small bone barbed points in order to infer on which game the points were used. This was tested by producing six experimental bone points that are a replica of an archaeological small bone barbed point with an oval base (find number 14.4 in appendix A). These experimental points were shot in three different targets: salmon, an artificial land mammal without bones, and an artificial land mammal with bones. Ideally the target which represented the land mammal should have been an actual land mammal, preferably a species that lived in Mesolithic Doggerland. However, because of the budget for this thesis this was not possible.

Another reason for the small size of the points was thought to be related to degree of wear (second hypothesis in section 2.2.1). It was hypothesized that the archaeological small barbed bone points would show differences in degree of wear because of a difference in the length of their use-lifes. This was tested with the help of categorizing the wear into five groups: a) no wear; b) little wear but still usable; c) little wear and unusable; d) lot of wear but still usable; e) lot of wear and unusable. If these groups can be made, it might be possible to divide the archaeological points into groups of expedient points and curated points.

4.3 Conducting the Experiments

For the experiment a complete salmon without intestines was used (it was not possible to buy a salmon with its intestines still inside). The salmon weighed about 4,5kg and was hung into a tree for the experiments 3640 and 3641 (fig. 13). For experiments 3642 and 3643 a target was made consisting of pork chops (without bones) and a deer skin. This was tight together with robe and hung into a tree (fig. 14). For experiments 3644 and 3645 fresh cow bones (mainly ribs) were added to the former target. It was chosen to separate the 'land mammal' target into one with cow bones and one without bones because the type and degree of wear was expected to be different when hitting just meat or hitting bone as well.

As discussed in section 2.2.3, two types of experiments were conducted per target in order to attempt to create an expedient (short use) and curated point (long use). This was found to be more difficult than expected, which will be further discussed below. The bow used for the experiments was a Polderweg-model flatbow (Louwe Kooijmans *et al.* 2001, 385). The bow was about 1,60m long, had a draw length of about 51cm and a draw weight of about 40 pounds. The arrow shafts were made of pinewood and about 85cm long. The points were hafted with sinew and tar (fig. 14) as suggested by Verhart (fig. 4).

On the day when the experiments were conducted it was warm outside with temperatures of 20°C and a humidity of 40% during the first experiment up to 26°C and a humidity of 29% during the last experiment. Every shot was filmed (in slow-motion) and photos were made of the setting of the experiments and the projectile into the different targets. After each shot the point was observed for wear with the naked eye and when necessary a looking glass and pocket microscope of 60x were used. In the beginning of the experiments the angle of impact was measured as well. However, due to lack of sufficient time and the lesser relevance of these measurements this was not done for every shot. The angle of impact was mainly about 90 degrees for all shots. The experiments will now be discussed individually.

Figure 12: Set-up of experiment 3640 and 3641.

Figure 13: Set-up of experiment 3642-3645.

Figure 14: Experimental point 3640 hafted on the arrow.

4.3.1 Experiment 3640 and 3641

For the first two experiments the salmon was hung into a tree (fig. 12). The distance to the target was two meters. This distance was chosen for accuracy of the shot and because this was expected to be about the distance the hunter would be from the fish.

The salmon was shot at with experimental point 3640 hafted on an arrow of 26 gram. The goal of this experiment was to create an expedient point. The arrow was shot once in the back of the salmon, which resulted in a penetration depth of 25cm. The second shot hit the salmon just below the back, which resulted in a penetration depth of 36cm. Some scales were visible in the manufacturing grooves of the point and some of the fish meat was mainly inside the barbs and on the shaft against the butt end of the bone point (fig. 15). After these first two shots into the fish, a shot was made into a pit filled up with sea clay from the Flevopolder (fig. 16). The point went completely through the sea clay and hit a piece of quartz stone in the clay-sand ground underneath, which resulted in the fracturing of the tip of the point on multiple locations. The tip of the point broke off when the point was removed from the shaft and put into a plastic find bag.


Figure 15: (left) Experimental point 3640 after being shot in the salmon once.

Figure 16: (right) Experimental point 3640 shot into sea clay from the Flevopolder.

Experimental point 3641 was hafted on an arrow of 32 gram and was shot as many times as possible into the salmon in order to create a curated point. The arrow was shot into the salmon for 20 times in total. The arrow went through the back (15x; fig. 17 and 18), belly (4x) and tail (1x) of the salmon. When it went through the belly the arrow had the highest penetration depth. The last shot went partly through an already existing hole. At this point it was decided that no more shots could be fired in undamaged parts of the salmon, ending this part of the experiment. After shooting the arrow for four times, some rounding seemed to occur on the tip of the point. However, it was not clear enough to be certain of this.

Figure 17: (left) Experimental point 3641 shot for the 12th time, into the back of the salmon with a penetration depth of 20.5cm.

Figure 18: (right) Close-up of experimental point 3641 shot for the 12th time into the salmon.

4.3.2 Experiment 3642 and 3643

The first two experiments were followed by experiments 3642 and 3643. For these experiments the target of deer skin with pork chops (without bones) was hung into the tree (fig. 13). The distance to the target was three meters. This is not a realistic distance from which hunters would usually shoot at a land mammal. However, it was necessary due to the required accuracy of the shots for the archer to be at maximum three meters from the target.

Experimental point 3642 was hafted on an arrow of 25 gram and was shot only four times at the target, in order to create an expedient point. It was shot into the target three times with penetration depths of 19cm, 17.5cm and 22cm. For the second and third shot it was difficult to get the arrow out of the target because the part where the arrow shaft and point attach was not the same height. This resulted in the point getting stuck. The fourth time the arrow was shot into the target the point got detached from the arrow shaft and was left inside the target (fig. 19). The point was recovered by opening up the target. The tip of the point seemed to show some microwear consisting of a chipped tip.

Figure 19: Experimental point 3642 detached from the shaft.

Experimental point 3643 was hafted on an arrow of 29 gram and was only shot once in the target instead of many times in order to create a curated point. The hafting part of the arrow shaft broke off with the point still attached (fig. 20 and 21). Therefore, it could not be used again and was considered the expedient point instead of curated. The use wear seemed to consist of a microscopically chipped tip.


Figure 20: (left) Experimental point 3643 in the target after the breakage of the shaft.

Figure 21: (right) Experimental point 3643 recovered from the target. Notice that the hafting is still intact.

Due to the fact that experimental point 3643 became the expedient point, the experiments with an artificial land mammal without bones as a target had two expedient points instead of an expedient point and a curated point. Therefore, experimental point 3642 was hafted again in order to make it the curated point for this target. The new arrow weighed 26 gram, which is one gram more than the first arrow with which the point was shot. The arrow was shot an additional six times into the target with a penetration depth of 13-19.5cm. Pulling the arrow out of the target seemed to be easier than the first set of shots with this point. After the target shots, the arrow was shot into the clay-sandy ground with grass twice (fig. 22 and 23), which represented the missing of the target when hunting. After shooting the arrow in the ground rounding of the tip occurred. Due to the fact that the tip of the point was already microscopically chipped, it was decided to end this experiment after the second shot in the ground. This was decided because the point needed to remain unbroken in order to observe the use wear.

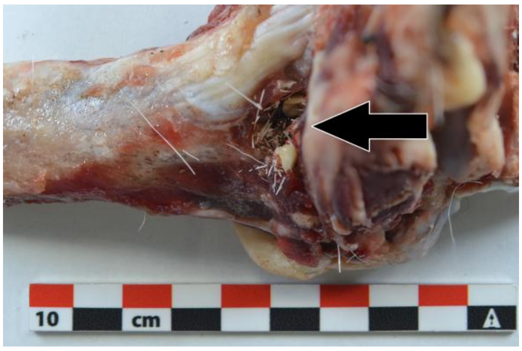

Figure 22: Set-up for shooting experimental point 3642 in the ground.

Figure 23: Experimental point 3642 after shooting it in the ground for the first time.

4.3.3 Experiment 3644 and 3645

For the last experiments fresh cow bones were added to the target of pork chops covered with deer skin (fig. 13). The points for these experiments were supposed to hit meat as well as bone. Like the previous two experiments, the arrows were shot from a distance of three meters from the target.

Experimental point 3644 was hafted on an arrow of 35 gram. The goal of this experiment was to create an expedient point. After the first shot it ended up in a humerus and splintered into many pieces. The pieces were found inside of the target (fig. 24 and 25) as well as on the ground under the target.



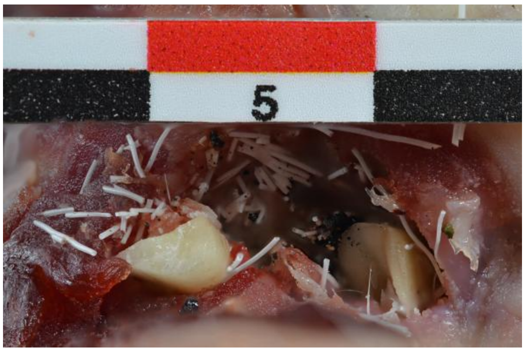


Figure 24: (right) Two pieces of experimental point 3644 in a piece of meat of a cow humerus.

Figure 25: (left) Close-up of the two pieces of experimental point 3644 inside the humerus.

Experimental point 3645 was hafted on an arrow of 29 gram and the goal of this experiment was to create a curated point. The first shot did not seem to have hit bone and had a penetration depth of 8.5cm. The second shot did hit bone and had a penetration depth of 12cm. The point as well as the arrow shaft broke. The point broke at the second barb from the tip and the third barb was flaked (fig. 26). The upper part of the point was recovered from the target and seemed to have hit at least two rib bones (fig. 27). Because of the breaking of the point due to the second shot, this point became an expedient point as well as experimental point 3644.

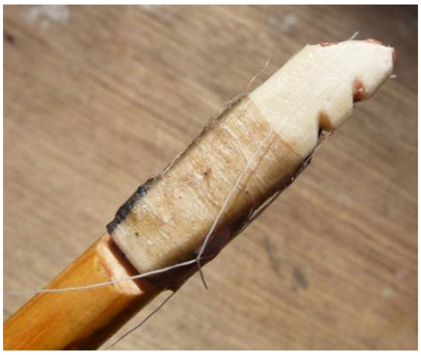


Figure 26: (left) Experimental point 3645 with broken tip and flaked barb.

Figure 27: (right) The arrangement of the two rib bones – after carefully opening op the target – that were hit by experimental point 3645.

4.4 Results of Use Wear Analysis on the Experimental Points

After the experiment the experimental points were cleaned in the ultrasonic tank for two and a half hours, washed off by hand and cleaned with alcohol (96%). Thereafter, the wear traces were documented and photographed (appendix B). A stereomicroscope as well as a metallographic microscope was used. Photos made before use could be compared with the present wear, which made it possible to answer the research questions stated for the experiments:

1. *'Is it possible to distinguish wear traces from shooting fish from those that develop due to hunting land mammals? If so, is it possible to distinguish these two types of traces on the archaeological small barbed bone points?*
2. *'Is there a relationship between the number of times that the small barbed bone points were used as projectiles and the degree to which wear traces developed?'*

However, it should first be noted that it seems that the 'unrealistic' distance from the target for experiments 3642-3645 did not result in unrepresentative use wear. This can be inferred from a comparison to the experiments of Bergman (1987). Bergman conducted 50 shooting experiments with experimental bone/antler points and a replica of a Mesolithic lemonwood selfbow with a draw weight of about 40 pounds and a draw length of about 26 inches (about 66cm). Bergman shot unfletched arrows from a distance of 5-8 meters into a piece of meat of circa 15cm thick, which was placed in front of two cow scapulas. Several fletched arrows were shot at a distance of 15 meters from the target (Bergman 1987, 118). According to Bergman 'For a bow of this draw-weight these distances are point blank range and place the arrow under maximum stress on impact'(Bergman 1987, 118). Almost all of the points from these experiments broke on impact. The points mainly broke on the tip (like experimental point 3645) and only one broke at the base (like experimental point 3644) (Bergman 1987, 123).

4.4.1 Fish versus Land Mammal

There were no distinct differences in wear traces found between the points that were shot into the salmon and the ones that were shot into the artificial land mammal. The breaking of the points only occurred when they hit a hard material, such as bone (experimental point 3644 and 3645) or when they hit a stone in the ground (experimental point 3640).

This means that as long as the hunter is fortunate enough not to hit a pebble when shooting fish, the point will be more durable than when the hunter would be shooting at land mammals. This is because when shooting land mammals there is a high chance that a bone will be hit. The chance of hitting a bone can be reduced by decreasing the distance to the target and increasing the accuracy of the shot, which correlates to certain hunting techniques as discussed in section 4.1.2. However, the fractures look the same when the experimental points hit bone and when they hit stone, which means that the difference between shooting at fish and shooting at land mammals cannot be distinguished on the archaeological points.

4.4.2 Degree of Wear Categorization

The experimental points can be divided into the categories of degree of wear that were discussed in section 2.2.1:

A. No wear: all experimental points before use
B. Little wear but still usable: 3641, 3643.
C. Little wear and unusable: 3640, 3644, 3645.
D. Lot of wear but still usable: 3642.
E. Lot of wear and unusable: not applicable for these experimental points.

The documentation and photos which were made before the use of the experimental point can be used as reference material for category A. Category B consists of points with little wear, which can still be used without repairing or reworking them. Category C consists of the points which are used to their full extent in their present state but only developed little wear. Category D consists of points which show more wear than the previous categories and which can still be used without repairing or reworking the point.

Rounding was the most common wear developing on the experimental points. It was visible on all experimental points, even though some were only shot once (fig. 28 and 29). The rounding was mostly present on the edges and ridges of the points but developed all over the points, including the base that was underneath the bindings and tar. In the incisions there was only rounding on the edges. The rounding seemed to increase when the points were being used more often. However, this difference is not distinct enough between the different categories to prove that rounding is gradually increasing when the points are being used.

The categorization of the experimental points based on the degree of wear shows that the degree of wear cannot be directly correlated to degree of use. Experimental point 3641 was shot into the salmon 20 times and was intended to represent a curated point. However, only little wear developed on the point and therefore it was grouped with experimental point 3643, which was only shot once at the artificial land mammal without bones. Experimental point 3642 is the only point that developed a lot of wear. This point was shot at the artificial land mammal without bones for 10 times and twice in the ground. Experimental point 3642 is also the only point that shows longitudinal striations overlapping the manufacturing traces, which could be related to the shots into the ground (fig. 29; Zhilin 2015, 44-46). Furthermore, the more heavily rounding on this point can be observed by the presence of broader manufacture grooves due to wear and tear. Moreover, some fractures on the tip started to develop and the most upper part of the tip was chipped. The wear traces on the other point which was shot into the same target only once (3643), only consisted of rounding. However, experimental point 3643 was not shot in the ground like experimental point 3642, which could also explain the difference in wear.

This categorization also shows that when hunters were shooting fish with their small barbed bone points the points were likely more durable than when shooting land mammals because the experimental point which was shot at the salmon for many times (3641) shows only a little wear in comparison to the experimental point that was shot at the artificial land mammal for many times (3642).

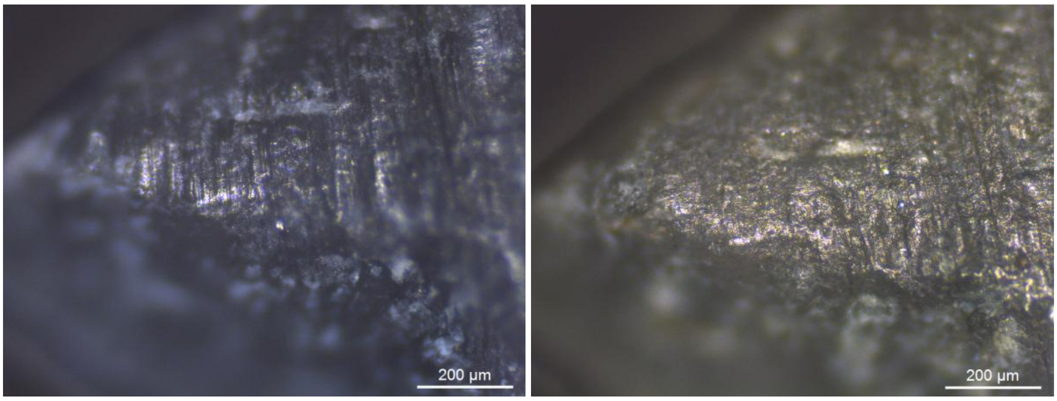


Figure 28: (left) Tip of experimental point 3642 before use and after use (right). Photo made under the metallographic microscope with a magnification of 10x.

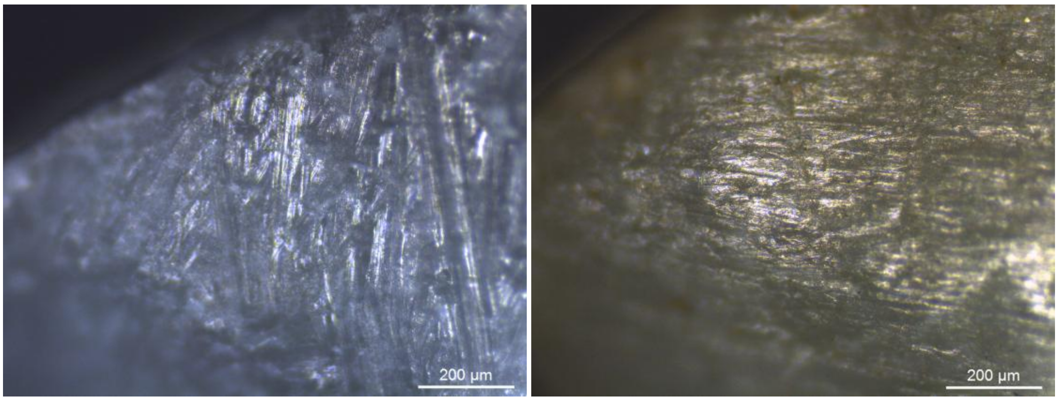


Figure 29: Figure 31: (left) Tip of experimental point 3642 before use (left) and after use (right). Photo made under the metallographic microscope with a magnification of 10x.

5. Use Wear Analysis on Archaeological Material

In this chapter the results of the functional analysis through use wear will be discussed. The experimental points – discussed in the previous chapter – will be used as a reference collection. In section 5.1 the results of experiments 3642 and 3643 will be compared to the archaeological points. In section 5.2 the archaeological points will be categorized in groups according to their degree of wear in order to study the use-life of the points. In section 5.3 the correlation between the morphological and technological characteristics with the function of the archaeological points will be discussed. Finally, in section 5.4, the biographies of the archaeological points will be reconstructed.

For this research 29 archaeological points were analyzed for use wear. Unfortunately, one of these points turned out to have modern glue covering its surface, making it unsuitable for use wear analysis. Therefore, the eventual assemblage consisted of 28 archaeological small barbed bone points (appendix A).

5.1 Land Mammal as Target

In chapter 4 the results of the experiments were discussed. The results showed that the fish versus land mammal distinction could only be made when longitudinal striations due to use would overlap the manufacturing traces on the point. However, this was not seen on the archaeological points observed for this research, making it impossible to infer if they were used on fish or land mammals. This could be caused by the extensive use-life of the archaeological points, which resulted in the heavy rounding of the surface. The degree of wear of the archaeological points will be discussed in the next section.

5.2 Degree of Wear on the Archaeological Points

The degree of wear was categorized in five groups in section 2.2.1. In section 4.3.2, the experimental points were categorized into these groups, which were used as a reference collection to categorize the archaeological points into these groups as well. The use wear of the experimental points and archaeological points is outlined in table 1.

None of the 28 archaeological points could be grouped in category A (no wear). This means that all points that have been studied for this research were used to some extent.

Two archaeological points (14.33 and 14.37) could be grouped in category B by comparing them to a reference collection of two experimental points (3641 and 3643).

The archaeological points show only some minor damage, consisting of some fractures for one point and a chipped tip for the other. Both points could still have been used because the damage is not severe enough to assume that the point would break on impact. The experimental points in this category are mainly rounded, which is also visible on the archaeological points in combination with polish. The archaeological points seem to have been used more often than the experimental points due to a higher degree of wear (more fractures, chipped tip, rounding, polish). Additionally, both archaeological points have two reworked barbs, which is an indication of maintenance of the points. The tip of the point was probably rejuvenated, resulting in a smaller length. The reworked barbs can be recognized as old incisions and/or an asymmetrical tip (fig. 30).

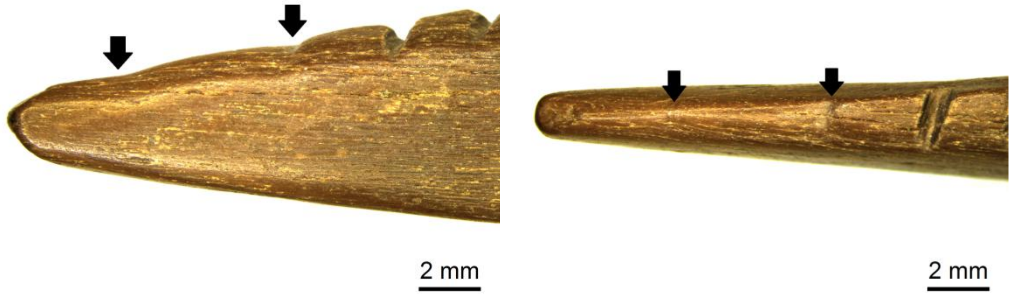


Figure 30: Archaeological point 14.33 (category B) with a chipped tip and indications of two reworked barbs above the present barbs (see arrows). Photos were made with a stereomicroscope with magnification of 0.75x.

11 Archaeological points could be grouped in category C by comparing them to a reference collection of three experimental points (3640, 3644 and 3645). All these experimental points were only shot once or a few times before hitting a hard material (stone/bone) and breaking. All of the archaeological points are rounded in combination with polish and have damaged tips. Six out of 11 tips are chipped, making the point unusable in its present state. The other tips are broken, for four out of the five broken points the fracture took place on the barbs. Furthermore, breakages of the barbs and base are common as well. Six out of 11 points have at least one broken barb and most have a broken base as well.

Table 1: Experimental and archaeological points categorized in groups according to degree of wear.

Category	A	B	C	D	E
Degree of wear	No wear	Little wear but still usable	Little wear and unusable	Lot of wear but still usable	Lot of wear and unusable
Amount of exp. points	0, but documentation and photos available	2	3	1	0
Use wear exp. points	Only manufacturing traces	Fracture, rounding	Fractures, breakages, broken barbs, rounding	Fractures, chipped tip, rounding	-
Amount of arch. points	0	2	11	3	12
Use wear arch. points	-	Fractures, breakages, chipped tip, rounding, polish	Fractures, breakages, chipped tip, broken barbs, binding impressions, surface differences between hafted part and rest, rounding, polish	Fractures, chipped tip, rounding, polish	Fractures, breakages, chipped tip, broken barbs, binding impressions, rounding, polish
Maintenance traces on arch. points	-	Reworked barbs	Reworked barbs, striations possibly due to rework	Reworked barbs, striations possibly due to rework	Reworked barbs, striations possibly due to rework

Binding impressions are visible on seven out of 11 points consisting of impressions and for one point (find number 21.1 in appendix A) the actual preservation of the bindings including glue residue, which will be discussed in section 5.3. Additionally, three points (14.57, 14.324 and 14.327) have a different surface on the base in comparison to the rest of the point. The surface where the haft was most likely present differs in colour from the rest of the point, it is smoother and displays a reflective polish (fig. 31). Another point (14.327) has a corrosion layer that decreases from the end of the last barb down along the base. These different surfaces could be related to the hafting of the point. The border between the hafted and non-hafted part of the points will be further discussed in section 5.3, as will the preservation of the binding materials found on point 21.1.

The maintenance traces in this group consist of one or more reworked barbs on three of the points (14.4, 14.25 and 14.87). Furthermore, some striations are present on a few points which could relate to the reworking of the point, such as rejuvenation, re-sharpening or haft retrieval (fig. 32), as discussed in section 2.1.3.6.

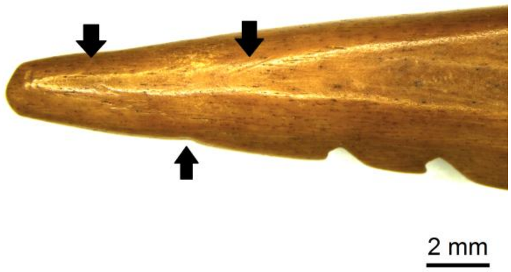


Figure 31: (left) Different surface characteristics for hafted part on archaeological point 14.57 (category C).
Figure 32: (right) Archaeological point 14.4 (category C) with an reworked barb and possible striations due to reworking of the tip. Photo was made with a stereomicroscope with magnification of 0.75x.

Three archaeological points could be grouped in category D by comparing them to one of the experimental points (3642). The archaeological as well as the experimental points show fractures, chipped tips, rounding and polish. However, all of these use wear traces are more developed on the archaeological points, which probably relates to a longer use-life of the archaeological points. The wear on the archaeological points of category D does not seem severe enough to interpret the points as being no longer usable in their present state.

Additionally, one of these points (14.47) has two reworked barbs and some striations on the base, which could have been made while reworking the point.

In category E the highest amount of archaeological points (12) could be grouped. However, no experimental points could be used as a reference collection. These points could be grouped in this category due to the fact that their degree of wear is at least as high as the points in category D. Additionally, the points of category E in their present state seem to be too severely damaged resulting in the point breaking on impact if it was used again without repairing it first.

Use wear consists of fractures, breakages, chipped tips, broken barbs, binding impressions, rounding and polish. Half of the points had a chipped tip and three tips were broken. One of these tips broke on a barb (14.324). The remaining three points from this group have no severe damage on the tip but have broken barbs, which led to the decision to categorize them as unusable in their present state. In total, eight of the points have one or more broken barbs. Six points have reworked barbs and two additional points have some striations that could be related to reworking.

Due to use all points are rounded all over their surface and have developed polish as well. These features are most developed on the tip, back of the barbs and the most upper parts of the surface. It was suggested by Zhilin that these features can be interpreted as hide-polish (zhilin 2015, 44). Since these features develop due to use, it is suggested that more heavily rounded and polished points had a longer use-life.

5.3 Morphological and Technological Characteristics

It was noted in chapter 1 that the small barbed bone points are morphologically and technologically different from other Mesolithic points in Europe and it was suggested that this could relate to function. This section will discuss if there are any correlations between the morphology and technology of the points and the function of the point. Since it could not be inferred from the experiments which type of animal the points were shot at, the function of the point will be discussed through possible correlations between the degree of wear of the points – as discussed in the previous section – and the length, shape, hafting and barbs of the points.

Firstly, the average length of the 28 archaeological points that were studied for this research is 43,4mm with a standard deviation of 8,66mm. As mentioned in the previous section, points were being reworked, which could result in the decrease of the total length of the point. Figure 33 shows the correlation between the total length of the studied points (divided in categories with a spread of 5mm) and the degree of wear categories. This means that when points are smaller and have a higher degree of wear in comparison to other points, that these smaller points have been repaired and used more intensively. Therefore, it can be concluded that the smaller points have had a longer use-life than the larger points from this assemblage.

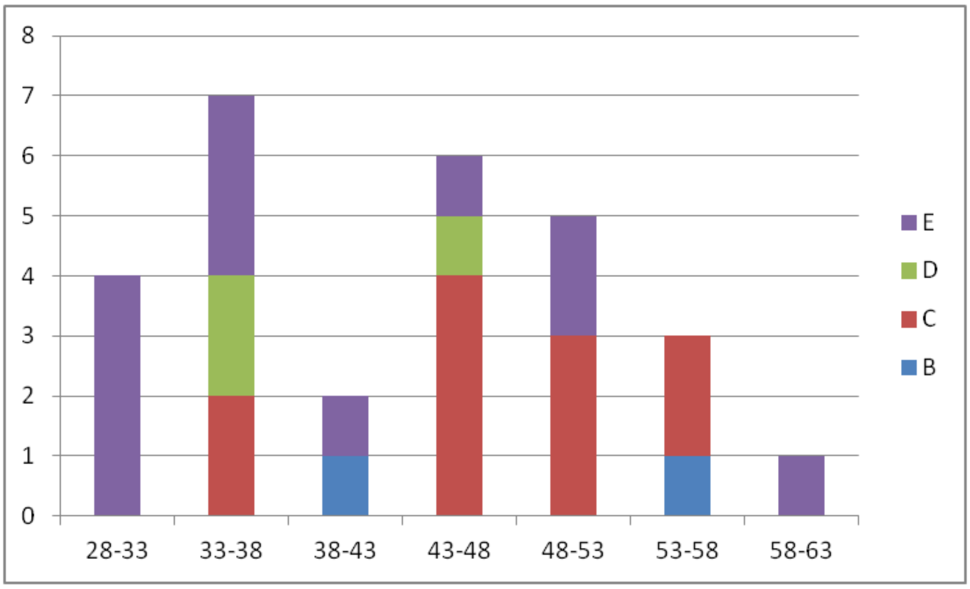


Figure 33: Stacked bar chart of total length in categories with a spread of 5mm in comparison to the degree of wear categories (B-E) where category B has the least wear and category E the most wear. (N=28).

Secondly, the shape of the point differs mainly at the base. Before this research it was thought that there were oval bases and square bases. However, there are more different shapes, mainly due to different butt ends. Six different types were found in the studied assemblage (fig. 34 and 35). Additionally, some points had a broken base that resulted in the shape of the butt end being indeterminable. Some base forms would have taken more time to produce because of a longer grinding process in order to grind off more bone, such as for the V-shaped butt ends. However, no correlation was found between the use wear of the points and the shape of the butt ends.

These different butt ends may relate to different hafting techniques. For the small barbed points two different hafting techniques have been tested. For the research of Tsiopelas (2010) the hafting technique with a slot for the weapon tip was tested. For this research the hafting technique as suggested by Verhart (fig. 4; Verhart 1988, 183) was tested. Both hafting techniques resulted in the point breaking from the shaft when shooting land mammals. This is probably due to the fact that land mammal meat and bones are of a harder material than fish meat and bones and thus will result in greater impact damage to the projectile.

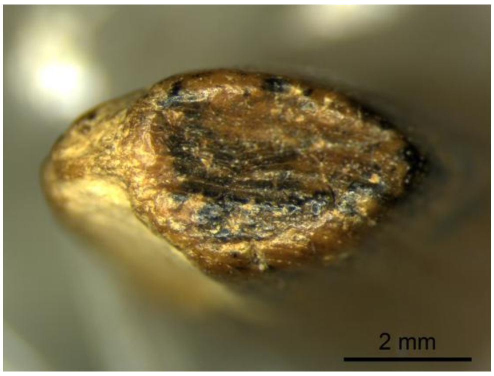


Figure 34: (left) Different types of base forms among the studied assemblage. From left to right: butt end with incision (see fig. 37); descending V-base; descending U-base; asymmetrical U-base; V-base; partly (intentionally?) broken base.

Figure 35: (right) Butt end of archaeological point 14.5 with an incision. Photo was made with a stereomicroscope with a magnification of 1.6x.

Thirdly, the border between the hafted and non-hafted part of the points could be identified for 27 out of 28 of the points. On average the non-hafted part of the point consists of about 43% of its total length with a standard deviation of 6%. The identification of this border was based on the different appearance of the surface of the two parts. The non-hafted part is generally smoother, more heavily rounded and polished. Therefore, manufacturing traces were generally better preserved on the hafted part of the point.

Most hafting traces are visible on both sides of the point at the base, which means the bindings were wrapped around the base and shaft in order to haft the point. On some points the binding traces overlap the lowest barb(s), such as on archaeological points 14.57 and 21.1 (find numbers in appendix A). The hypothesis is that this was done in order to create a more secure hafting.

Most hafting traces are only present on the medial and proximal part of the point under the barbs. The binding traces are present on the most proximal part of the point as well. Bindings would not touch these parts of the point when they were hafted into a slot, which means that the hafting technique which Tsiopelas used could not have been used on these points. The hafting technique Verhart suggested could not have created the binding traces on both sides of the proximal part because one part of the point would touch the wood of the shaft instead of the bindingmaterial. Therefore, it is suggested that these points have been hafted with the hafting technique suggested by Verhart at least twice. In order to develop binding traces on both sides of the proximal end, the point would have been hafted with the wood touching one side of the proximal end and another time with the other side of the proximal end touching the wood.

However, the clear border between the non-hafted and hafted part of the point is could be an indication of the points being reworked while still hafted. When the points would be reworked while still hafted, the decrease in point size would result in a lower percentage of the non-hafted part. However, no correlation was found between the total length of the point and the non-hafted part percentage. A correlation between the non-hafted part percentage and degree of wear was not found either. There was also no indication of a standard length for the hafted part. This could mean that minor repairs – such as re-sharpening of the tip or barbs – were carried out with the point still attached to the shaft, whereas for larger repairs the point would be taken of the shaft. For example, when the entire tip needed to be reshaped (rejuvenation) the point would be taken out of the shaft.

Additionally, some points were found with binding material still preserved. The best preserved binding material was found on point 21.1. On point 21.1 the bindings are pressed into a black residue and overlap three barbs (fig. 36 and 37). This hafting technique could also be inferred from the Colinda point – discussed in chapter 1 – due to the incisions to secure the hafting on the base of the point (fig. 1). On point 21.1 only a few fibres of the bindings are still partly intact (fig. 38 and 39). It is unclear what sort of fibres they are. They are most likely plant fibres rather than tendons or other animal based binding material. They were tightly wrapped together, leaving no space in between. The black residue in which the bindings were pressed was compared to similar palaeoglues and seems to be tar (pers. comm. Kozowyk 2018; Langejans and Lombard 2015) This black residue seems to be preserved in nine more points in microscopic amounts captured in groves or holes.

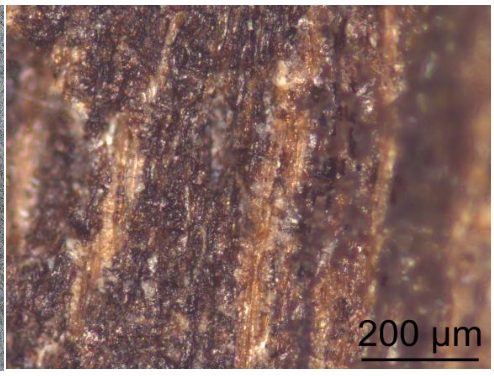
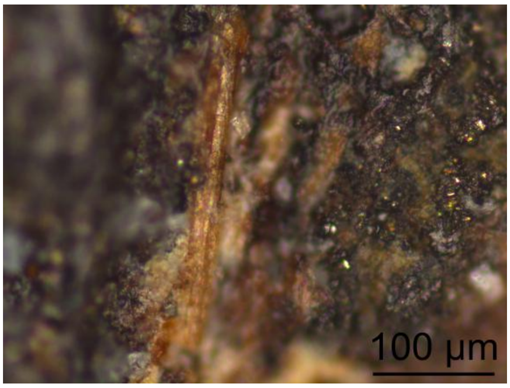


Figure 36: (left) Archaeological point 21.1 with bindingmaterial preserved.

Figure 37: (right) The preserved bindings impressed in tar, on point 21.1. Photo was made with a polarizing light metallographic microscope with a magnification of 10x.



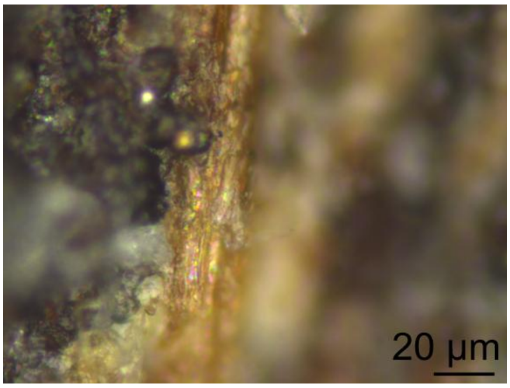


Figure 38: (left) Part of an intact fibre of the bindingmaterial of point 21.1. Photo was made with a polarizing light metallographic microscope with a magnification of 20x.

Figure 39: (right) A knot in the fibre of the bindingmaterial of point 21.1. Photo was made with a polarizing light metallographic microscope with a magnification of 50x.

Similar looking glue was also present on points from other Mesolithic sites: Starr Carr in England (Clark 1954), Pulli in Estonia (Vahur *et al*. 2011), Stanovoye 4 in Central Russia (layer IV)(Zhilin 2015, 47). The first two sites identified the black residue as birch tar. On the surface of the black residue found at the Stanovoye 4 site thin plant materials were visible (Zhilin 2015, 47). These could have belonged to bindings similar to the binding on point 21.1 from this research.

Furthermore, the parts on point 21.1 where the binding material used to be are orange/brown coloured. On three other points orange residues are visible with a rainbow coloured shine on the base of the points (fig. 40). However, the orange parts of point 21.1 do not have the same rainbow glow. Therefore, point 21.1 could not be used as a reference for the identification of the residue on those points. It is not clear what the residue is and if it is ancient or modern.

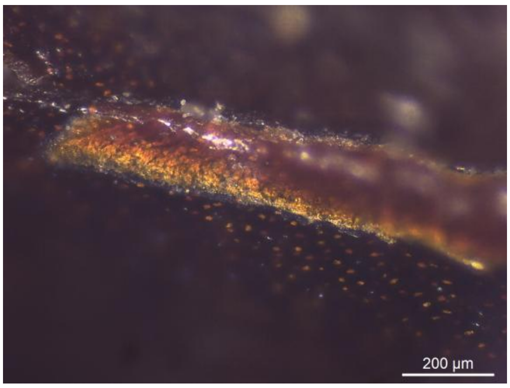


Figure 40: Orange residue on archaeological point 14.258. Photo was made with a metallographic microscope with a magnification of 10x.

Finally, there are different shapes of incisions used to produce barbs on the points. Shape incision types 1-4 (see fig. 3) only require cutting in one direction whereas the other types require cutting in two directions. However, no correlation was found between the shape of incisions and degree of wear on the points. No correlation was found between the shape of the incisions and the breakage of the tip on a barb either.

There is a correlation between the amount of reworked barbs present and the percentage of the non-hafted part of the point, as can be seen in figure 41. The chance of a reworked barb being present on a point decreases when the percentage of the non-hafted part of the point decreases. The meaning of this correlation is unclear because there is no relationship between the degree of wear and the presence of reworked barbs. Furthermore, as was already mentioned above, there is no correlation between the non-hafted part percentage and the total length of the point either. The average length of the points without reworked barbs is smaller than the average length of points with reworked barbs: 41,2mm in comparison to 45,5mm (1 reworked barb) and 47,6mm (2 reworked barbs). Since the smaller points are assumed to have had a longer use-life with more repairs, the absence of reworked barbs could be explained by this. The reworking of the tip could have resulted in the further grinding of the reworked barbs. The more intensive use would have resulted in more rounding of the barbs, also resulting in the slow disappearing of the reworked barbs.

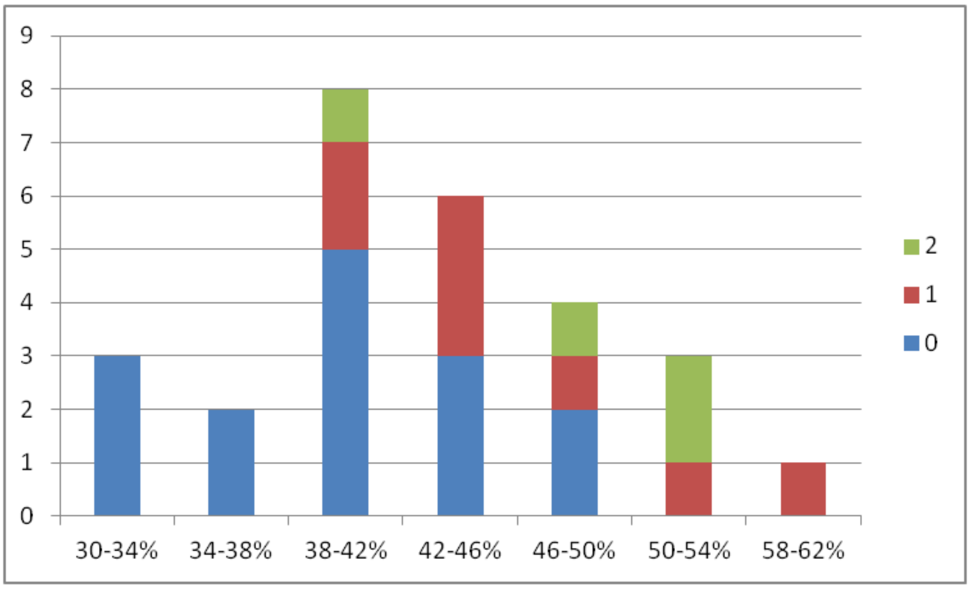


Figure 41: Stacked bar chart of the non-hafted part percentage of the point in comparison to the amount of reworked barbs present. The non-hafted part percentages have been categorized with a spread of 4%. (N=27).

5.4 Reconstructed Biographies

In order to conclude this chapter, the biographies for each of the categories will be reconstructed (fig. 42) and the biography of one individual point will be outlined as an example.

5.4.1 General Biographies of the Categories

First of all – as discussed in section 5.2 – none of the archaeological points that were studied for this research could be placed within category A (no use wear traces). This means that all points which were studied for this research were at least used once. However, it should be noted that when there is no use wear visible on archaeological points, this does not mean that they were not used (Van Gijn 1990; 2010).

If in future research archaeological points can be placed into category A, it means that they were probably not extensively used or possibly not at all. Secondly, the points which will fall within category A were probably larger than the ones studied for this research, because on 12 out of 28 of the points one or more reworked barbs are still visible on the points which were grouped into the other categories. This means that the tips of the points have been reworked at least once in order to extend their use-life, which results in the points becoming smaller. The tips could have been rejuvenated or just re-sharpened. The difference between rejuvenation and re-sharpening is – as discussed in section 2.1.3.6 – that for re-sharpening only the tip or barbs were ground whereas for rejuvenation an entire part(s) of the point would be reshaped. Thus, a part of the production process would be repeated when the point was being rejuvenated, including the production of new barbs (fig. 42).

Reworking could have taken place multiple times, each time extending the use-life of the point. However, the reworking of the point results in the point becoming smaller, meaning that it could only be reworked a finite number times. Every time the point got damaged to the extent that it was no longer usable as weapon tip a decision would have been made between rejuvenation, re-sharpening (of the tip and/or one or multiple barbs) or discarding.

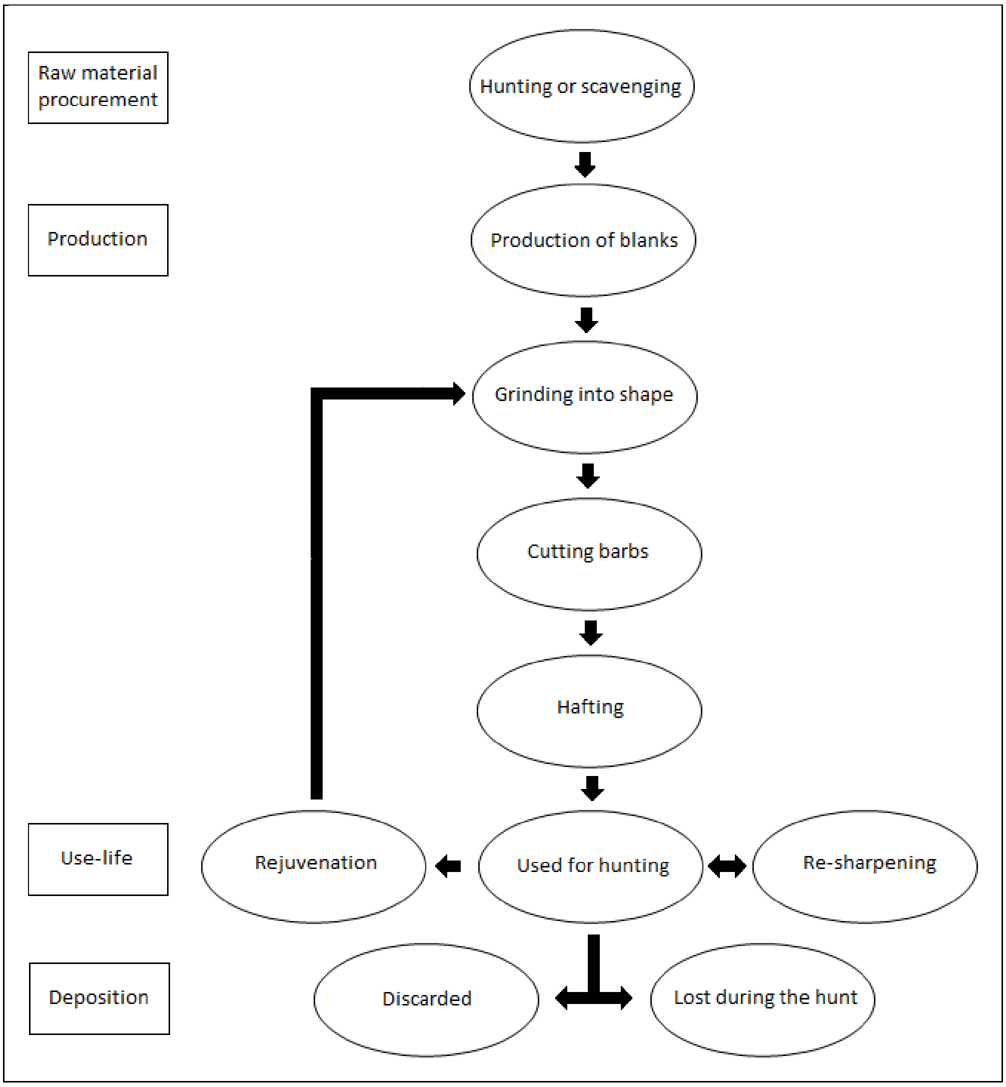


Figure 42: Flow chart of the biography of the archaeological points from this research.

The decision to not rework a point could be related to the size of the point, meaning that the point could have been too small to rework it. Furthermore, the decision could have been based on the amount of damage of the point as well. Some points could have been deposited due to the fact that too many breakages or fractures were present on the point. However, it should be noted that the decision that an object is 'unusable' is socially based as well, which will be further discussed in chapter 6.

Points in categories C and E seem no longer usable in the state they were deposited – due to the severe damage – which means that they were most likely thrown away. Categories B and D consist of points that seem still usable in the state they were deposited. This could relate to social factors, as noted above. Another reason is that these points represent points which were lost during the hunt. For example, points could have missed the target and were not recovered or the animal run off with the arrow still inside.

5.4.2 Biography of an Individual Point (14.56)

In this section the complete biography of point 14.56 (fig 43; find number in appendix A) will be outlined in order to give an impression of the long life of these artifacts.

Figure 43: Archaeological point 14.56.

5.4.2.1 Raw Material and Production

Point 14.56 was made of bone. It cannot be determined what bone was used or from what animal because the point is only 28,93mm in length, 6,57mm in maximum width and 3,39mm in maximum thickness. It is the smallest complete point from Mesolithic Doggerland, weighing only 0,9gr.

Manufacturing traces are still visible on the point. The point was ground into shape and then the part where the barbs were going to be cut was narrowed by grinding it further. Grinding traces are still visible as long grooves all over the surface of the point. These traces are best preserved at the hafted part of the point, which starts just below the first barb from the bottom (fig. 44). The hafting border is slightly higher at the non-barb side of the point reaching a length of 16mm for the hafted-part. Furthermore, at the proximal end the cross section was made flat (fig. 45). This shaping of the proximal end can be seen on most of the points and was probably related to the hafting arrangement.

The barbs were cut with flint in an oblique direction (incision type 2 in fig. 3; fig. 46). The point in its present state has three barbs but a shallow incision just below the tip shows that there used to be a fourth barb. There is also a striation just beside the incision which could be related to reworking when the barb was removed.

Figure 44: Base of archaeological point 14.56 with well preserved manufacturing traces (grooves). A fracture runs up from the butt end to the lowest barb (indicated with arrows). Photo was made with a stereomicroscope with a magnification of 0.75x.

Figure 45: Flat grinded surface at the proximal end of the base of archaeological point 14.56. Photo was made with a stereomicroscope with a magnification of 0.75x.

5.4.2.2 Use-life and Maintenance

The reworked barb is one of the features of this point that gives an indication of its long use-life. Other features which indicate the long use-life of this point are the smooth and polished surface and the heavy rounding, all of which are most prominent on the non-hafted part of the point and especially on the tip.

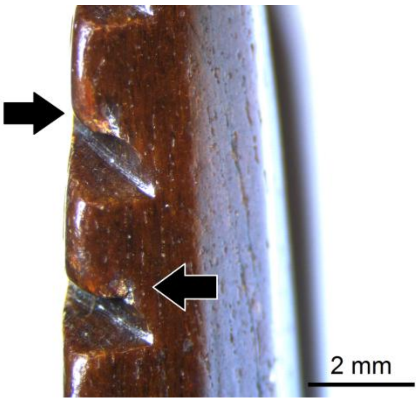


Figure 46: Two lowest barbs of archaeological point 14.56. The arrows indicate where the barbs are broken. Photo made with a stereomicroscope with a magnification of 0.75x.

Figure 47: All present barbs of archaeological point 14.56, including an reworked barb above the present barbs (indicated by the arrow). Photo made with a stereomicroscope with a magnification of 0.75x.

Furthermore, a lot of damage is visible on the point as well. The two lowest barbs are partly broken at their ends (fig. 46). The butt end of the point has impact scars in the shape of fractures across the butt end itself and fractures which run up the point (fig. 48). One of the fractures runs from the butt end up until the first barb (fig. 44) and two other fractures run from the butt end until the tip. The direction of these last two fractures cannot be identified. However, for the fracture which runs from the butt end to the first barb it can be inferred that the scar was probably caused by the impact of the shaft to the butt end of the point. Impacting the target caused the butt end of the point to impact in turn the haft, causing a fracture. Both types of fractures can be seen on most of the studied archaeological points. No such fractures were seen on the experimental points, which could mean that it takes more intensive use of the points in order to develop these types of fractures.

Figure 48: Butt end of archaeological point 14.56 with multiple impact scars in the shape of fractures. Photo was made with a stereomicroscope with a magnification of 0.75x.

In conclusion, point 14.56 has multiple indications of a long use-life: its small size; the clear border between the hafted and non-hafted part; the reworked barb; the smooth, polished and heavily rounded surface; the partly broken barbs; and the impact scars at the tips as well as the butt end. Therefore, it is inferred that this point was probably used to its full extent and was therefore grouped in category E (lot of wear and unusable). The point was probably thrown away by its owner.

5.4.2.3 Second Use-life and Deposition

However, the biography of this point – like that of many other points from Mesolithic Doggerland – did not end when it was deposited in the Mesolithic period. Every few months, new points are recovered from the beaches of Zuid-Holland by private collectors. From that moment onwards the 'second use-life' of these points starts. The points become part of a new cultural context with a new set of object/people interactions, as suggested by Hurcombe (2007, 36).

Point 14.56 was found on the beach of Rockanje on the 6th of april in 2009 by Peter Soeters, a private collector who has the largest collection of barbed bone and antler points from Mesolithic Doggerland. Points which are found from Mesolithic

Doggerland are now being exhibited by private collectors as well as museums. These points are available for research, which leads to the reconstruction of their biographies. These points become symbols of Mesolithic Doggerland and can educate people about their shared past. However, at times these points might even get 'deposited' again because of the demise of their owner. Their use-life could be prolonged if their new owner appreciates their value, but points could also be thrown away, ending their second use-life.

6. Discussion

In this chapter three subjects that need to be mentioned before coming to final conclusions in chapter 7 will be discussed. In the first section it will be discussed which social factors may have influenced people to consider a point 'unusable', leading to the discarding of the point. In section 6.2, it will be explained if the archaeological points from this research can be interpreted as expedient and/or curated points. In section 6.3, it will be explained what this means for the function of the points. In the last section, 6.4, the representativeness of the material used for this research – specifically the experimental points, experiment targets and assemblage of archaeological points – will be discussed. Furthermore, it will be explained if the results of chapter 5 are representative for the (entire) assemblage of small barbed points from Mesolithic Doggerland.

6.1 Social Factors Influencing the Deposition of Points

In chapter 5 it was discussed that the points in categories C and E were considered unusable, because they have a severely damaged tip and/or broken barbs. This damage changed the fundamental shape of the points in a way that seems less efficient. However, the decision to deem a point 'unusable' is based on the physical properties of a point as well as social factors of the owner. For example, a point can be deemed damaged to the extent that it is no longer worth repairing. Physical properties involved can be that a point has become too small to repair.

The decision to repair or deposit a point is a technological choice which is intertwined with social factors. Dobres and Hoffman (1994, 247) stated: 'Technological choices and the organization of production activities are materially grounded but intrinsically social phenomena.' Social dynamics influence technological choices, resulting in an assemblage of certain types of points, used for their intended function to a certain extent. These characteristics of the points are all reflections of culture (Lechtman and Steinberg 1979, 139). However, it should be noted that the points from the archaeological record were probably made by many different people and that the underlying values of these points could differ between cultures and individuals as well. Therefore, the decision to repair or deposit a point is based on the total value of the point in question as perceived by the owner (Hodder 2011, 163-164).

As discussed in chapter 3, Mesolithic Doggerland was a changing landscape to which people could have responded with technological innovation or change in point production. These morphological and technological choices could be made by individuals within a group: some will make different choices due to the changing environment. This results in a heterogeneous assemblage of archaeological artifacts within a group, as can be seen for the studied assemblage of Doggerland points (Dobres and Hoffman 1994, 246). Within Mesolithic Doggerland different morphological and technological choices could have resulted in groups or individuals using different shapes hafting techniques and/or incision types. As discussed in section 5.3, only one correlation was found between the length of the points and their degree of wear. It can be assumed that smaller points have had a longer use-life than larger points. Additionally, no correlations were found between the use wear of the points and their technological characteristics. This means that these morphological and technological choices were probably not based on the function the point. Therefore, it is more likely that the technological choices about the production of the points were based on social factors influencing the creator of the point, such as identity and/or tradition.

When the size (<88,5mm; Spithoven 2016, 43) of the small barbed points from Doggerland is compared to other points from Mesolithic assemblages the Doggerland points are very small in comparison. As discussed in section 1.2.3.2, some authors have even called points of this size ‘miniature points’. Only about 40 of these points have been found outside of Doggerland so far and they all belong to the Magdalenian culture (Late Paleolithic). The reason for the small size of the Doggerland points could be related to different perceptions of a point being ‘unusable’. For example, at the La Vache site in France, Langley observed that the Magdalenian people probably considered antler and bone points which reached a length of about 110mm already unusable (Langley 2015, 354). The ‘big’ barbed points from Mesolithic Doggerland are between 88,5mm and 190mm. Only 24 complete large barbed points have been found from Mesolithic Doggerland so far and half of these points are smaller than 110mm. This relative small size of the points from Mesolithic Doggerland can (partly) be explained by the duration of their use-life. As will be further discussed in the next section.

6.2 Curated versus Expedient Points

First of all, it should be noted that points do not become expedient or curated. As discussed in section 1.2.4, tools are produced and used with an estimated use-life in mind. Generally, tools which are expected to only be used for a short period of time are called expedient tools and tools which are expected to be used for a longer period of time are called curated tools (Binford 1973, 143). In order to infer if a point can be interpreted as an expedient or curated tool, features of use need to be observed.

Features that indicate that a point is curated are a high degree of use wear and maintenance features. All studied points show a high degree of use wear, even the points with the lowest use wear (category B: little wear and still usable) have developed a high degree of wear in comparison to the most intensively used experimental points (3641 and 3642). Use wear consists of rounding, the development of polish, impact scars and a clear border between the hafted and non-hafted part of the point. This border indicates that the point has been hafted for a long period of time and was probably reworked when still hafted (see section 5.3).

Furthermore, about half of the points have indications of reworked barbs present, which is a clear indication of maintenance of the points. Even the two points with the lowest degree of wear have two reworked barbs each (14.33 and 14.37 in appendix A). When the tip of the point would be re-sharpened or the point rejuvenated the length of the point would decrease. As discussed in section 5.3, a correlation was found between the degree of wear and the size of the points. Therefore, the small size of the studied points is another indication of the curation of these points.

In conclusion, it is inferred that all studied points can be interpreted as being (heavily) curated. However, some points could have been lost during the hunt or thrown away for social reasons, as discussed in section 6.1. Therefore, it should not be inferred that all studied points were used to their full technological extent.

6.3 Function of the Point

In section 1.2.3 the possible functions of the points were outlined. This research has found that the points are heavily curated, which has implications for the proposed functions of the points. First of all, it can be stated that the points were used, intensively. The fact that they were used rejects the hypothesis that these 'miniature points' – as Langley calls them – were examples of 'artisan virtuoso' (Langley 2014, 113). Secondly, the hypothesis that these points were children's toys can be rejected as the primary function because of the many impact scars on them (Politis 1998 in Langley 2014, 113; Stapert 2007). These impact scars are an indication that these points were used as weapon tips. The clear border between the hafted and non-hafted part is an indication of their use as weapon tips as well. The use as children's toys could have been a secondary function but the primary function was the use as weapon tips.

The small barbed points could have been used as big barbed points (>88,5mm) first, which could have had a different function. However, they were used and hafted for a long time as a small barbed point in order to develop the clear border between the hafted and non-hafted part and to have preserved the manufacturing traces on the hafted area. This clear hafting border is present on the small points in their present state. The hafting border – which developed due to a period of use as a big barbed point – is not visible on the small barbed points. However, the old hafting border could have disappeared due to grinding and use. Furthermore, the underrepresentation of big barbed points within the archaeological record of Mesolithic Doggerland could be an indication of the re-use of big barbed points as small barbed points. Therefore, extensive reworking could certainly not be ruled out.

6.4 Representativeness of the Research Material

Firstly, the small number of experiments conducted for this research has repercussions for the representativeness of the results. For the shooting experiment of this research only one type of point was made. Therefore, it was not possible to test if different types of point would develop different use wear. However, in chapter 5 it was shown that there is no correlation between the different types of points and the use wear present. Secondly, for each target only one expedient and one curated point were created experimentally. There is variation in wear developing on different points because each point is unique. The experimental sample is not large enough to comprehend this variation in use wear development. However, the degree of wear developing on the experimental points could be used as a reference collection for wear on the archaeological points. Thirdly, the target used as land mammal could have influenced the results of the points shot at this target. First of all, the target was not a live animal and secondly the three parts of the target were of different animals: pork meat, cow bones and deer skin. In order to improve the representativeness of the target it was tightly knotted together. Furthermore, several other types of game could have been hunted as well and were not part of the experiments, such as sea mammals and birds.

The hunting of birds with the small barbed points was suggested by Verhart (1988, 185). The hunting of sea mammals is solely based on the presence of the animals at the time of Mesolithic Doggerland. No evidence has been found yet to confirm the hunting of birds or sea mammals.

Fourthly, the archaeological points show more use wear than the experimental points, which is probably related to the intensity of use. Another explanation could be that invisible use wear on the archaeological points has further developed into visible use wear due to taphonomical processes. For example, small fractures could have developed into larger fractures.

Fifthly, the archaeological assemblage studied for this research is limited to an amount of 28 points of over 800 small antler/bone points in total. This limitation is caused by the choice for small barbed bone points, preservation state and recent chemical treatments of the points. Only untreated small barbed bone points with well-preserved surfaces were chosen for this research, as discussed in 2.1.4.

In conclusion, the experimental assemblage was small – consisting of six points of one type – but was large enough to use as a reference collection to interpret the wear on the archaeological points. For the shooting experiment not every possible target was tested. However, the differences between points which were shot at the salmon and the ones which were shot at the artificial land mammal were not visible on the archaeological points. Therefore, the target was not the most important part of the experiment. Furthermore, the archaeological points seem to have been used more than the experimental points. Therefore, the experimental points that were created to be curated should have been used for a longer period of time as well. However, the degree of wear which developed on the experimental points was sufficient to categorize the archaeological points in groups of degree of wear. Finally, the size of the studied archaeological assemblage was small in comparison to the total amount of archaeological small barbed points found. Less well-preserved points could have been studied as well, resulting in a larger assemblage. However, for this research the assemblage was large enough to provide preliminary results about the function of the small barbed bone points from Mesolithic Doggerland, which will be discussed in chapter 7, the final chapter of this thesis.

7. Conclusion

With this research a first attempt was made to thoroughly investigate the small barbed bone points from Mesolithic Doggerland. It was hypothesized in chapter 1 that the small size of the points could be related to the function of the points and local subsistence strategies. Therefore, the research question stated for this research was: '*What was the function of the Mesolithic small (<88,5mm) barbed bone points from the North Sea and what does this contribute to our understanding of subsistence strategies of the inhabitants of the North Sea Basin?*'

In order to answer this question, several sub-questions needed to be answered as well. In chapter 1, the information about the biography of the points as shown by previous research was outlined and in chapter 3 their archaeological context was discussed. For this research the use-life of the points was studied through use wear analysis of 28 archaeological small barbed bone points that originate from the North Sea Basin in front of the Dutch coast of Zuid-Holland. A shooting experiment was conducted with six experimental points of which the use wear was compared to the use wear on the archaeological points. Additionally, social factors which could have influenced the biography of the points were discussed in chapter 6.

7.1 Function

Verhart (1986) suggested that these points were lost hunting gear. From the results of the use wear analysis it can be inferred that the points are (heavily) curated weapon tips, as was discussed in chapter 6. Most points were probably used until their owner deemed them 'unusable' – meaning that the points were not worth repairing anymore in order to further extent their use-life – and were thrown away. Some small barbed points could represent lost hunting gear. These will be the largest points with the lowest degree of wear. The big barbed points (>88,5mm; Spithoven 2016, 43) could represent an assemblage of lost hunting gear as well, which could explain their underrepresentation within the archaeological record of Mesolithic Doggerland.

7.2 Subsistence Strategies

As discussed in chapter 3, the small barbed points could have been a response to the changing landscape, a way to hunt the new fauna. Stable isotopes analysis in combination with C^{14}-dating showed that the diet of the inhabitants from Mesolithic

Doggerland changed from a terrestrial to a more aquatic diet (section 3.4.1). The production of small barbed points could be related to the change in game. However, it was not possible to determine which game was hunted with these points.

Furthermore, some interpretations about subsistence strategies can be inferred from the points being curated. Binford anticipated that curated tools could be 'the best material markers of ethnic identity' (Binford 1973, 144). Therefore, the knowledge acquired by studying these points is important to understand the inhabitants of Mesolithic Doggerland.

The curation of the points suggests that the owners probably took great care of them, repairing them whenever they thought it was necessary, as was illustrated by the case study of Binford in section 1.2.4. Repairing the points would have been an important activity related to hunting.

Binford stated that curated tools would be less frequently represented in the archaeological record (Binford 1973, 144). However, these points are the most frequently found artefacts from Mesolithic Doggerland. A small area of Doggerland (fig. 8) – where the studied assemblage is from – yielded already about 800 of these small barbed points. If the studied assemblage is representative for the entire assemblage, then all points from Mesolithic Doggerland are curated. This large-scale curation in combination with their use as weapon tips suggests that these points are some of the most produced and used artefacts found within the archaeological record of Mesolithic Doggerland. Therefore, it can be inferred that hunting was an important subsistence strategy.

Verhart (1986) suggested that the small barbed points were used as arrowheads, which would make hunting with bow and arrow the main hunting strategy for the inhabitants of Mesolithic Doggerland. The small size of the points makes them a better fit as arrowheads than larger points because of the compatibility of their shape with arrow shafts and the fact that they are significantly lighter than big points. Furthermore, the points would easily break when they hit a hard surface, such as bones from land mammals or stones in the water. Since the points are used for a long period of time they were probably shot with high accuracy, which makes the use of a bow more likely (section 4.1). However, no clear indications could be found to differentiate between weapon types based on the use wear on the points.

7.3 Review Methodology and Future Research

The representativeness of this research was discussed in chapter 6. The research strategy was sufficient to provide new results about the function of the small barbed bone points from Mesolithic Doggerland and the subsistence strategies of its inhabitants, as discussed above. However, some aspects of the methodology could be improved in future research.

The results of the shooting experiment would have been more useful if the experimental points were shot many times more, in order to improve the comparability with the heavily curated archaeological points. Furthermore, it would have been more representative if the land mammal was an actual deer instead of an artificial land mammal because the structure of the target would have been truer to the potential original game. Additionally, different game should be tested as targets of the points, such as birds.

The archaeological assemblage would be more representative of the research area if it had been larger and consisted of antler as well as bone points. In future research the less well-preserved points and big barbed points should be studied as well, even if they provide less detailed information on their use-life.

Furthermore, other methods could be applied to further study the biography of the points, such as C^{14}-dating to confirm if the small barbed points are of the Mesolithic period and ZooMS (ZooArchaeology by Mass Spectrometry) to identify the animal species of the material. Both studies are already planned to be conducted in the near future.

Summary

This research attempted to answer the following question: '*What was the function of the Mesolithic small (<88,5mm) barbed bone points from the North Sea and what does this contribute to our understanding of subsistence strategies of the inhabitants of the North Sea Basin?*'

In order to answer this question an assemblage of 28 archaeological small barbed bone points – that originate from the North Sea in front of the Dutch coast of Zuid-Holland – was studied. This thesis started in chapter 1 with an outline of research that was already conducted on these points by Verhart (1986; 1988; 2000) Tsiopelas (2010) and Spithoven (2016). Thereafter, it was explained in chapter 2 how the research was conducted: literature research, experimental archaeology and use wear analysis. In chapter 3, it was outlined how these points fit within the archaeological context: Mesolithic Doggerland. The shooting experiment conducted for this research was discussed in chapter 4 and in chapter 5 the results of this experiment were compared with the results of the use wear analysis. The use wear analysis was conducted on 28 archaeological points in comparison to six experimental points from the shooting experiment. In chapter 6, the social factors which could have influenced the life history of the points were discussed, as well as their function and the representativeness of this research. In the concluding chapter of this thesis (7) the research question was answered followed by a review of the used methods and suggestions for future research.

The function of the small barbed bone points from Mesolithic Doggerland could be inferred from the use wear analysis. The points are all (heavily) curated weapon tips. They have developed a high degree of wear and about half of the studied points have remains of reworked barbs present as well. The research area is only a small area of Mesolithic Doggerland which already yielded about 800 of these small barbed bone/antler points. The curation of these points, the function as weapon tips and the overrepresentation within the archaeological record of Mesolithic Doggerland suggests that these weapons were used very frequently. Therefore, it can be inferred that hunting was one an important subsistence strategy. The most used hunting weapon could have been the bow and arrow because the small points are interpreted as arrowheads. However, the use wear analysis could not confirm that the points were specifically used as arrowheads.

Samenvatting

Het doel van dit onderzoek was om de volgende vraag te beantwoorden: ‘Wat was de functie van de mesolithische kleine (<88,5mm) benen spitsen met weerhaken van de Noordzee en wat draagt dit bij aan ons begrip van levensonderhoud strategieën van de bewoners van het Noordzeebekken?’

Om deze vraag te beantwoorden zijn er 28 archeologische kleine benen spitsen met weerhaken onderzocht die afkomstig zijn uit de Noordzee voor de kust van Zuid-Holland. Deze scriptie begon in hoofdstuk 1 met een samenvatting van eerder onderzoek naar deze spitsen door Verhart (1986; 1988; 2000) Tsiopelas (2010) en Spithoven (2016). Vervolgens werd in hoofdstuk 2 uitgelegd hoe het onderzoek was uitgevoerd: literatuuronderzoek, experimentele archeologie en gebruikssporen analyse. In hoofdstuk 3 werd de archeologische context van deze spitsen besproken: mesolithisch Doggerland. Het schietexperiment dat is uitgevoerd voor dit onderzoek werd behandeld in hoofdstuk 4 en in hoofdstuk 5 werden de resultaten van dit experiment vergeleken met de resultaten van de gebruikssporen analyse. De gebruikssporen analyse werd uitgevoerd op 28 archeologische spitsen in vergelijking met zes experimentele spitsen. In hoofdstuk 6 werden de sociale factoren besproken die de levensgeschiedenis van de spitsen kunnen hebben beïnvloedt, evenals de functie van de spitsen en de representativiteit van dit onderzoek. In het concluderende hoofdstuk (7) werd de onderzoeksvraag beantwoord, met daarop volgend een evaluatie van de gebruikte methoden en suggesties voor toekomstig onderzoek.

De functie van de spitsen kon worden afgeleid van de gebruikssporen analyse. Al deze spitsen zijn (zwaar) ‘*curated*’ wapenpunten. Op de spitsen bevindt zich een hoge mate van slijtage en ongeveer de helft van de onderzochte spitsen zijn nog overblijfselen van bijgewerkte weerhaken zichtbaar. Het onderzoeksgebied van deze scriptie is slechts een klein gebied van mesolithisch Doggerland waar al bijna 800 van deze kleine spitsen met weerhaken zijn gevonden. De ‘*curation*’ van deze spitsen, de functie als wapenpunten en de oververtegenwoordiging in het archeologisch bodembestand suggereert dat deze wapens relatief vaak werden gebruikt. Hieruit kan worden afgeleid dat jagen een van de belangrijkste levensonderhoud strategieën was. Het meest gebruikte jachtwapen zou dan de pijl en boog kunnen zijn geweest, omdat de kleine spitsen worden geïnterpreteerd als pijlpunten. Het gebruik van de kleine spitsen als pijlpunten kon echter niet worden bevestigd door middel van gebruikssporen analyse.

Bibliography

Amkreutz, L.W.S.W., 2013. *Persistent Traditions. A Long-Term Perspective on Communities in the Process of Neolithisation in the Lower Rhine Area (6000–2500 cal BC).* Leiden: Sidestone Press.

Amreutz, L., A. Verpoorte, A. Waters-Rist, M. Niekus, V. van Heekeren, A. van der Merwe, H. van der Plicht, J. Glimmerveen, D. Stapert and L. Johansen, 2018. What lies beneath: Late Glacial human occupation of the submerged North Sea landscape. *Antiquity* 92 361, 22-37.

Arndt, S. and M. Newcomer, 1986. Breakage patterns of prehistoric bone points: an experimental study, in D. Roe (ed), *Studies in the Upper Palaeolithic of Britain and Northwest Europe*. Oxford: British Archaeological Reports, International Series 296, 165-173.

Bailey, G.N., 2007. The Palaeogeography of the North Sea Basin, in C. Waddington and K. Pedersen (eds), *Mesolithic Studies In The North Sea Basin And Beyond: Proceedings of a Conference held at Newcastle in 2003*. Oxford: Oxbow Books, 3-11.

Bailey, G.N. and P. Spikins (eds), 2008. *Mesolithic Europe*. Cambridge: Cambridge University Press.

Ballin, T.B., 2017. Rising waters and processes of diversification and unification in material culture: the flooding of Doggerland and its effect on north-west European prehistoric populations between ca. 13 000 and 1500 cal BC. *Journal of Quaternary Science* 32(2), 329-339.

Barton, R.N.E., Berridge, P.J., Walker, M.J.C., Bevins, R.E., 1995. Persistent places in the Mesolithic landscape: An example from the Black Mountain uplands of South Wales. *Proceedings of the Prehistoric Society* 61, 81–116.

Bergman, C. and M. Newcomer, 1983. Flint arrowhead breakage: examples from Ksar Akil, Lebanon. *Journal of Field Archaeology* 10, 238-243.

Bergman, C.A., 1987. Hafting and use of bone and antler points from Ksar Akil, Lebanon, in, D. Stordeur-Yedid (ed), La Main et l'Outil: Manches et Emmanchements Préhistorique. *Travaux de la Maison de l'Orient* 15, 117–126.

Binford, L.R., 1973. Interassemblage Variability: The Mousterian and the 'Functional Argument', in C. Renfrew (ed), *The Explanation of Culture Change: Models in Prehistory: Proceedings of a Meeting of the Research Seminar in Archaeology and Related Subjects Held at the University of Sheffield*. London: Duckworth, 131-153.

Binford, L.R., 1976. Forty-seven Trips, in E.S. Hall (ed), *Contributions to Anthropology: Interior Peoples of Northern Alaska*. Ottawa: Archaeological Survey Canada Paper 49, 299-350.

Binford, L.R., 1977. Forty-seven Trips: A Case Study in the Character of Archaeological Formation Processes, in R.V.S. Wright (ed), *Stone Tools as Cultural Markers: Change, Evolution and Complexity*. Canberra: Australian Institute of Aboriginal Studies, 24-36.

Binford, L.R., 1979. Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3), 255-273.

Bondevik, S., J.I. Svendsen, G. Johnsen, J. Mangerud and P.E. Kaland, 1997. The Storegga tsunami along the Norwegian coast, its age and runup. *Boreas* 26, 29-53.

Bradfield, J.B., 2012a. A comparison of three Later Stone Age bone point assemblages from South Africa. *South African Archaeological Bulletin* 67, 32-43.

Bradfield, J.B., 2012b. Macrofractures on bone-tipped arrows: analysis of hunter-gatherer arrows in the Fourie collection from Namibia. *Antiquity* 86, 1179-1191.

Bradfield, J.B. and T. Brand, 2015. Further tests of the macrofracture method: results of utilitarian and accidental breakage experiments on bone points. *Journal of Anthropological and Archaeological Science* 7, 27-38.

Bradfield, J.B., 2016. Fracture analysis of bone tools: a review of the micro-CT and macrofracture methods for studying bone tool function, in S. Vitezović (ed), *Close to the bone: current studies in bone technologies*. Belgrade: Institute of Archaeology, 71-79.

Bryn, P., K. Berg, C.F. Forsberg, A. Solheim and T.J. Kvalstad, 2005. Explaining the Storegga Slide. Marine and Petroleum. *Geology* 22, 11-19.

Buc, N. 2011. Experimental series and use-wear in bone tools. *Journal of Archaeological Science* 38, 546-557.

Campana, D., 1980. An Analysis of the Use-Wear Patterns on Natufian and Protoneolithic bone Implements. New York (unpublished PhD thesis of Colombia University, University Microfilm International).

Cattelain, P., 1997. Hunting during the Upper Paleolithic: Bow, Spearthrower, or Both?, in H. Knecht (ed), *Projectile technology*. New York: Plenum Press, 213-240.

Churchill, S.E., 2008. Weapon Technology, Prey Size Selection, and Hunting Methods in Modern Hunter-Gatherers: Implications for Hunting in the Palaeolithic and Mesolithic. *Archeological Papers of the American Anthropological Association* 4(1), 11-24.

Christenson, A.L., 1997. Side-notched and Unnotched Arrowpoints, in H. Knecht (ed), *Projectile technology*. New York: Plenum Press, 131-142.

Clark, J.G.D., 1936. *The Mesolithic Settlement of Northern Europe*. Cambridge: Cambridge University Press.

Clark, J.G.D., 1954. *Excavations at Star Carr*. Cambridge: Cambridge University Press.

Coles, B.J., 2000. Doggerland: the cultural dynamics of a shifting coastline, in K. Pye and J.R.L. Allen (eds), *Coastal and Estuarine Environments: sedimentology, geomorphology and geoarchaeology.* London: The Geological Society of London. Special Publications 175, 393-401.

Crombé, P., J. Sergant, E. Robinson and J. De Reu, 2011. Hunter-gatherer responses to environmental change during the Pleistocene-Holocene transition in the southern North Sea basin: Final Palaeolithic-Final Mesolithic land use in northwest Belgium. *Journal of Anthropological Archaeology* 30, 454-471.

Crombé, P., 2016. Forest fire dynamics during the early and middle Holocene along the southern North Sea basin as shown by charcoal evidence from burnt ant nests. *Vegetation History and Archaeobotany* 25, 311-321.

Crosby, A.W., 2002. *Throwing Fire: Projectile Technology Through History*. Cambridge: Cambirdge University Press.

Deeben, J. and N. Arts, 2005. Van jagen op de toendra naar jagen in het bos. Laat paleolithicum en vroeg-mesolithicum, in L.P. Louwe Kooijmans, P.W. van den Broeke, H. Fokkens and A. van Gijn (eds), *Nederland in de Prehistorie*, Amsterdam: Uitgeverij Bert Bakker, 139-156.

Dickson, D.B., 2001. *Western European Mesolithic, in Peregrine, P.N. and M. Ember. Encyclopedia of prehistory. Vol. 4: Europe*. College Station, Texas: Texas A&M University, 436-444.

Dobres, M. and C.R. Hoffman, 1994. Social Agency and the Dynamics of Prehistoric Technology. *Journal of Archaeological Method and Theory* 1(3), 211-258.

Dusseldorp, G.L., 2010. Prey choice during the South African Middle Stone Age: avoiding dangerous prey or maximising returns? *African Archaeological Review* 27, 107-133.

Elliott, B.J., 2009. *Artefact biographies of the Star Carr barbed points.* York (unpublished MA thesis of the University of York).

Faith, J.T., 2008. Eland, buffalo, and wild pigs: were Middle Stone Age humans ineffective hunters? *Journal of Human Evolution* 55, 24-36.

Fischer, A., P. Vemming Jansen and P. Rasmussen, 1984. Macro and microwear traces on lithic projectile points: experimental results and prehistoric examples. *Journal of Danish Archaeology* 3, 19-46.

Fischer, A., J. Olsen, M. Richards, J. Heinemeier, Á.E. Sveinbjörnsdóttir and P. Bennike, 2007. Coast - inland mobility and diet in the Danish Mesolithic and Neolithic: evidence from stable isotope values of humans and dogs. *Journal of Archaeological Science* 34, 2125-2150.

Fitch, S., V. Gaffney and K. Thomson, 2007a. The Archaeology of the North Sea Palaeolandscapes, in V. Gaffney, K. Thomson and S. Fitch (eds), *Mapping Doggerland: the Mesolithic landscapes of the Soutern North Sea*, Oxford: Archaeopress, 105-118.

Fitch, S., V. Gaffney and K. Thomson, 2007b. In Sight of Doggerland: From speculative survey to landscape exploration. *Internet Archaeology* 22, http://intarch.ac.uk/journal/issue22/3/toc.html .

Friis-Hansen, J., 1990. Mesolithic cutting arrows: functional analysis of arrows used in the hunting of large game. *Antiquity* 64: 494-504.

Frison, G. 1989. Experimental use of Clovis weaponry and tools on African elephants. *American Antiquity* 54, 766-784.

Gaffney V., K. Thomson and S. Fitch (eds), 2007. *Mapping Doggerland: the Mesolithic Landscapes of the Southern North Sea*. Oxford: Archaeopress.

Gaffney, S. Fitch and D. Smith, 2009. *Europe's Lost World: the Rediscovery of Doggerland*. York: Council for British Archaeology.

Gijn, A.L. van, 1990. The wear and tear of flint: principles of functional analysis applied to Dutch Neolithic assemblages. *Analecta praehistorica Leidensia* 22. Leiden: Institute of Prehistory Leiden.

Gijn, A.L. van, 2005. A functional analysis of some late Mesolithic bone and antler implements from the Dutch coastal zone, in H. Luik, A.M. Choyke, C.E. Batey and L. Lougas (eds), *From Hooves to Horns, from Mollusc to Mammoth: manufacture and use of bone artefacts from prehistoric times to the present*. Oxford: Oxbow Books, 47-67.

Gijn, A.L., 2014. Science and interpretation in microwear studies. *Journal of Archaeological Science* 48, 166-169.

Gibbard, P., 2007. Palaeogeography: Europe cut adrift. *Nature* 448(7151), 259-260.

Glimmerveen, J., D. Mol and J. van der Plicht, 2006. The Pleistocene reindeer of the North Sea - initial palaeontological data and archaeological remarks. *Quaternary International* 142-143, 242-246.

Gosden, C. and Y. Marshall, 1999. The cultural biography of objects. *World Archaeology* 31(2), 169-178.

Griffin, P.B., 1997. Technology and Variation in Arrow Design among the Agta of Northeastern Luzon, in H. Knecht (ed), *Projectile technology*. New York: Plenum Press, 267-286.

Griffitts, J. 2001. Bone tools from Los Pozos, in A.M. Choyke, and L. Bartosiewicz (eds), *Crafting Bone: Skeletal Technologies through Time and Space. Proceedings of the 2nd Meeting of the (ICAZ) Worked Bone Research Group, Budapest, 31 August – 5 September 1999*. Oxford: British Archaeological Reports, International Series 937, 185–195.

Griffitts, J. and C. Bonsall, 2001. Experimental determination of the function of antler and bone 'bevelended tools' from prehistoric shell middens in Western Scotland., in A. M. Choyke and L. Bartosiewicz (eds), *Crafting Bone: Skeletal Technologies through Time and Space. Proceedings of the 2nd Meeting of the (ICAZ) Worked Bone Research Group, Budapest, 31 August – 5 September 1999*. Oxford: British Archaeological Reports, International Series 937, 207-220.

Guthrie, R.D., 1983. Osseous projectile points: biological considerations affecting raw material selection and design among Palaeolithic and Palaeolndian peoples, in J. Clutton-

Brock and C. Grigson (eds), *Animals and Archaeology: 1. Hunters and their Prey*. Oxford: British Archaeological Report, International Series 163, 273-294.

Hayden, B., 1987. Past to present uses of stone tools and their effects on assemblage characteristics in the Maya highlands, in B. Hayden (ed), *Lithic Studies Among the Contemporary Highland Maya*. Tuscon: University of Arizona Press, 160-234.

Hebels, S., 2014. *The Diet of Mesolithic Humans: Stable isotopes from North Sea skeletal remains*. Leiden (unpublished BA thesis of the University of Leiden).

Hedges, R. E. M., R. A. Housley, I. A. Law and C. R. Bronk, 1990. Radiocarbon dates from the Oxford AMS system: Archaeometry Datelist 10. Oxford: Oxford Radiocarbon Accelerator Unit, Research Laboratory for Archaeology and the History of Art, Oxford University. *Archaeometry* 32(1), 101-108.

Heteren, S. van, J.A.C. Meekes, M.A.J. Bakker, V. Gaffney, S. Fitch, B.R. Gearey and B.F. Paap, 2014. Reconstructing North Sea palaeolandscapes from 3D and high-density 2D seismic data: An overview. *Netherlands Journal of Geosciences: Geologie en Mijnbouw* 93(1/2), 31-42.

Hodder, I., 2011. Human-thing entanglement: towards an integrated archaeological perspective. *Journal of the Royal Anthropological Institute* 17, 154-177.

Holst, D., 2010. Hazelnut economy of early Holocene hunter-gatherers: a case study from Mesolithic Duvensee, northern Germany. *Journal of Archaeological Science* 37, 2871-2880.

Hurcombe, L.M., 2007. *Archaeological Artefacts as Material Culture*. Abingdon: Routledge.

Ingold, T., 2000. *The Perception of the Environment. Essays in Livelihood, Dwelling and Skill*. London: Routledge.

Ingold, T., 2007. Materials against materiality. *Archaeological Dialogues* 14(1), 1-16.

Lovis, W.A., R. Whallon and R.E. Donahue, 2006. Introduction to Mesolithic mobility, exchange, and interaction: A special issue of the *Journal of Anthropological Archaeology 25*, 175-177.

Keeley, L.H., 1974. Techniques and methodology in micro-wear studies: a critical review. *World Archaeology* 5, 323-336.

Keeley, L.H., 1980. Not less than two, not more than three. *World Archaeology* 12, 166-180.

Kitagawa, K., M. Julien, O. Krotova, A.A. Bessudnov, M.V. Sablin, D. Kiosak, N. Leonova, B. Plohenko and M. Patou-Mathis, 2018. Glacial and post-glacial adaptations of hunter-gatherers: Investigating the late Upper Paleolithic and Mesolithic subsistence strategies in the southern steppe of Eastern Europe. *Quaternary International* 465, 192-209.

Knecht, H. (ed), 1997. *Projectile technology*. New York: Plenum Press.

Knecht, H., 1997. Introduction Part IV: Ethnoarchaeological Perspectives, in H. Knecht (ed), *Projectile technology*. New York: Plenum Press, 263-266.

Kopytoff, I., 1986. The cultural biography of things: commoditization as process, in A. Appadurai (ed), *The social life of things*: commodities in cultural perspective. Cambridge: Cambridge University Press, 64-91.

Langejans, G.H.J. and M. Lombard, 2015. About small things and bigger pictures: An introduction to the morphological identification of micro-residues on stone tools, in J. Marreiros, M. Gibaja Bao, J. F. Ferreira and N. Bicho (eds), *Use-Wear and Residue Analysis in Archaeology*. Heidelberg: Springer, 199-219.

Langley, M.C., 2014. Magdalenian antler projectile point design: Determining original form for uni- and bilaterally barbed points. *Journal of Archaeological Science* 44, 104-116.

Langley, M.C., 2015. Investigating maintenance and discard behaviours for osseous projectile points: A Middle to Late Magdalenian (c. 19,000–14,000 cal. BP) example. *Journal of Anthropological Archaeology* 40, 340–360.

Lauwerier, R.C.G.M., T. van Kolfschoten and L.H. van Wijngaarden Bakker, 2005. De archeozoölogie van de steentijd, in Deeben, J., E. Drenth, M.F. van Oorsouw and L. Verhart (eds). *De steentijd van Nederland* (Archeologie 11/12). Zutphen: Stichting Archeologie, 39-66.

Lawn, B.R. and D.B. Marshall, 1979. Mechanisms of microcontact fracture in brittle solids, in B. Hayden (ed) *Lithic use wear analysis*. New York: Academic Press, 63-82.

Leary, J., 2009. Perceptions of and Responses to the Holocene Flooding of the North Sea Lowlands. *Oxford Journal of Archaeology* 28(3), 227-237.

Lechtman, H., and A. Steinberg, 1979. The history of technology: An anthropological perspective, in G. Bugliarello, and D.B. Doner (eds), *History and Philosophy of Technology.* Urbana: University of Illinois Press, 135-160.

LeMoine, C.M., 1994. Use wear on bone and antler tools from the Mackenzie delta, Northwest territories. *American Antiquity* 59(2), 316-334.

LeMoine, C.M., 1997. *Use wear analysis on bone and antler tools of the Mackenzie Inuit*. Oxford : Hedges.

Lombard, M., 2005. A method for identifying Stone Age hunting tools. *South African Archaeological Bulletin* 60, 115-120.

Louwe Kooijmans, L.P., C.E. Vermeeren and A.M.I. van Waveren, 2001. Artefacten van hout en vezels, in L.P. Louwe Kooijmans (ed), *Archeologie in de Betuwerout: Hardinxveld-Giessendam Polderweg. Een mesolithisch jachtkamp in het rivierengebied (5500-5000 v. Chr.)*. Rapportage Archeologische Monumentenzorg 83. Utrecht: NS Railindrabeheer B.V., 379-418.

Louwe Kooijmans, L.P., 2007. The Gradual Transition to Farming in the Lower Rhine Basin, in A. Whittle and V. Cummings (eds), *Going over: The Mesolithic-Neolithic Transition in north-West Europe Vol. 144*. Oxford: Oxford University Press, 287-309.

Louwe Kooijmans, L.P., 2009. The agency factor in the process of Neolithisation: a Dutch case study. *Journal of Archaeology in the Low Countries* 1, 27-54.

Lovis, W.A., R. Whallon and R.E. Donahue, 2006. Social and spatial dimensions of Mesolithic mobility. *Journal of Anthropological Archaeology* 25, 271-274.

Miller, R., E. McEwen and C. Bergman, 1986. Experimental approaches to ancient Near Eastern archery. *World Archaeology* 18, 178-95.

Milner, N., 2012. Destructive events and the impact of climate change on Stone Age coastal archaeology in North West Europe: past, present and future. *Journal of Coastal Conservation* 16, 223-231.

Milner, N., C. Conneller, and B. Taylor, 2018a. *Star Carr Volume 1: A Persistent Place in a Changing World*. York: White Rose University Press.

Milner, N., C. Conneller, and B. Taylor, 2018b. *Star Carr Volume 2: Studies in Technology, Subsistence and Environment*. York: White Rose University Press.

Mol, D., K. Post, J.W.F. Reumer, J. van der Plicht, J. de Vos, B. van Geel, G. van Reenen, J.P. Pals, J. Glimmerveen, 2006. The Eurogeul—first report of the palaeontological, palynological and archaeological investigations of this part of the North Sea. *Quaternary International* 142-143, 178-185.

Mol, D., J. de Vos, R. Bakker, B. van Geel, J. Glimmerveen, J. van der Plicht and K. Post, 2008. *Kleine encyclopedie van het leven in het Pleistoceen: mammoeten, neushoorns en andere dieren van de Noordzeebodem*. Diemen: Veen Magazines.

Mol, D., 2016. Mammoth fossils recovered from the seabed between the British isles and the European continent. *Bulletin du Musée d’Anthropologie préhistorique de Monaco* 6, 129-142.

Momber, G., 2011. Submerged landscape excavations in the Solent, southern Britain: climate change and cultural development, in Benjamin, J., Bonsall, C., Pickard, C. and Fischer, A. (eds*), Submerged Prehistory*. Oxford: Oxbow Books, 85-98.

Moree, J.M. and M.M. Sier (eds), 2015. *Interdisciplinary Archaeological Research Programme Maasvlakte 2, Rotterdam : Twenty meters deep! The mesolithic period at the Yangtze Harbour site - Rotterdam Maasvlakte, the Netherlands*. BOORrapporten 566. Bureau Oudheidkundig Onderzoek Rotterdam: Rotterdam.

Neer, W. van, Ervynck, A., Lentacker, A., 2005. Features: archaeozoological analyses, in P. Crombé (ed), *The Last Hunter–Gatherer–Fishermen in Sandy Flanders (NW Belgium): The Verrebroek and Doel Excavation Projects. Part 1*: *Palaeoenvironment, Chronology and Features.* Gent: Archaeological Reports Ghent University 3, 279-294.

Nelson, M.C., 1997. Projectile Points: Form, Function, and Design, in H. Knecht (ed), *Projectile technology*. New York: Plenum Press, 371-384.

Newcomer, M.H., 1974. Study and Replication of Bone Tools from Ksar Akil (Lebanon). *World Archaeology* 6(2), 138-153.

Noe-Nygaard, N., 1974. Mesolithic hunting in Denmark illustrated by bone injuries caused by human weapons. *Journal of Archaeological Science* 1(3), 217-224.

O'Connor, S., Robertson, G. and K.P. Aplin, 2014. Are osseous artefacts a window to perishable material culture? Implications of an unusually complex bone tool from the Late Pleistocene of East Timor. *Journal of Human Evolution* 67, 108-119.

O'Driscoll, C.A. and J.C. Thompson, 2014. Experimental projectile impact marks on bone: implications for identifying the origins of projectile technology. *Journal of Archaeological Science* 49, 398-413.

Odell, G.H and F. Odell-Vereecken, 1980. Verifying the reliability of lithic use wear assessments by blind tests: the low-power approach. *Journal of Field Archaeology* 7, 87-120.

Olsen, S.L. and P. Shipman, 1988. Surface Modification on Bone: Trampling versus Butchery. *Journal of Archaeological Science* 15, 535-553.

Outram, A.K., 2008. Introduction to Experimental Archaeology. *World Archaeology* 40 (1): Experimental Archaeology, 1-6.

Pargeter, J. and J. Bradfield, 2012. The effects of Class I and II sized bovids on macrofracture formation and tool displacement: Results of a trampling experiment in a southern African Stone Age context. *Journal of Field Archaeology* 37(3), 238-251.

Peeters, H. and M.J.L.Th. Niekus, 2005. Het Mesolithicum in Noord-Nederland, in Deeben, J., E. Drenth, M.F. van Oorsouw and L. Verhart (eds), *De steentijd van Nederland* (Archeologie 11/12). Zutphen: Stichting Archeologie, 201-234.

Peeters, J.H.M. and K.M. Cohen, 2014. Introduction to North Sea submerged landscapes and prehistory. *Netherlands Journal of Geosciences*: Geologie en Mijnbouw 93(1/2), 3-5.

Peeters, J.H.M. and G. Momber, 2014. The southern North Sea and the human occupation of northwest Europe after the Last Glacial Maximum. *Netherlands Journal of Geosciences: Geologie en Mijnbouw* 93(1/2), 55-70.

Plew, M.G. and J.C. Woods, 1985. Observation of edge damage and technological effects on pressure-flaked stone tools, in M.G. Plew, J.C. Woods and M.G. Pavesic (eds), *Stone tool analysis. Essays in honor of Don C. Crabtree*. Albuquerque: University of New Mexico Press, 211-228.

Plicht, J. van der, L.W.S.W. Amkreutz, M.J.L.Th. Niekus, J.H.M. Peeters and B.I. Smit, 2016. Surf'n Turf in Doggerland: Dating, stable isotopes and diet of Mesolithic human remains from the southern North Sea. *Journal of Archaeological Science*: Reports 10, 110-118.

Pokines J. and M. Krupa, 1997. Self-Barbed Antler Spearpoints and Evidence of Fishing in the Late Upper Paleolithic of Cantabrian Spain, in H. Knecht (ed), *Projectile technology*. New York: Plenum Press, 371-384.

Reynolds, P.J., 1999. The Nature of Experiment in Archaeology, in A.F. Harding (ed), *Experiment and Design in Archaeology*. Barnsley: Oxbow Books, 156-162.

Rots, V. and H. Plisson, 2014. Projectiles and the abuse of the use-wear method in a search for impact. *Journal of Archaeological Science* 48, 154-165.

Semenov, S.A. and M.W. Thompson, 1964. *Prehistoric technology: an experimental study of the oldest tools and artefacts from traces of manufacture and wear*. London : Cory, Adams & Mackay.

Shott, M., 1989. On Tool-Class Use Lives and the Formation of Archaeological Assemblages. *American Antiquity* 54, 9-30.

Shott, M.J., 1996. An Exegesis of the Curation Concept. *Journal of Anthropological Research* 52(3), 259-280.

Smits, L., van der Plicht, J., 2009. Mesolithic and Neolithic human remains in the Netherlands: physical anthropological and stable isotope investigations. *Journal of Archaeology in the Low Countries* 1, 58-85.

Spithoven, M., 2016. *Spitsen van been en gewei uit Zuid-Holland, Nederland: Een typologische intra-site vergelijking*. Leiden (unpublished BA thesis of the University of Leiden).

Stapert, D., 2007. Neanderthal children and their flints. *Journal of archaeology of Northwest Europe* 1(2), 16-39.

Sturt, F., 2015. From sea to land and back again: understanding the shifting character of Europe's landscapes and seascapes over the last million years, in H. Anderson-Whymark, D. Garrow and F. Sturt (eds), *Continental Connections: Exploring Cross-Channel Relationships from the Mesolithic to the Iron Age*. Oxford, Oxbow Books, 7-27.

Torrence, R., 1983. Time budgeting and hunter-gatherer technology, in G.N. Bailey (ed), *Hunter-gatherer economy in prehistory: a European perspective*. Cambridge: Cambridge University Press, 11-22.

Towner, R.H. and M. Warburton, 1990. Projectile point rejuvenation: a technological analysis. *Journal of Field Archaeology* 17(3), 311-321.

Tringham, R., Cooper, G., Odell, G., Voytek, B. and A. Whitman, 1974. Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1(1/2), 171-196.

Tsiopelas, N., 2010. *Mesolithic bone and antler barbed points from Europoort. An experimental approach.* Leiden (unpublished Msc thesis of the University of Leiden).

Tyzzer, E.E., 1936. The "Simple Bone Point" of the Shell-Heaps of the Northeastern Algonkian Area and Its Probable Significance. *American Antiquity* 1(4), 261-279.

Vahur, S., A. Kriiska I. and Leito, 2011. Investigation of the adhesive residue on the flint insert and the adhesive lump found from the Pulli Early Mesolithic settlement site (Estonia) by MICRO-ATR-FT-IR spectroscopy. *Estonian Journal of Archaeology* 15(1), 3-17.

Vaughan, P.C., 1985. *Use-wear analysis of flaked stone tools*. Tucson: The University of Arizona Press.

Verhart, L.B.M., 1986. *Een beschrijving van mesolithische benen artefacten uit Europoort en een typo-chronologische vergelijking met noordwesteuropees materiaal.* Leiden (Unpublished MA thesis of the University of Leiden).

Verhart, L.B.M., 1988. Mesolithic barbed points and other implements from Europoort, the Netherlands, in *Oudheidkundige Mededelingen uit het Rijksmuseum van Oudheden te Leiden 68*, 1988, 145-194.

Verhart, L.B.M., 2000. The Function of Mesolithic Bone and Antler Points. *Anthropologie et Préhistoire* 111, 2000, 114-123.

Vos, P.C., F.P.M. Bunnik, K.M. Cohen and H. Cremer, 2015. A staged geogenetic approach to underwater archaeological prospection in the Port of Rotterdam (Yangtzehaven, Maasvlakte, The Netherlands): A geological and palaeoenvironmental case study for local mapping of Mesolithic lowland landscapes. *Quaternary International* 367, 4-31.

Waddington, C. (ed), 2007*. Mesolithic settlement in the North Sea basin. A case study from Howick, North-East England*. Oxford: Oxbow Books.

Ward, I. and P., Larcombe, 2008. Determining the preservation rating of submerged archaeology in the post-glacial southern North Sea: a first-order geomorphological approach. *Environmental Archaeology* 13(1), 59-83.

Ward, I., 2014. Depositional Context as the Foundation to Determining the Palaeolithic and Mesolithic Archaeological Potential of Offshore Wind Farm Areas in the Southern North Sea. *Conservation and Management of Archaeological Sites* 16(3), 212-235.

Weaver, T.D., Steele, T., Klein, R., 2011. The abundance of eland, buffalo, and wild pigs in Middle and Later Stone Age sites. *Journal of Human Evolution* 60, 309-314.

Weninger, B., R. Schulting, M. Bradtmöller, L. Clare, M. Collard, K. Edinborough, J. Hilpert, O. Jöris, M. Niekus, E.J. Rohling, B. Wagner, 2008. The catastrophic final flooding of Doggerland by the Storegga Slide tsunami. *Documenta Praehistorica* XXXV, 1-24.

Zhilin, M., 2015. Early Mesolithic bone arrowheads from the Volga-Oka interfluves, Central Russia. *Fennoscandia archaeologica* XXXII, 35-54.

Websites

www.nationalgeographic.org/maps/doggerland

www.nationalgeographic.com/magazine/2012/12/doggerland

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Appendices

Appendix A: Photos, Drawings and Data of Archaeological Points

Photos and drawings of the archaeological points are presented below. Photos are made with a Nikon D5100 camera, a stereomicroscope and sometimes with a metallographic microscope as well. All relevant data of the assemblage of archaeological points is shown in the table at the end of this appendix.

Photos and Drawings Archeological Points

Archaeological point 14.4

IIII

Use Wear Form Laboratory For Artefact Studies
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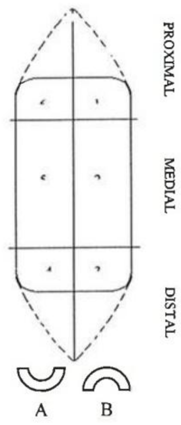


Date 31-05-2018 **Individual nr** 14-4

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

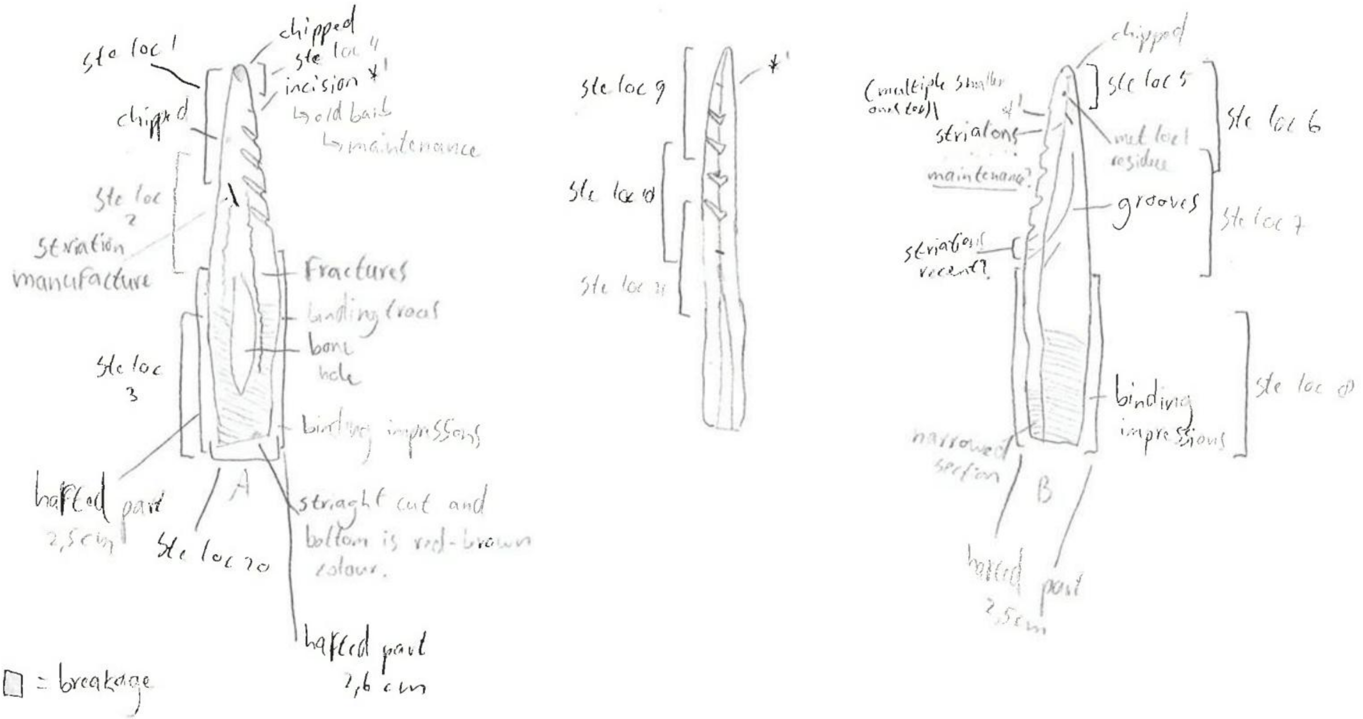
coordinate
extent
sec mod
edge angle
degree wear
motion
HP material
LP material
residue black
macro wear
directionality

Cleaning desalted

Taphonomy North Sea; beach

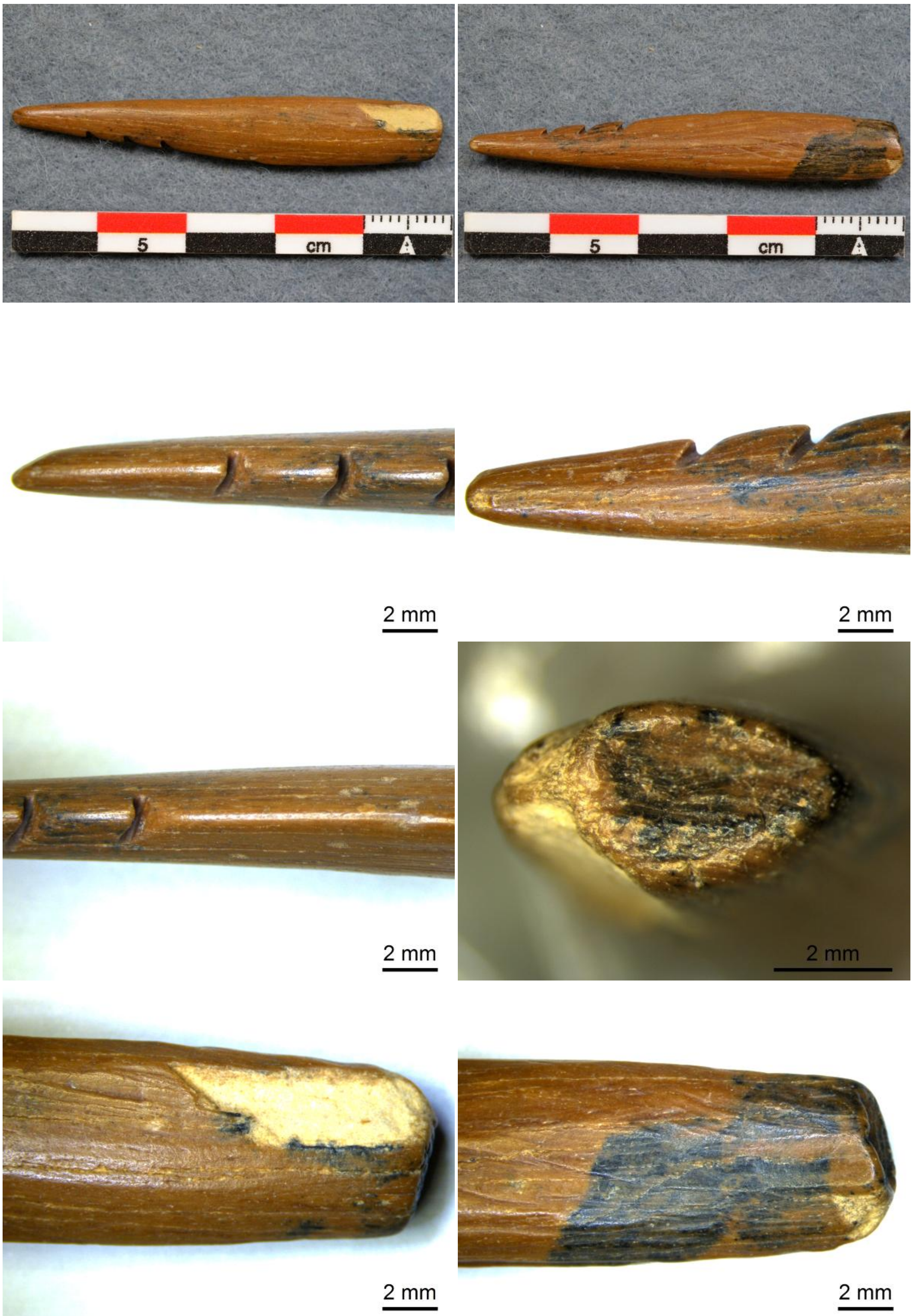
Photo/Video yes

Munsell: 10YR, 5/6 → yellowish brown



- hafting U

Archaeological point 14.5



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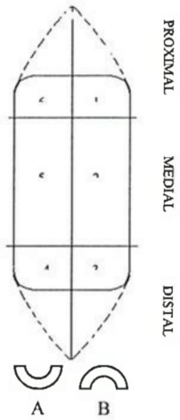


Date 28-05-2018 **Individual nr** 14-5

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

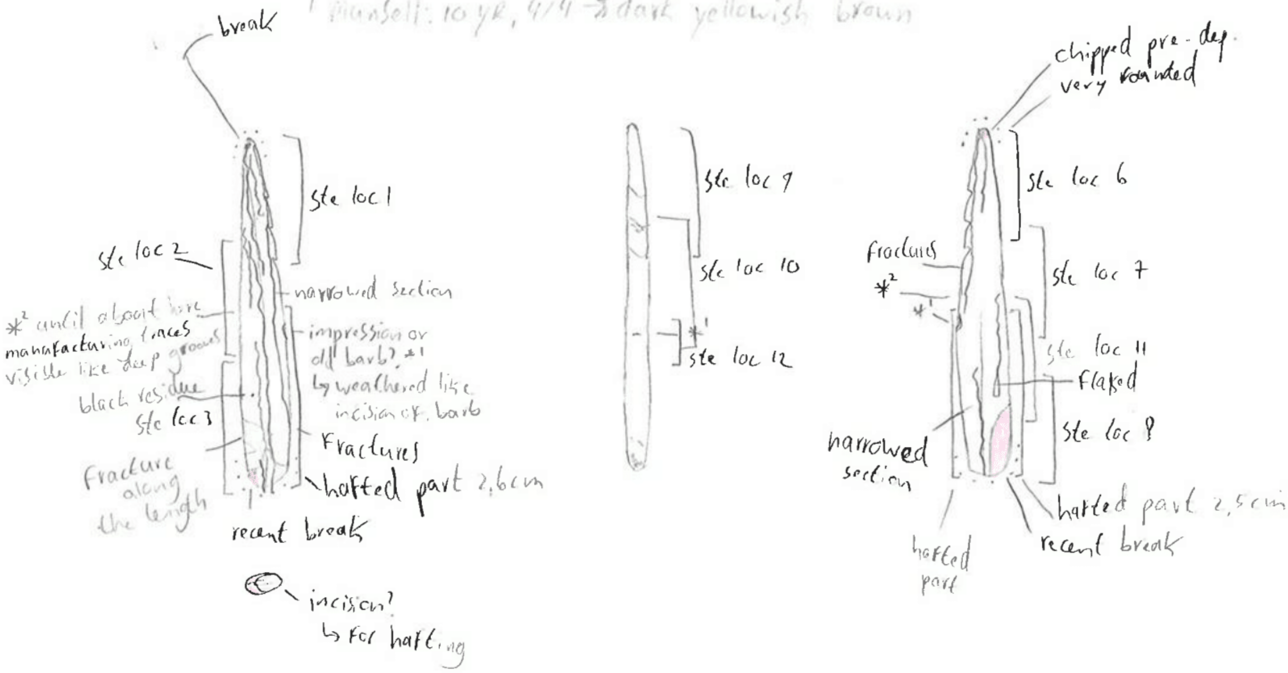
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

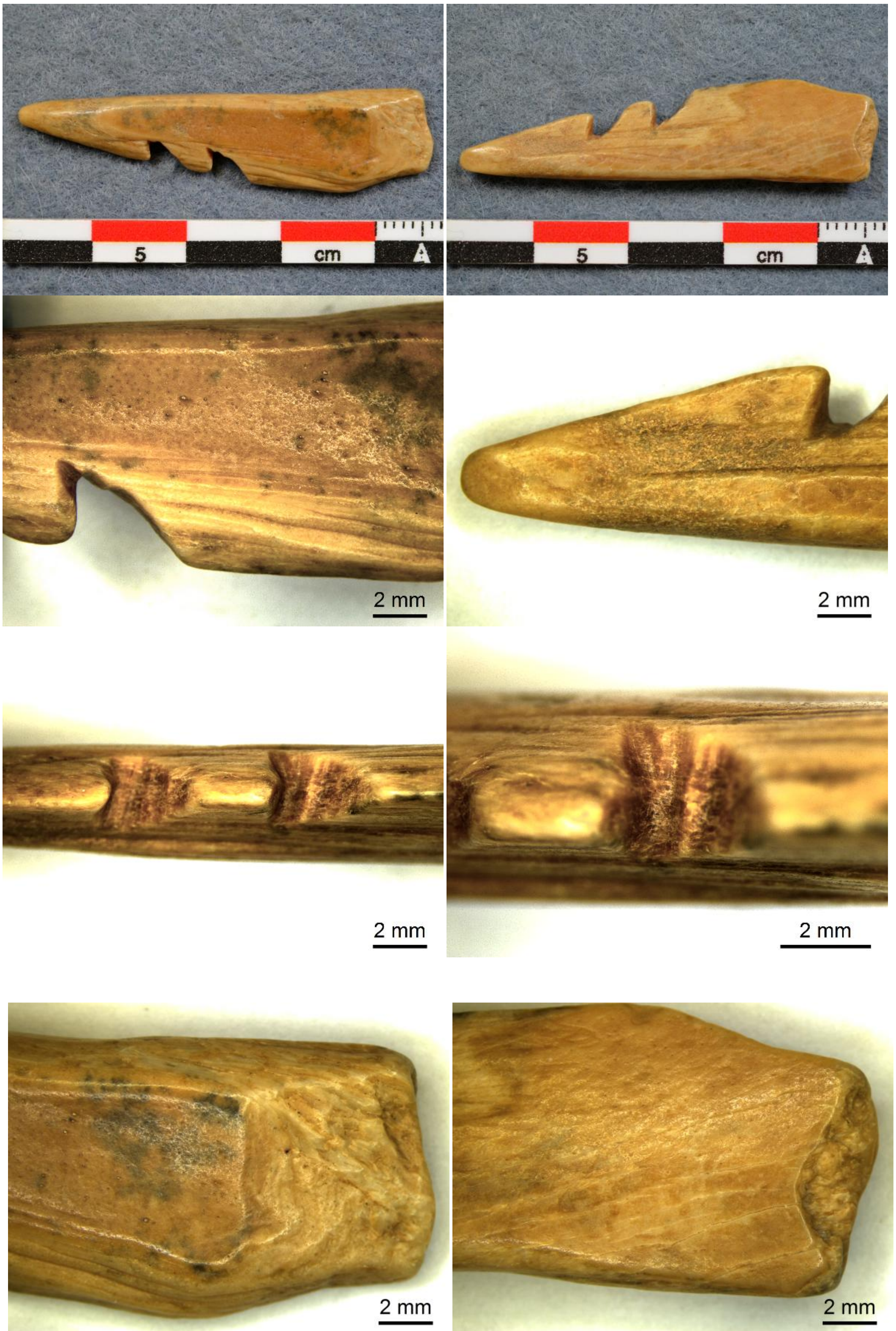
Munsell: 10 YR, 4/4 → dark yellowish brown



▢ = black residue? → met. confirms it's not
▢ = breakage

- hafting with incision

Archaeological point 14.7



III

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Date 31-05-2018 **Individual nr** 14-7

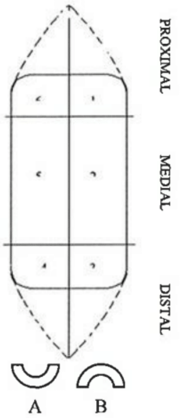
Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point



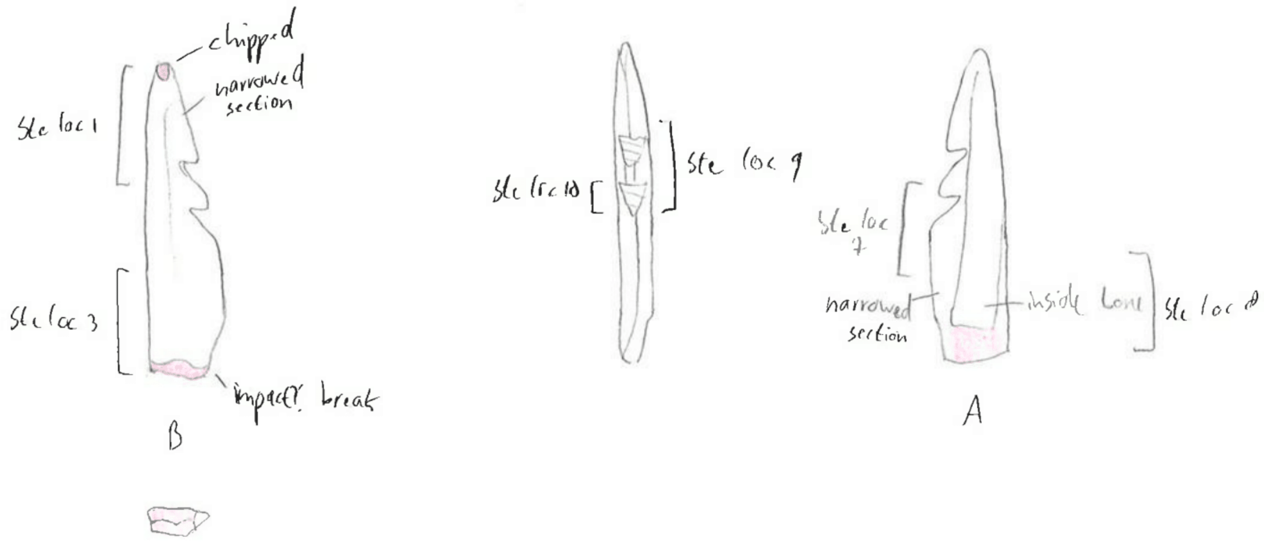
coordinate	A+B				
extent	micro in holes				
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

Cleaning U.S. bath

Taphonomy North Sea; beach

Photo/Video yes

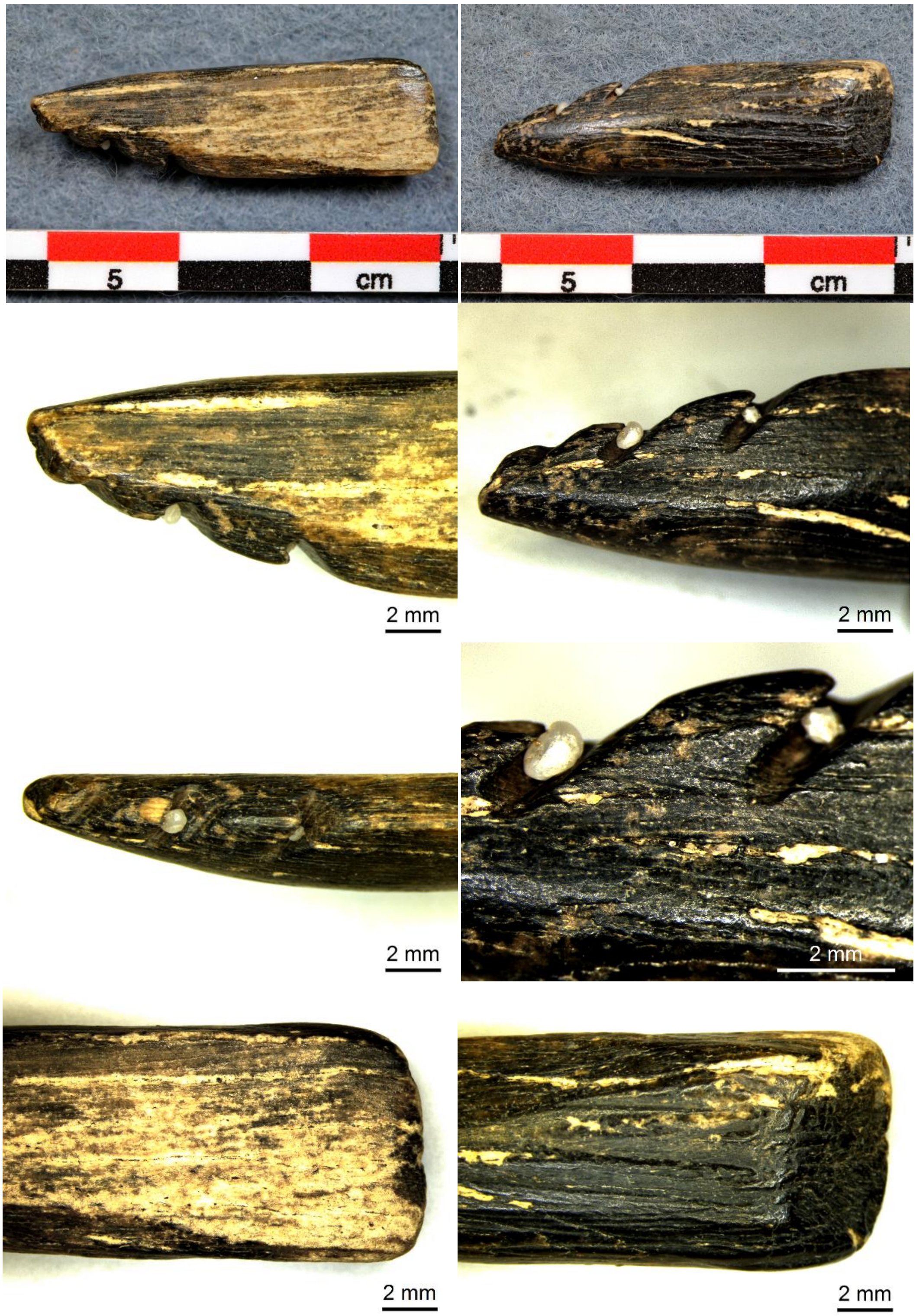
Munsell: 10 YR, 6/4 → light yellowish brown



□ = breakage

- hafting ✓ + descending

Archaeological point 14.10



III

Use Wear Form Laboratory For Artefact Studies
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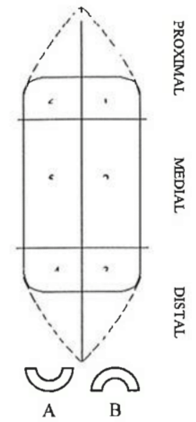


Date 29-05-2010 **Individual nr** 14:10

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Souters

Tool type: barbed point

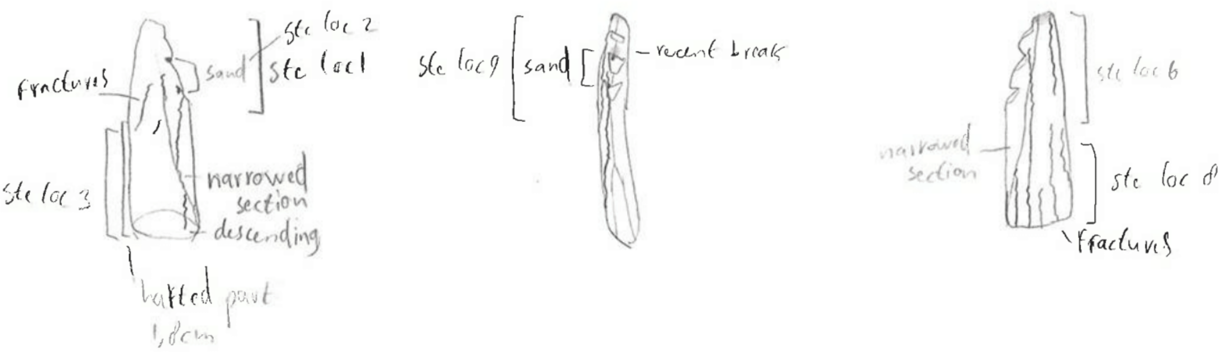
coordinate	right draw. base				
extent	in holes				
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

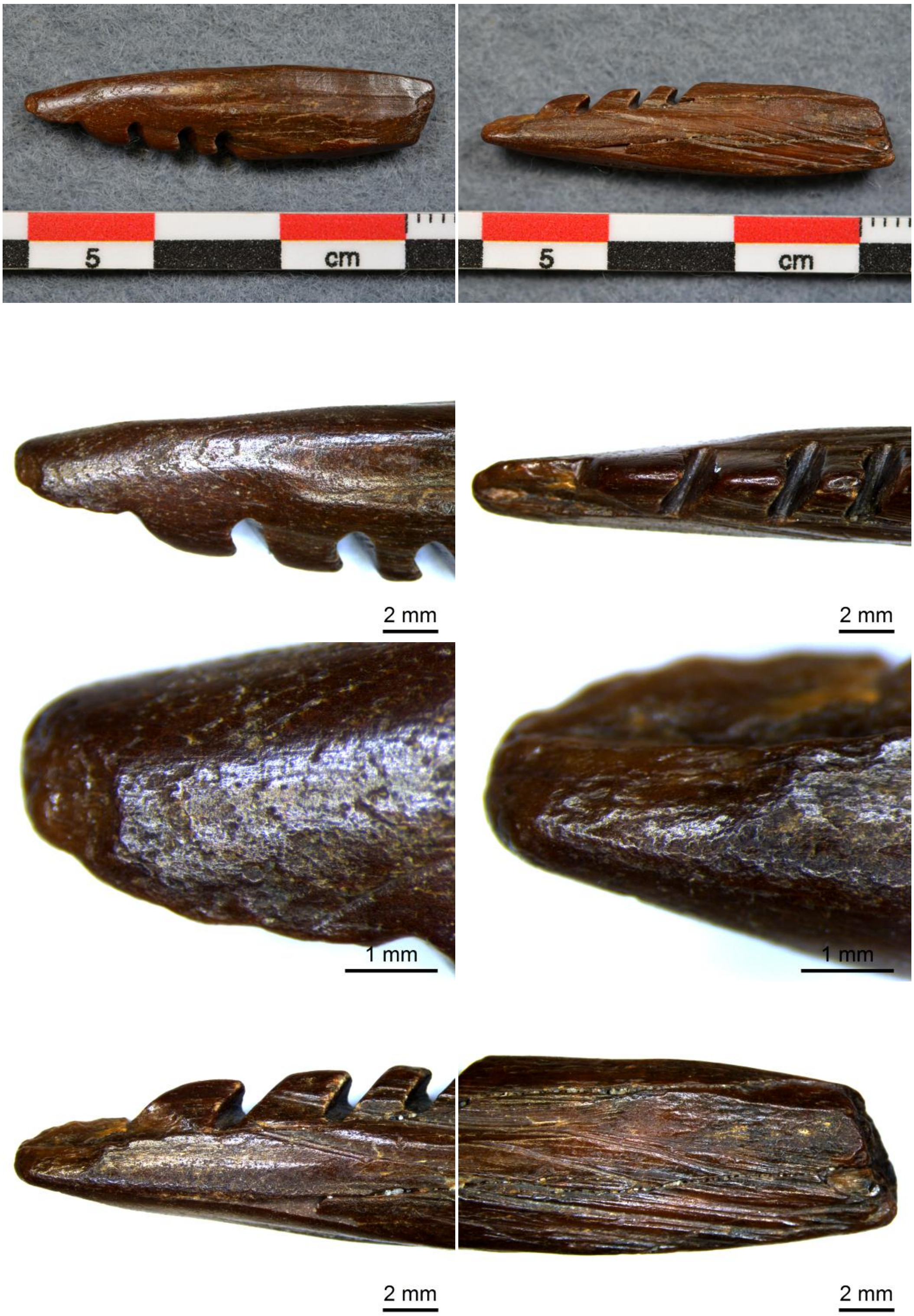
Munsell: 10YR, 3/1 → very dark gray



☐ = breakage

- hafting ↓ + descending

Archaeological point 14.11



||||

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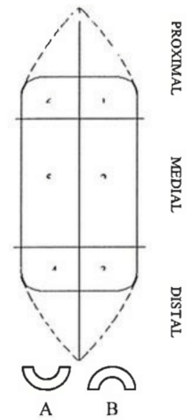


Date 30-05-2018 **Individual nr** 14-11

Analyst M Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

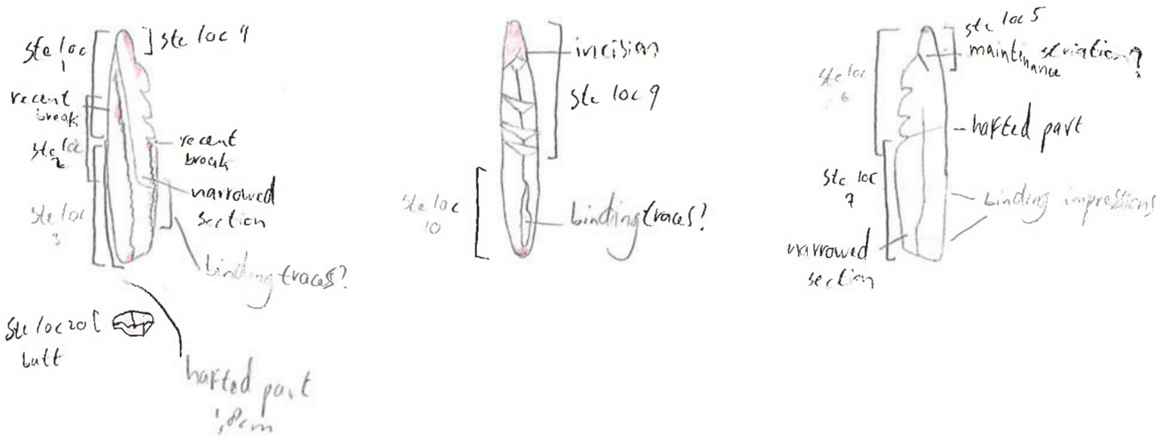
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

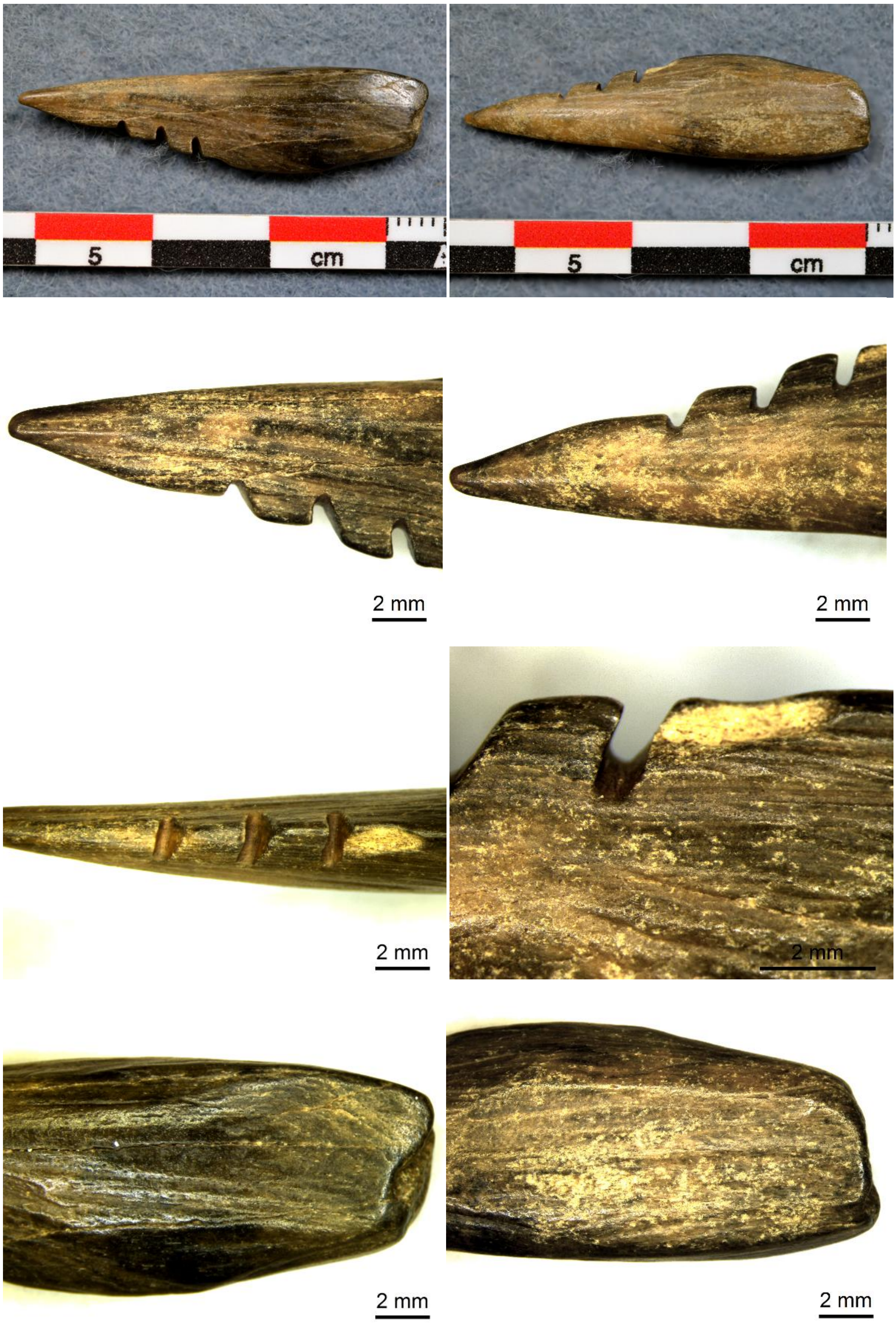
Munsell: 5YR, 4/2 → dark reddish gray



☐ = breakage

_hafting U

Archaeological point 14.13



IIII

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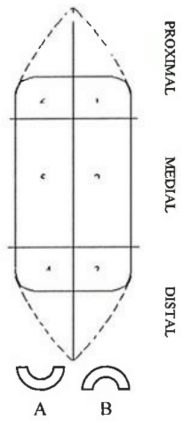


Date 29-05-2018 **Individual nr** 14-13

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soelers

Tool type: barbed point

coordinate
extent
sec mod
edge angle
degree wear
motion
HP material
LP material
residue
macro wear
directionality

Cleaning desalted

Taphonomy North Sea; beach

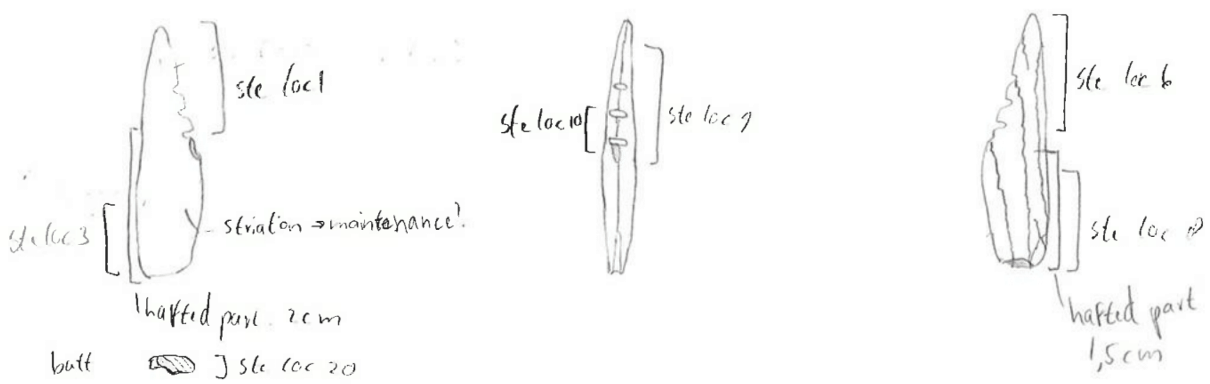
Photo/Video yes

Munsell: 2,5Y 5/2 → grayish brown

- some large fractures and recent(?) breakage

↳ base

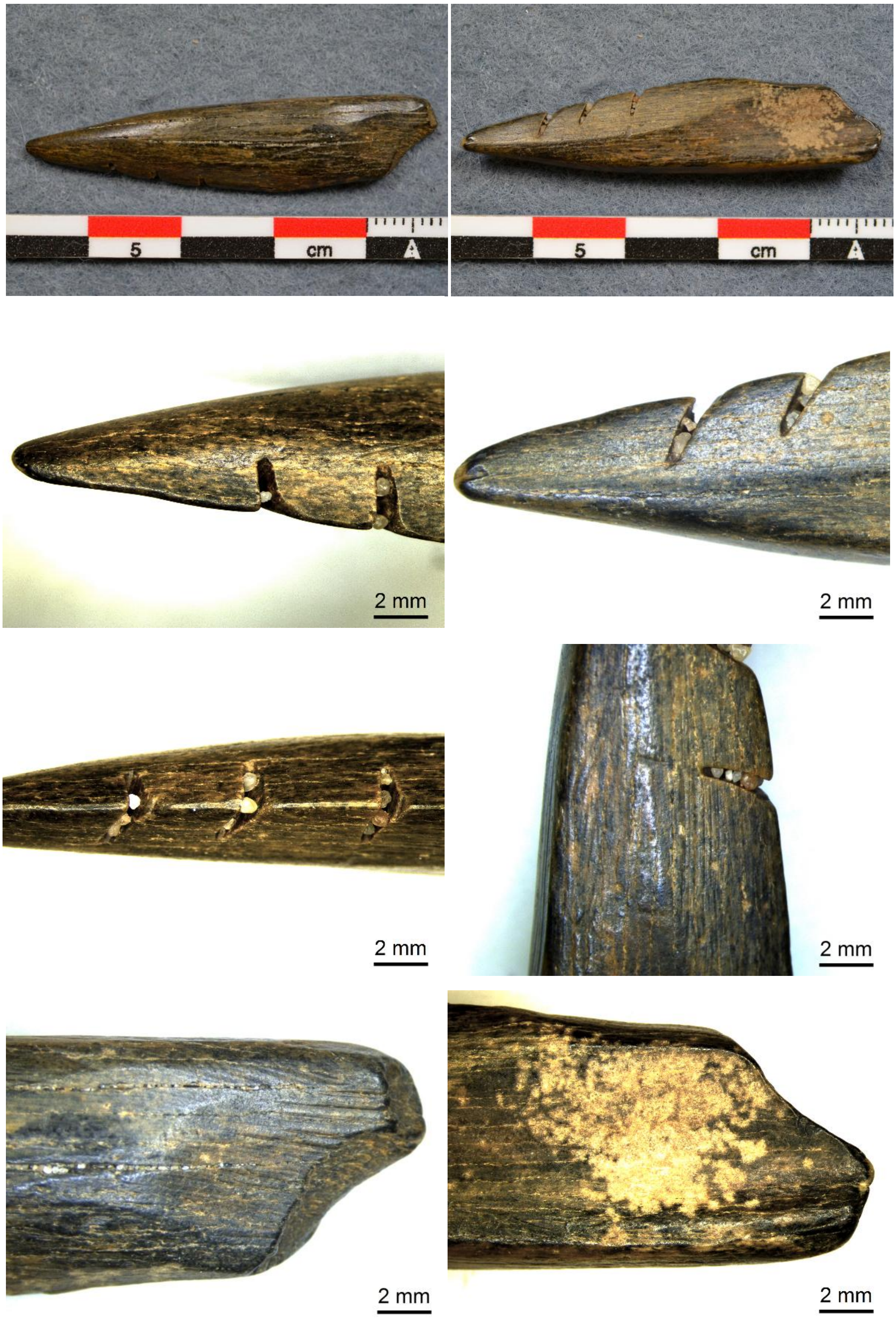
↳ sustained impact at least once



☐ = breakage

- hafting ∪

Archaeological point 14.22



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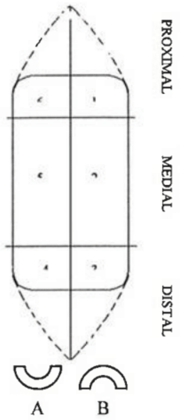


Date 30-05-2018 **Individual nr** 14-22

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

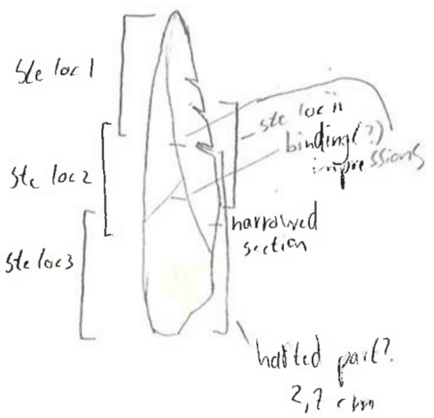
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

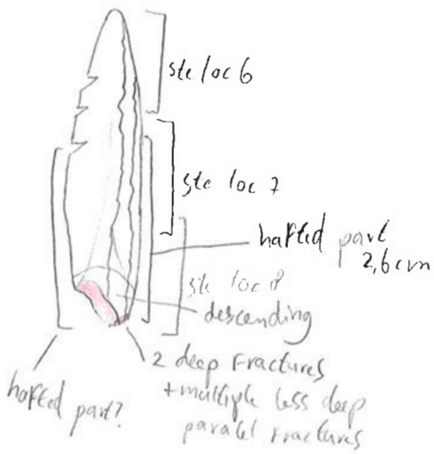
Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell: 10YR, 5/2 + 3/1 → grayish brown + very dark grey





■ = breakage
□ = residue / erosion? → corrosion

– hafting v + descending

Archaeological point 14.24

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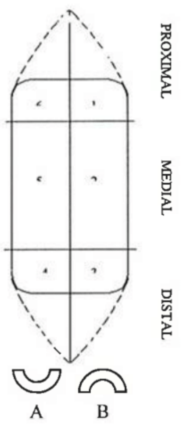


Date 29-05-2010 **Individual nr** 14-24

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

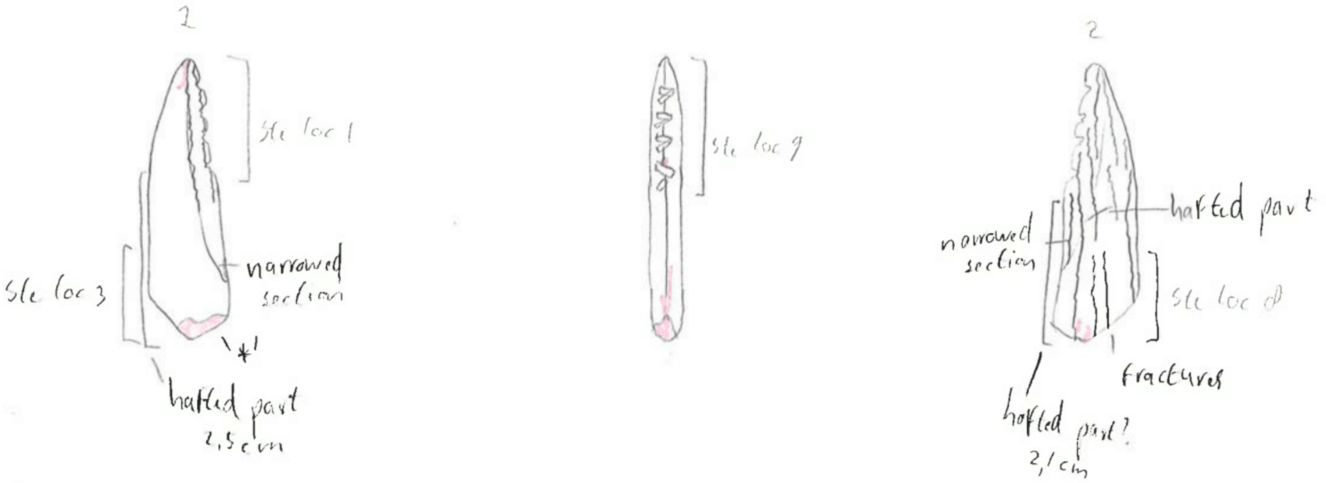
Taphonomy North Sea; beach

Photo/Video yes

Munsell 1: 5 YR, 3/2 + 4/2 → dark reddish brown + dark reddish gray
Munsell 2: 10 YR, 4/4 + 3/4 → dark yellowish brown

Ste loc 20 [

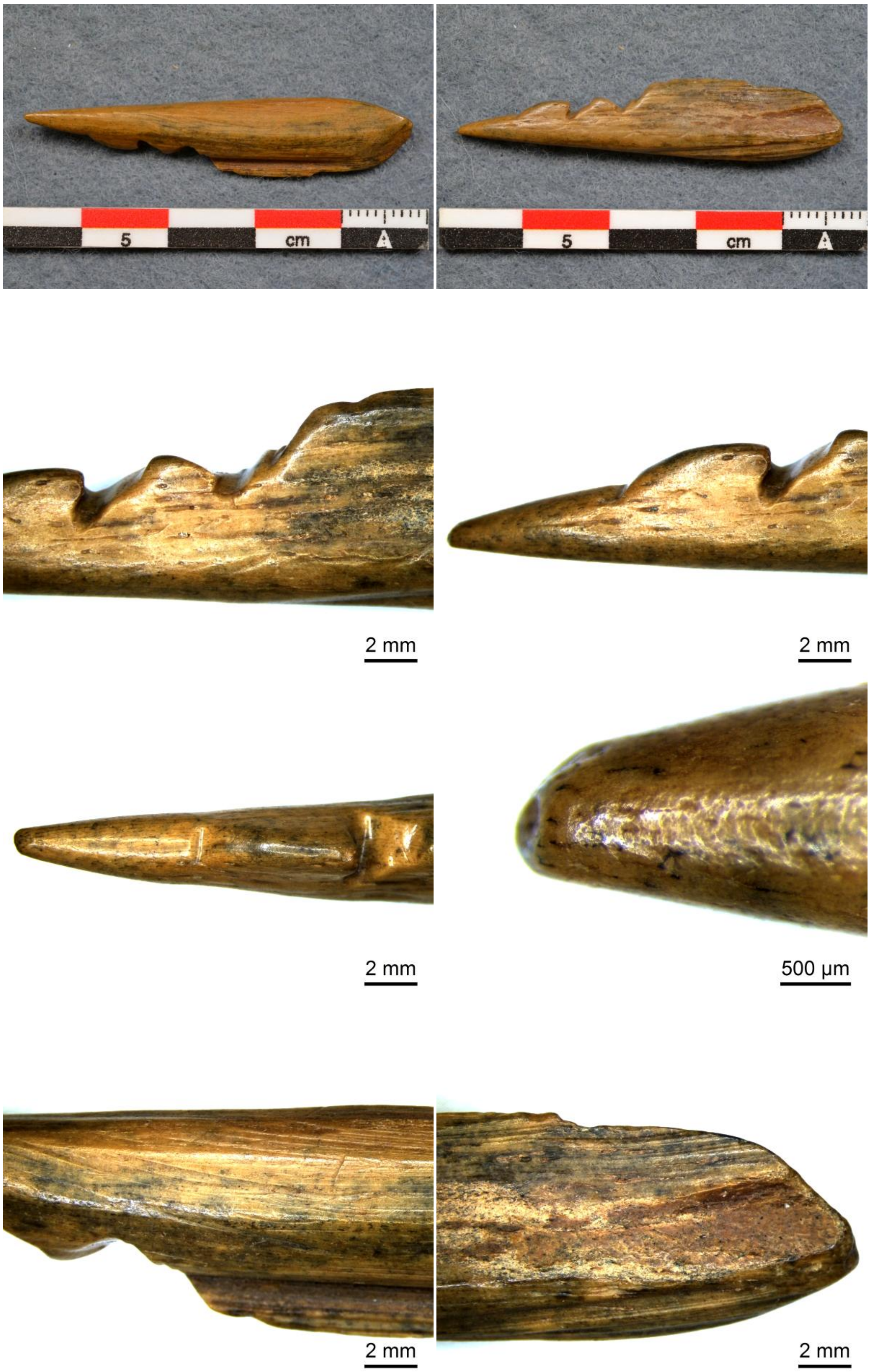
yellow is weathering = old breaks



▢ = breakage

- hafting V

Archaeological point 14.25



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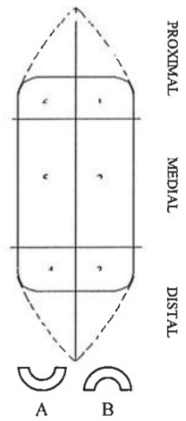


Date 01-06-2018 **Individual nr** 14-25

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

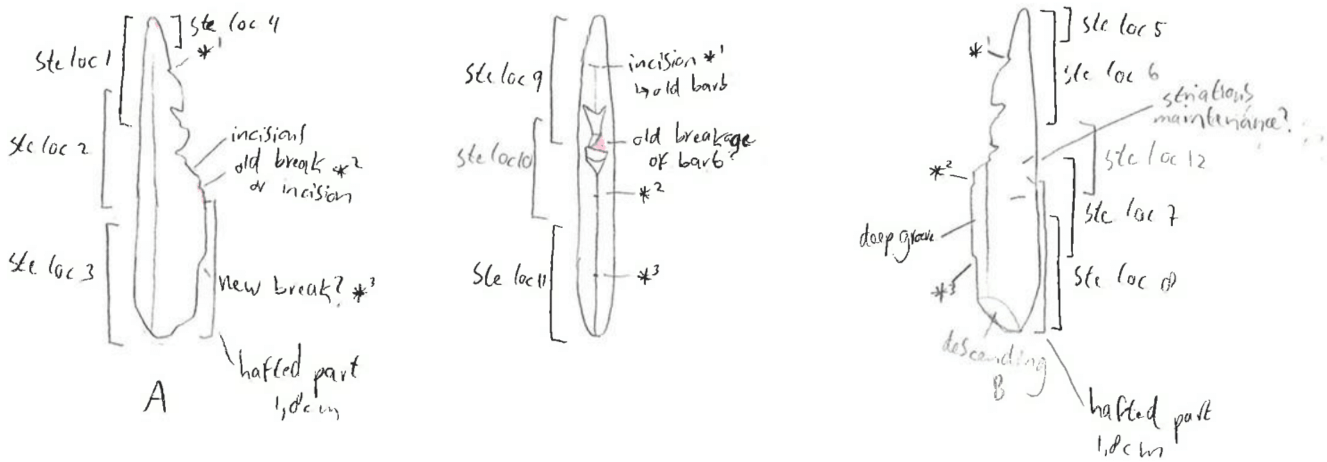
coordinate	A+B				
extent	in holes				
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

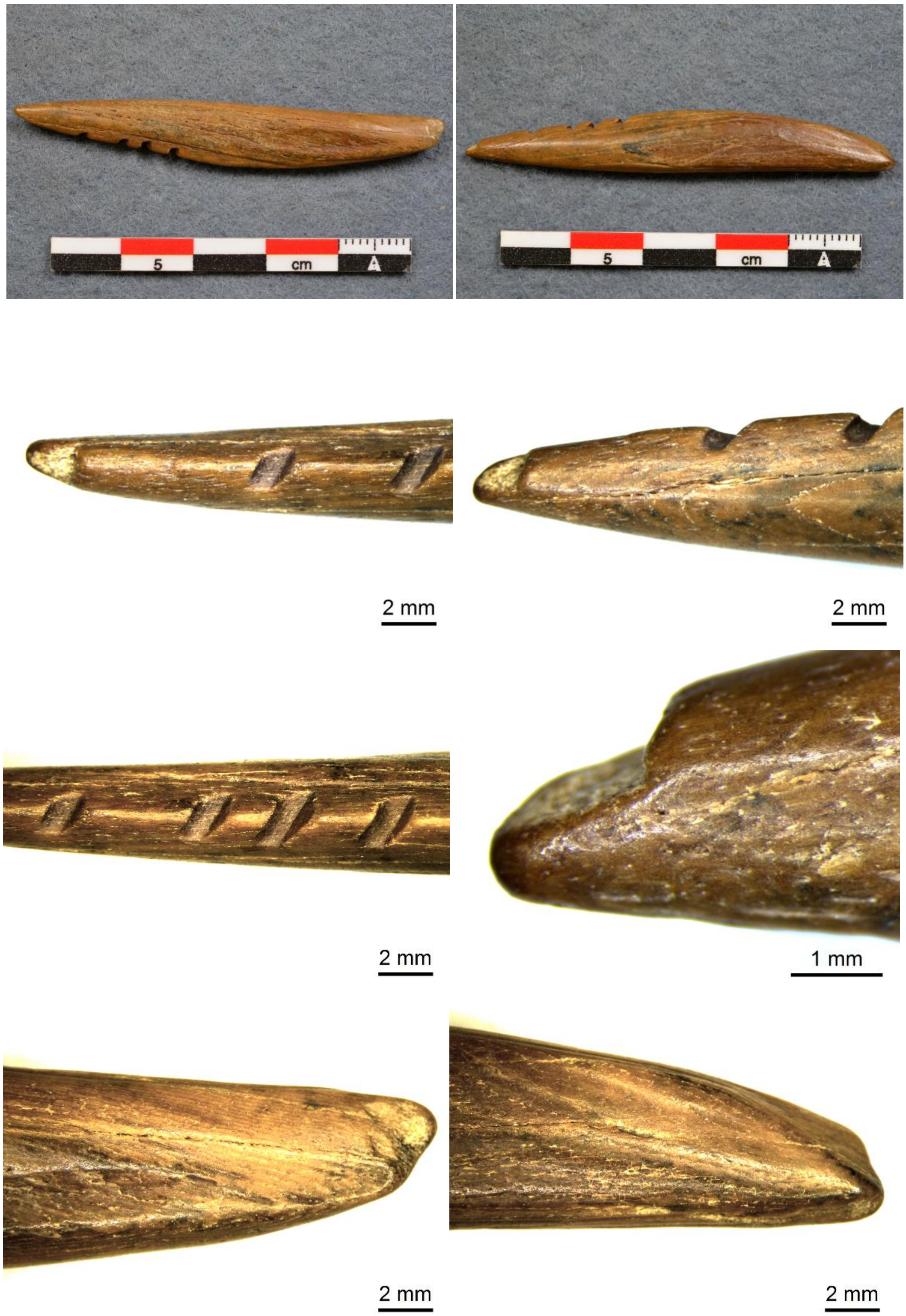
Munsell: 10 YR, 5/4 → yellowish brown



▢ = breakage

- barbs seem to have been reworked multiple times
- hafting V + descending

Archaeological point 14.27



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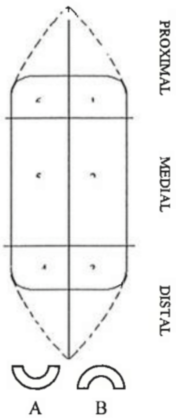


Date 01-06-2010 **Individual nr** 11-27

Analyst M. Smithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

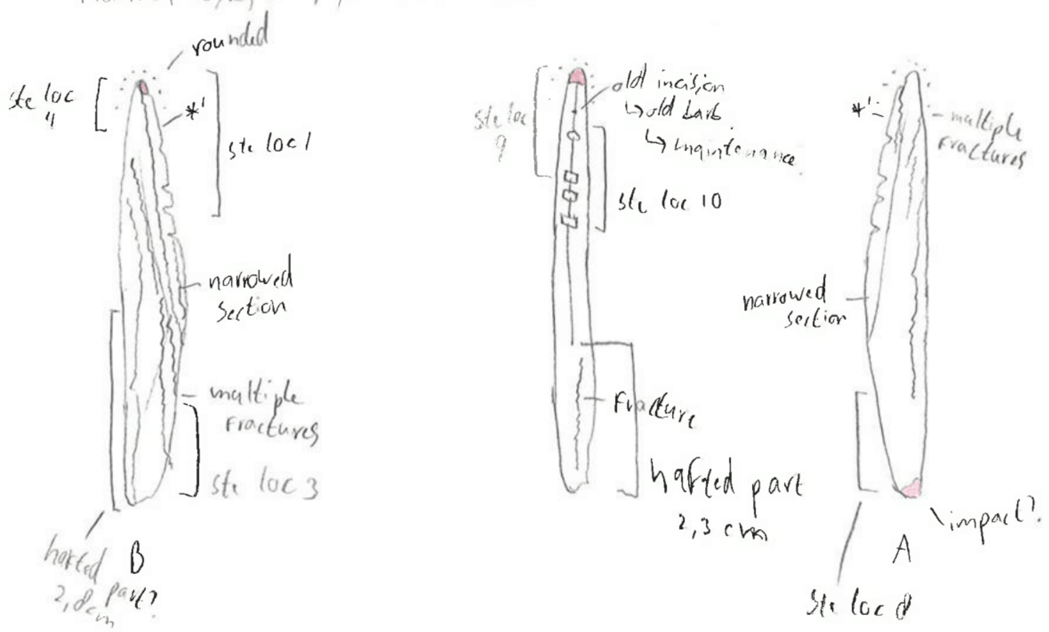
coordinate
extent
sec mod
edge angle
degree wear
motion
HP material
LP material
residue
macro wear
directionality

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell 10YR, 5/4, yellowish brown



▢ = breakage

– hafting V

Archaeological point 14.29

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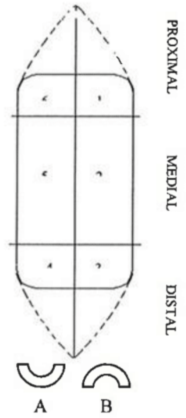


Date 29-05-2018 **Individual nr** 14-29

Analyst M. Spithoven **Site** Rockanje

Raw material Bone **Antler Teeth, Ivory, Horn**

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

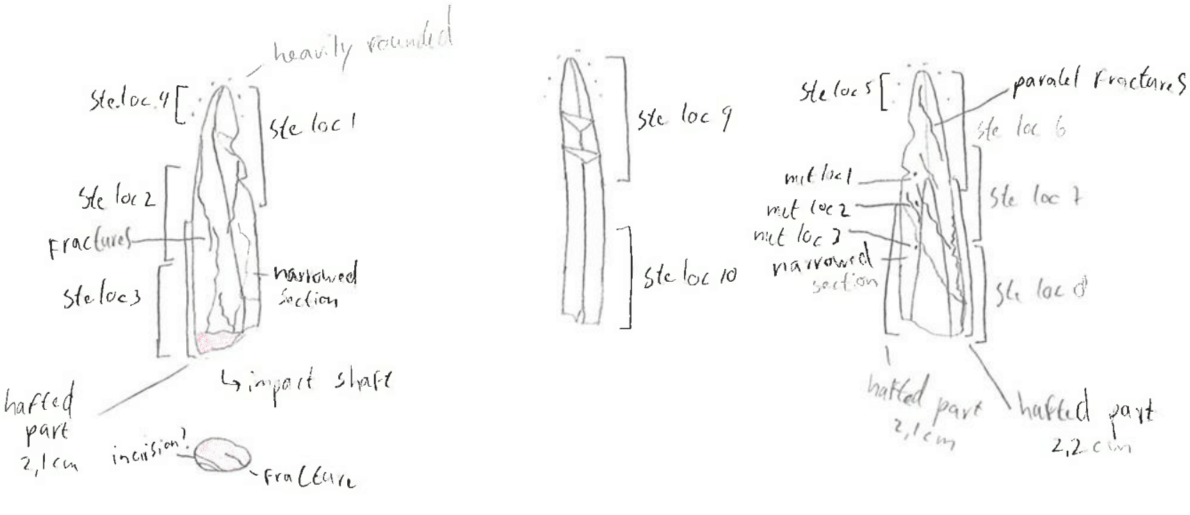
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning d. Salted

Taphonomy North Sea; beach

Photo/Video yes

Munsell: 5YR, 3/4 dark reddish brown



☐ = breakage

met loc 1-3 decreasing corrosion further down the base
↳ hafting?

Archaeological point 14.30

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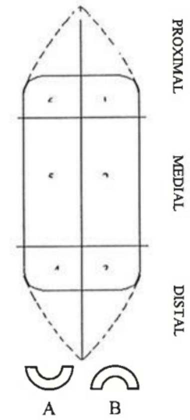


Date 31-05-2018 **Individual nr** 14-30

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

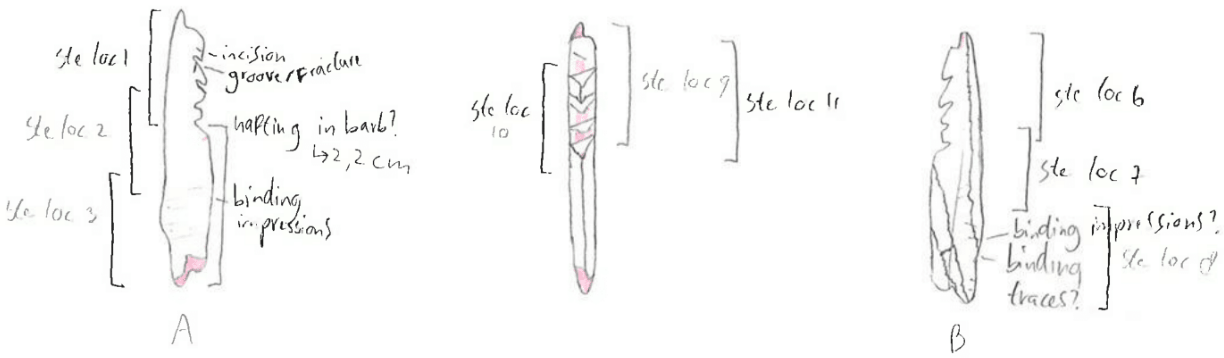
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

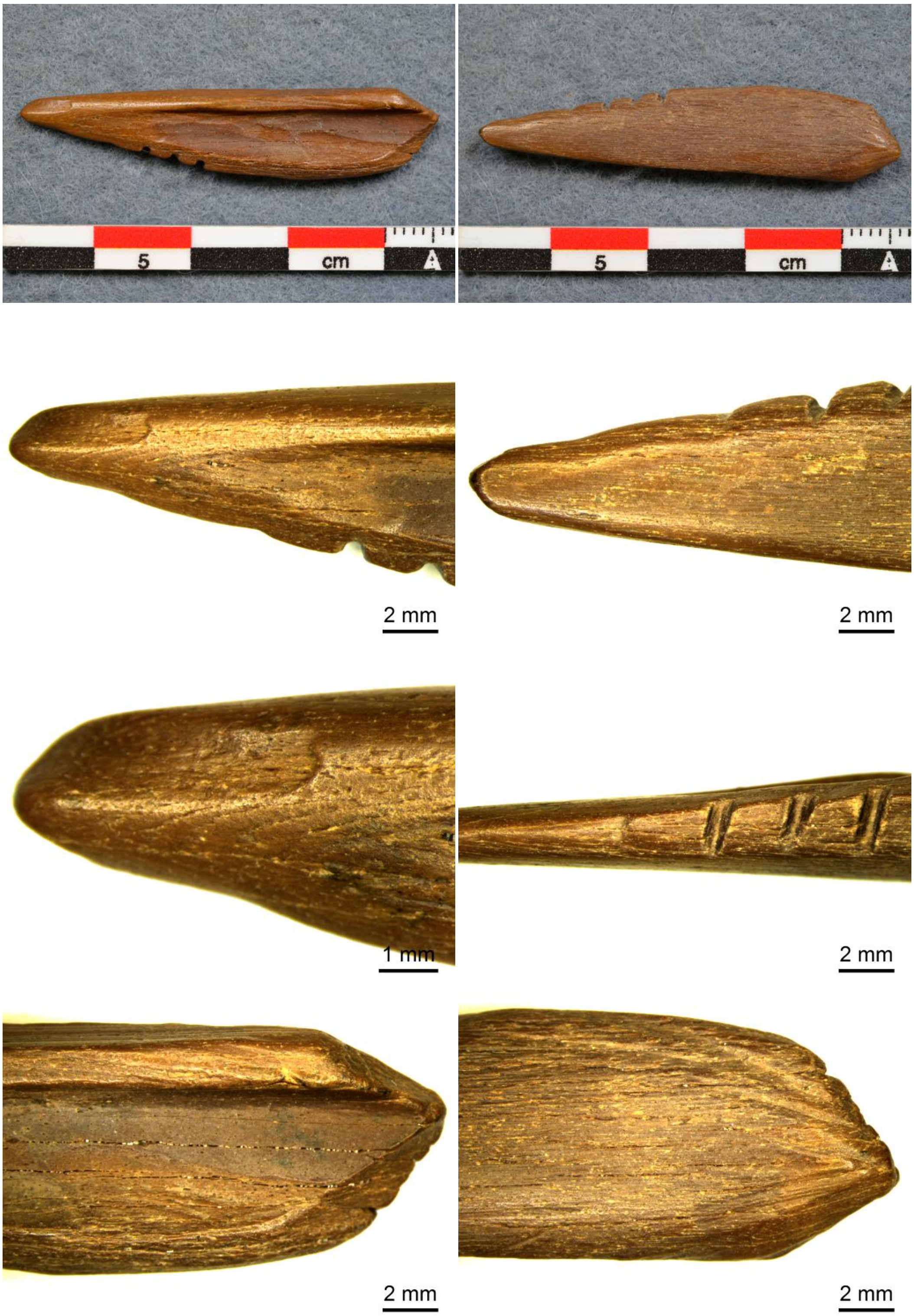
Photo/Video yes

Munsell 5YR, 3/4, dark reddish brown



□ = breakage

Archaeological point 14.33



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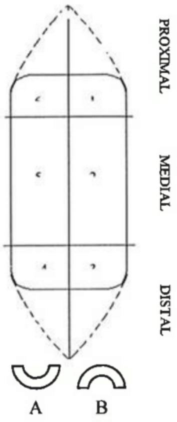


Date 31-05-2010 **Individual nr** 14-33

Analyst M. Smithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

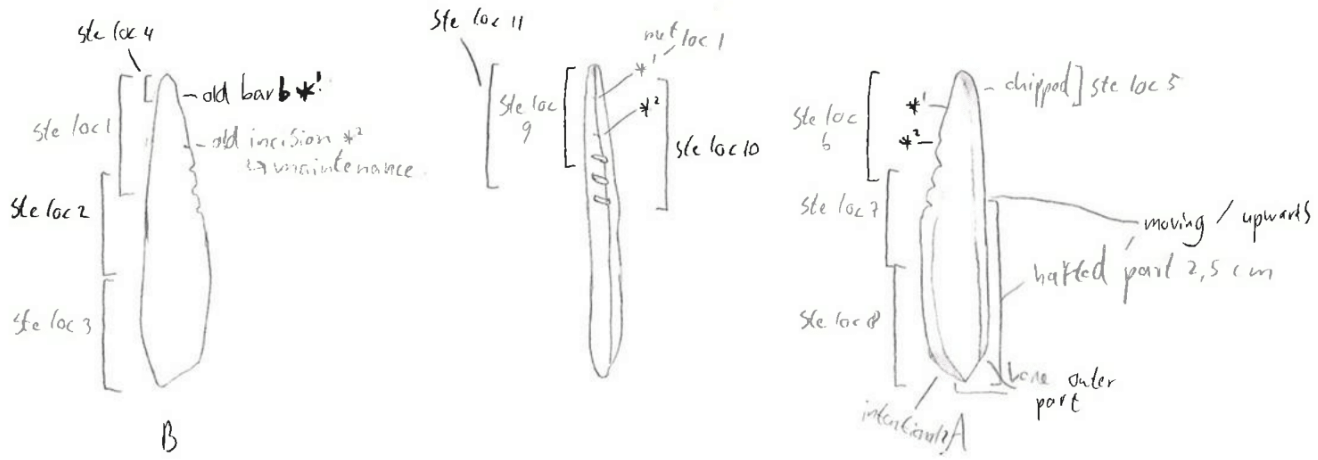
coordinate						
extent						
sec mod						
edge angle						
degree wear						
motion						
HP material						
LP material						
residue						
macro wear						
directionality						

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell: 5 YR, 4/2, dark reddish grey

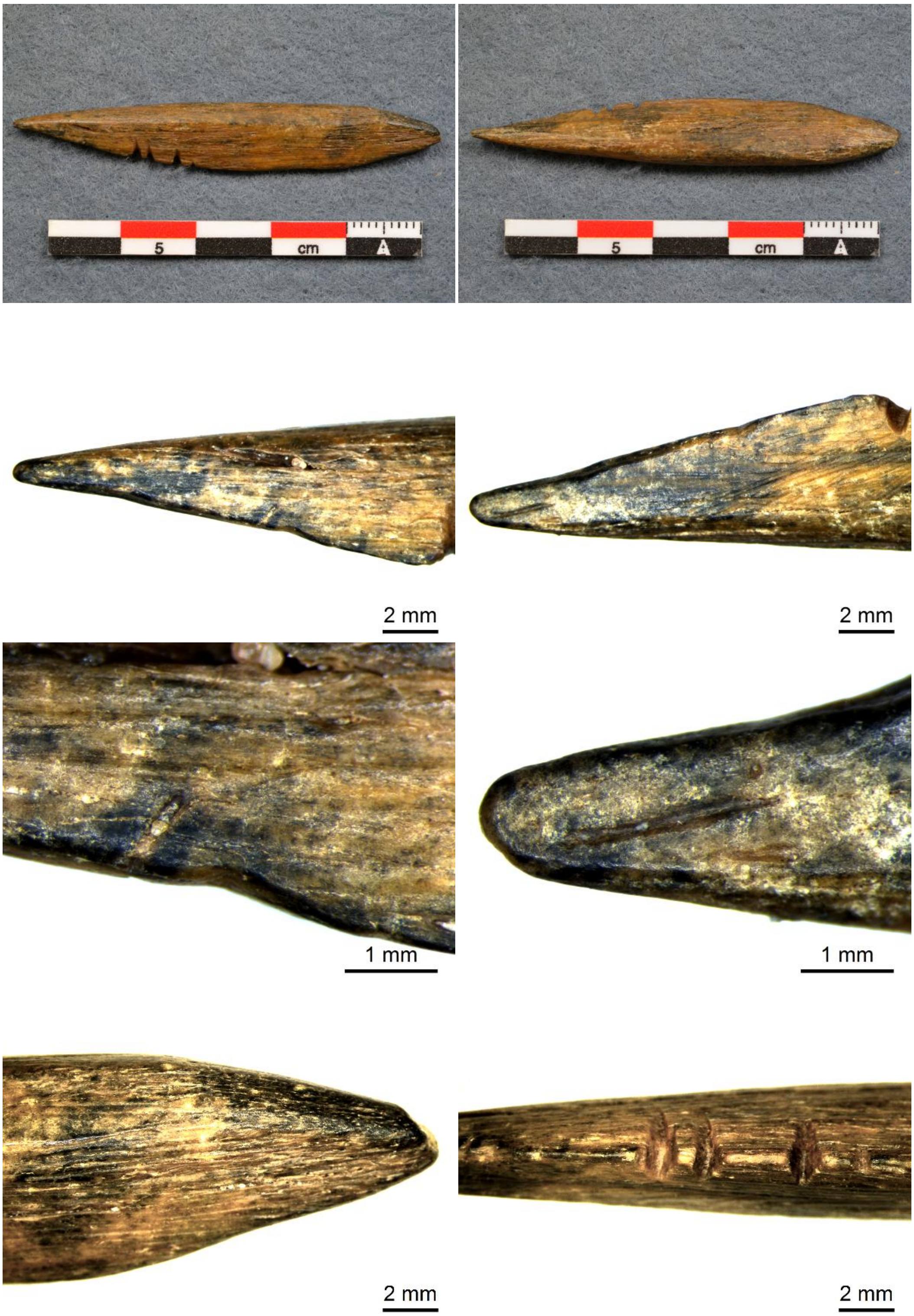


▯ = breakage

multiple fractures parallel → bone structure

– hafting V

Archaeological point 14.37



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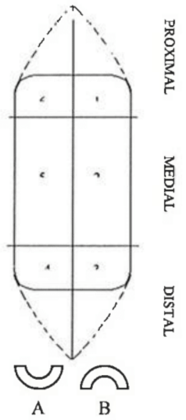


Date 01-06-2018 **Individual nr** 14-37

Analyst M. Spijlhoven **Site** Rockanje

Raw material **Bone** Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

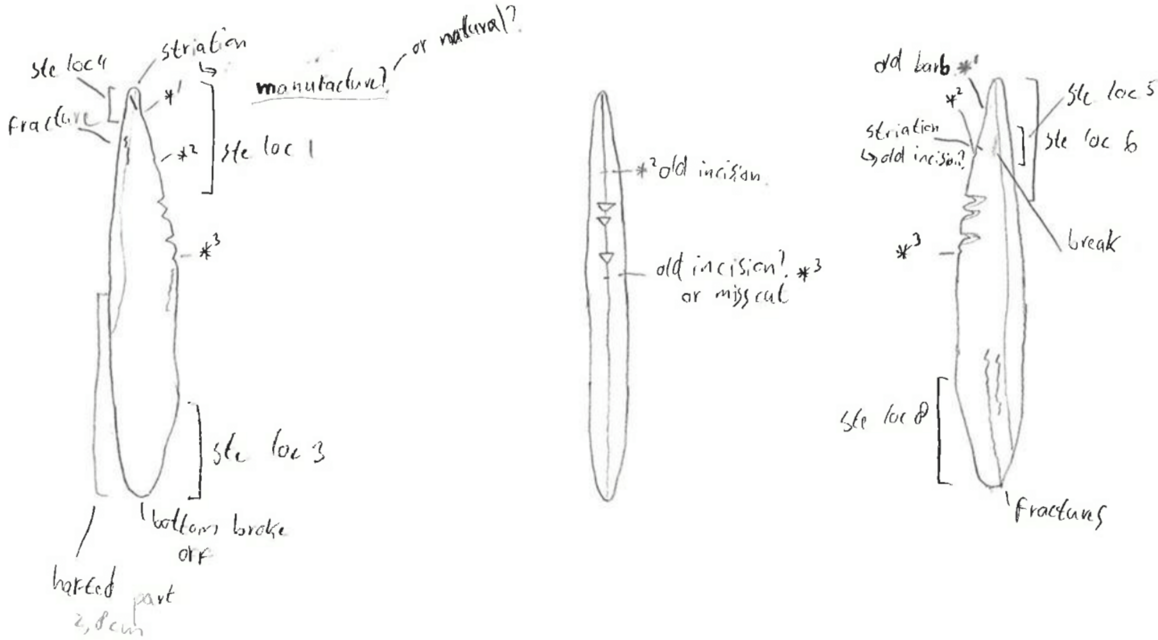
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted for 12 days

Taphonomy North Sea; beach

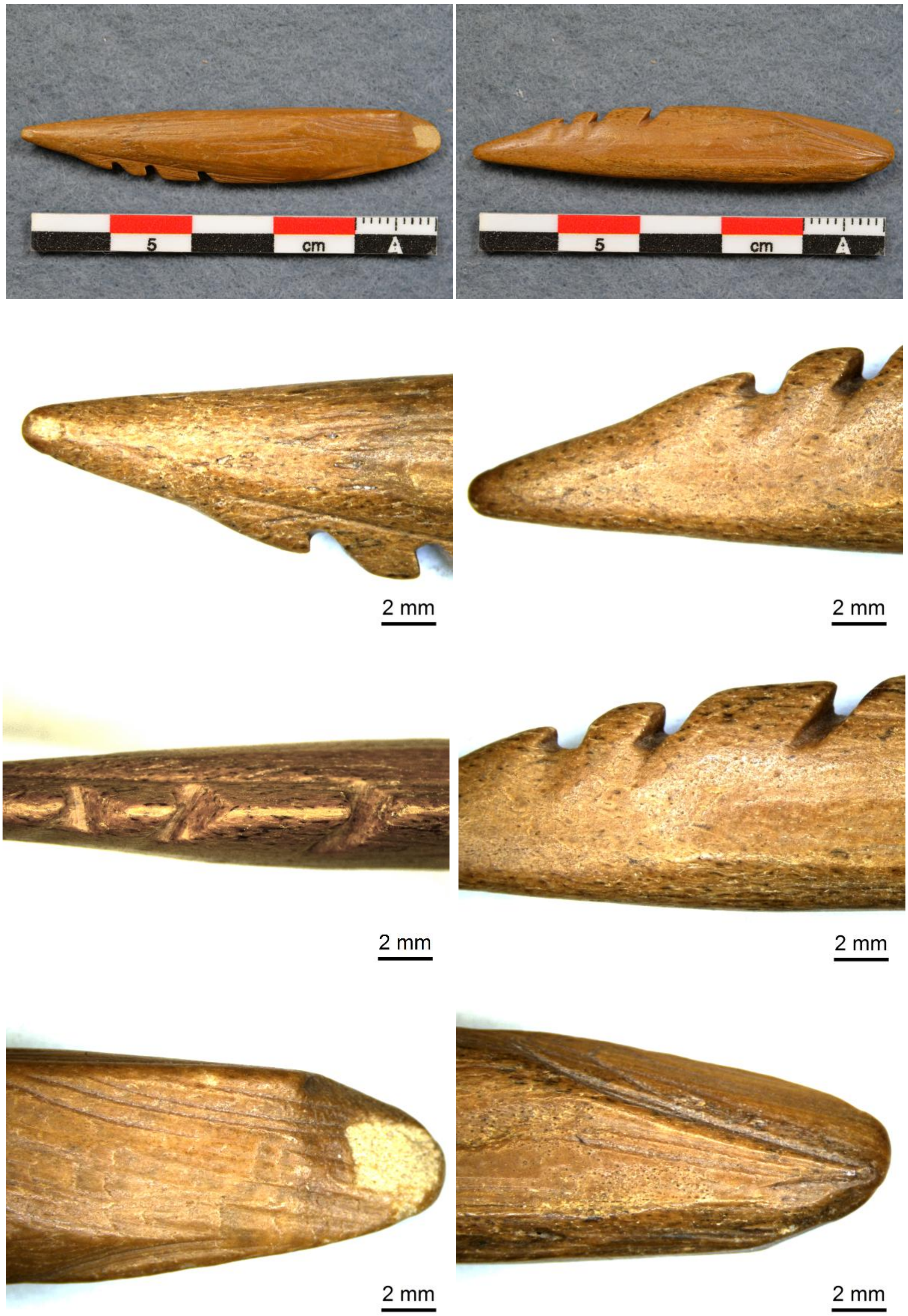
Photo/Video yes

Munsell: 10YR, 6/4 → light yellowish brown



- hafting V

Archaeological point 14.39



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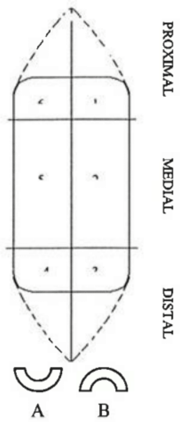


Date 30-05-2018 **Individual nr** 14-39

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

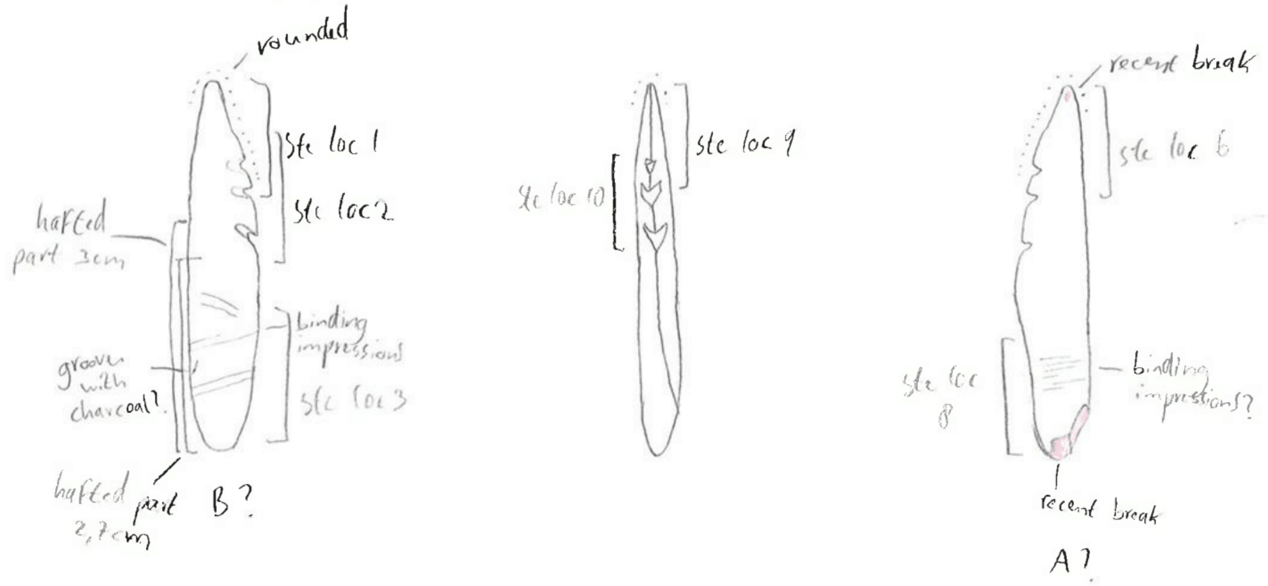
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
maybe – **residue**	black				
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

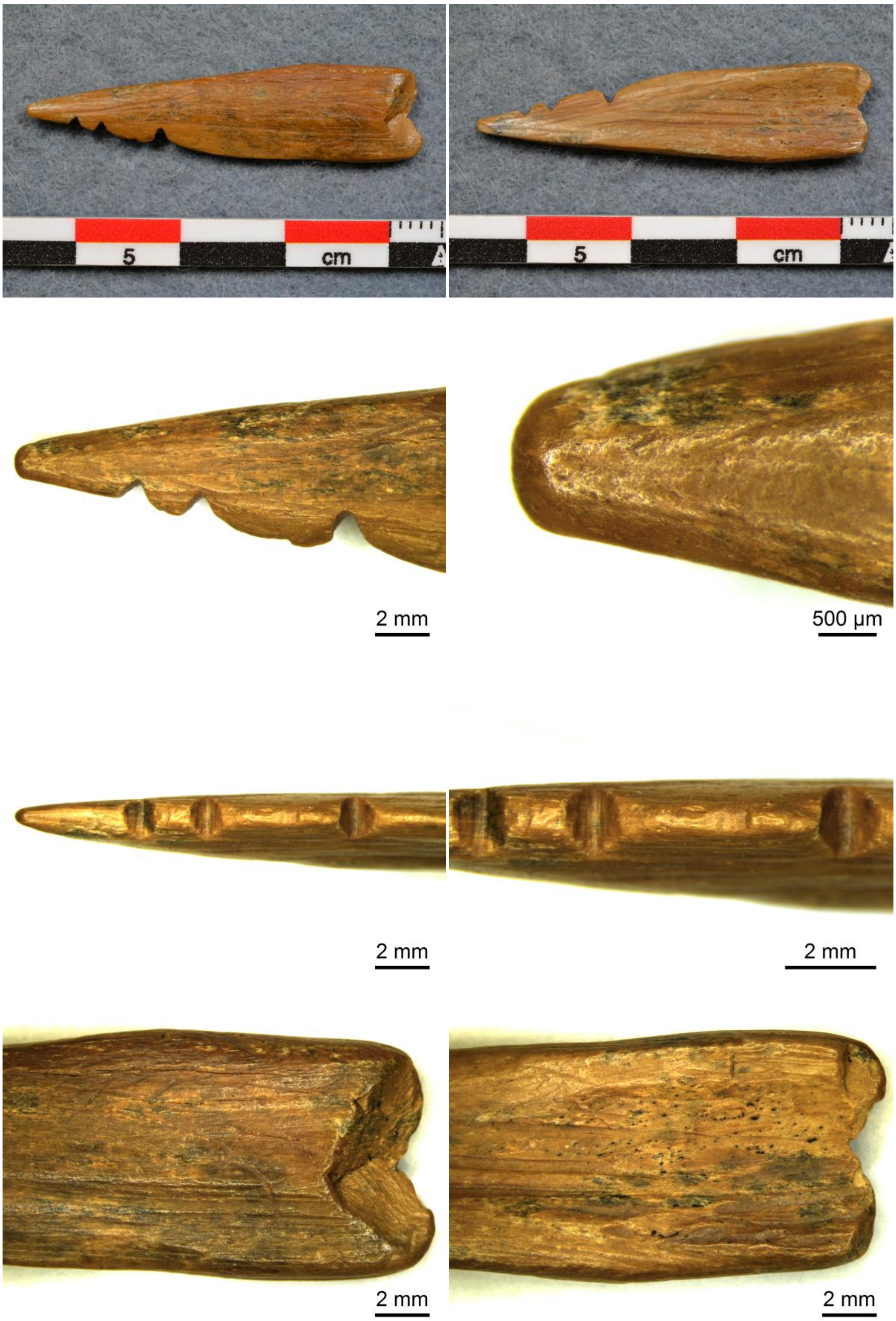
Munsell 10 YR, 5/4, yellowish brown



▨ = breakage

- hafting V

Archaeological point 14.47



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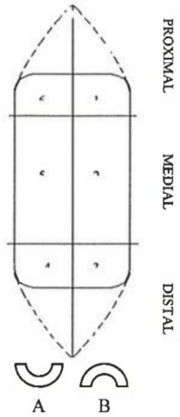


Date 31-05-2010 **Individual nr** 14-47

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

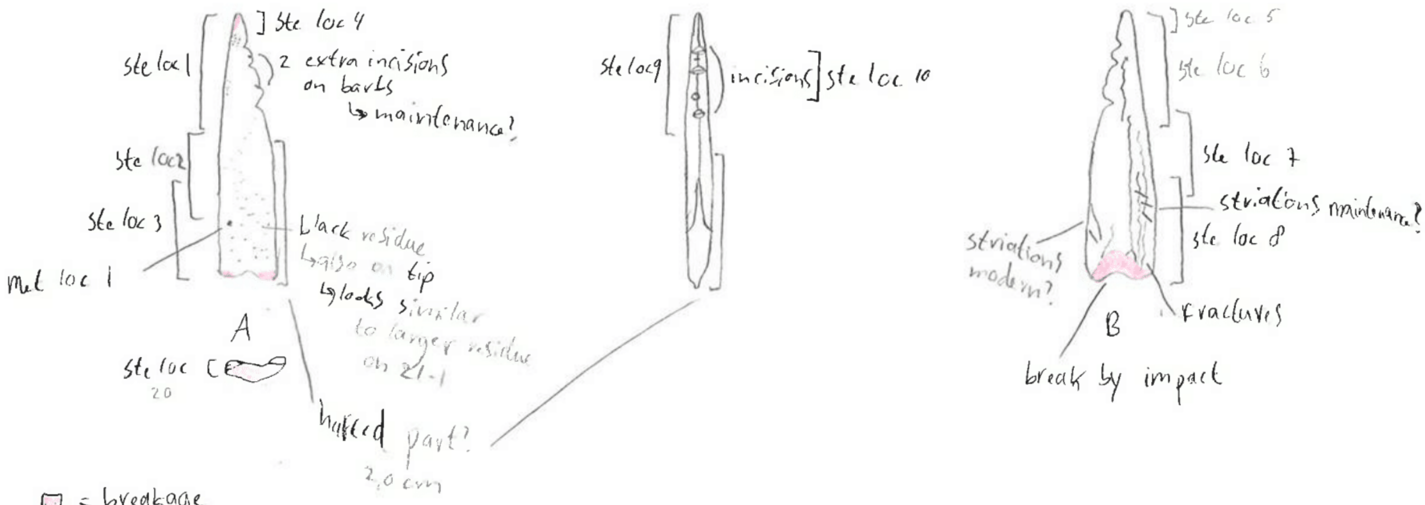
coordinate	A				
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

Cleaning de-salted

Taphonomy North Sea; beach

Photo/Video yes

Munsell 7,5 YR, 5/4, brown



□ = breakage

little wear

Archaeological point 14.56

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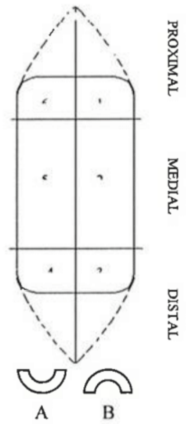


Date 29-05-2018 **Individual nr** 14-36

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

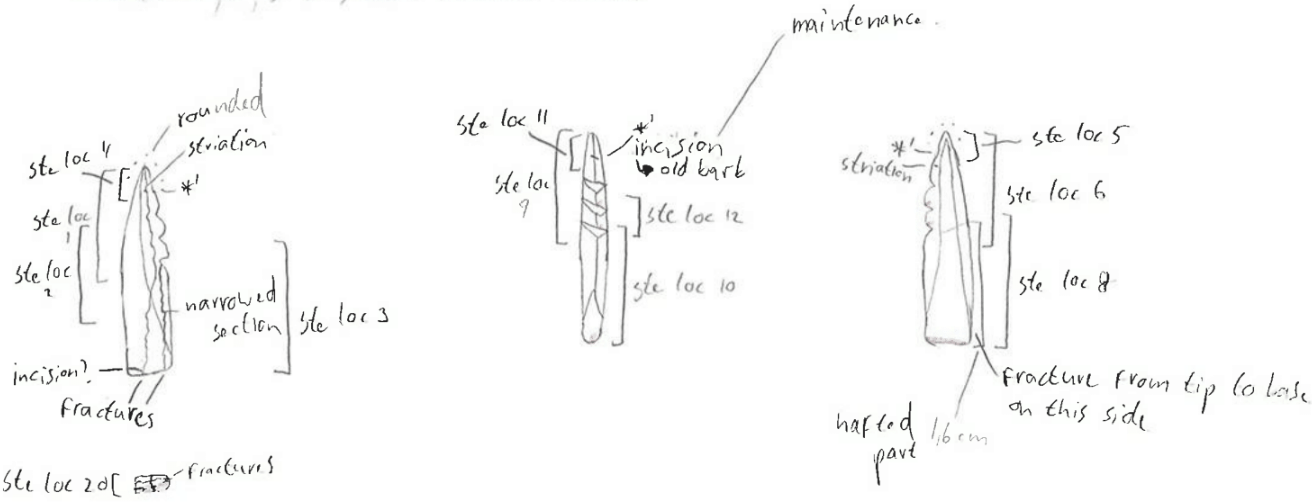
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell: 5 YR, 3/3 → dark reddish brown

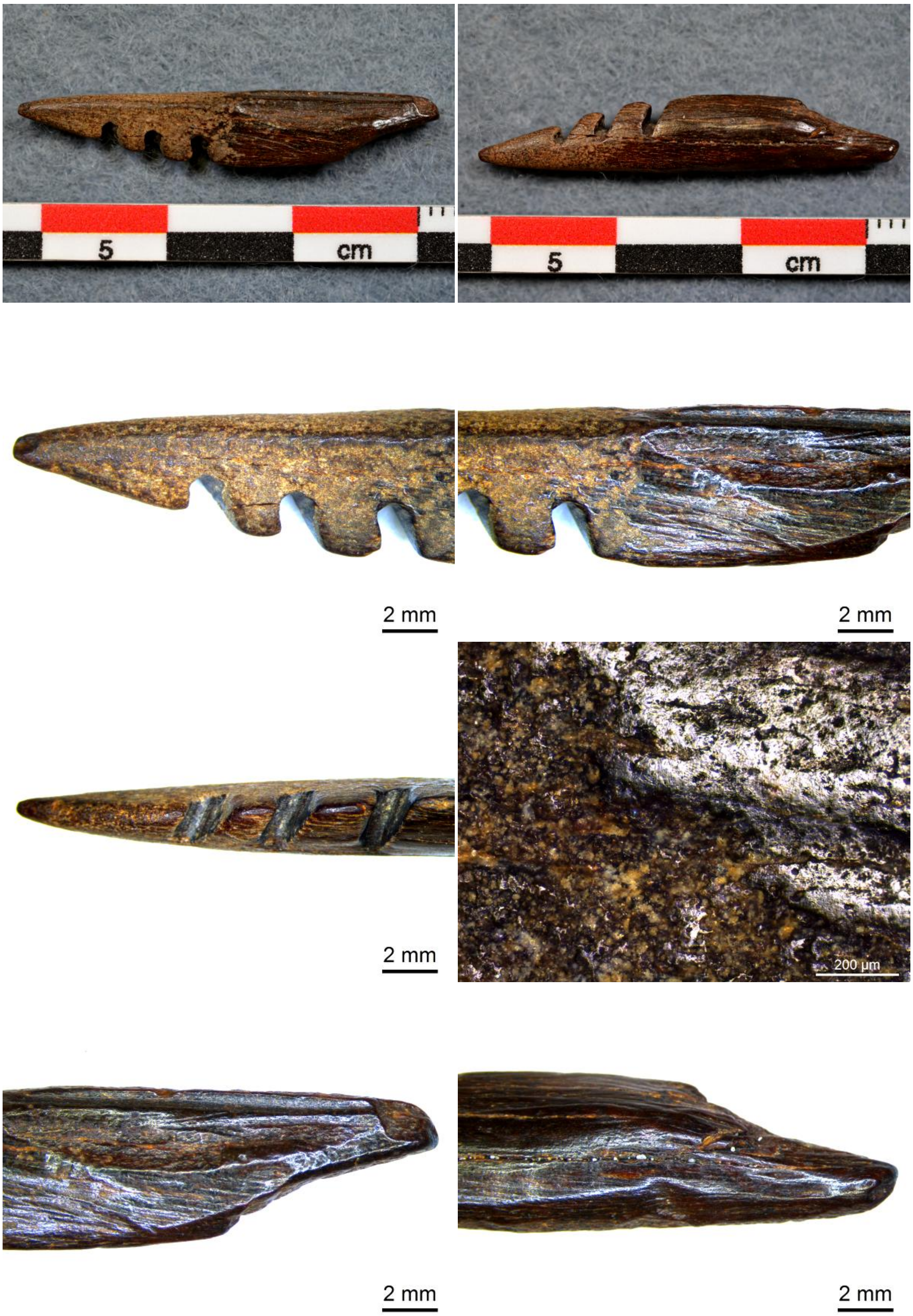


□ = breakage

- orange, rainbow shine residue everywhere in holes and grooves

- hafting U

Archaeological point 14.57



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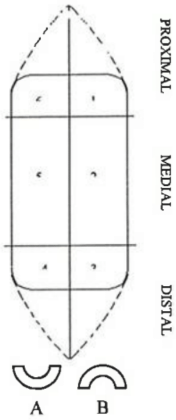


Date 29-05-2018 **Individual nr** 14-57

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Seelers

Tool type: barbed point

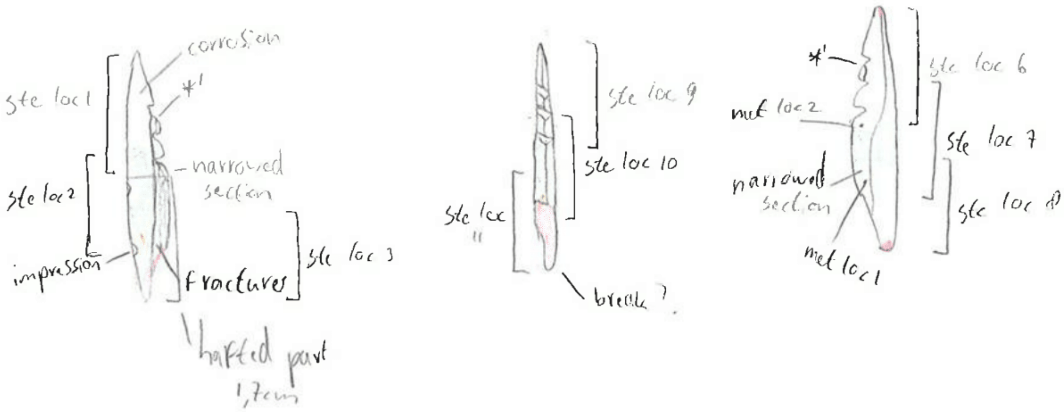
coordinate	mainly corrosion on tip				
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue		resin?			
macro wear					
directionality					

Cleaning desalted for 2 days

Taphonomy North Sea; beach

Photo/Video yes

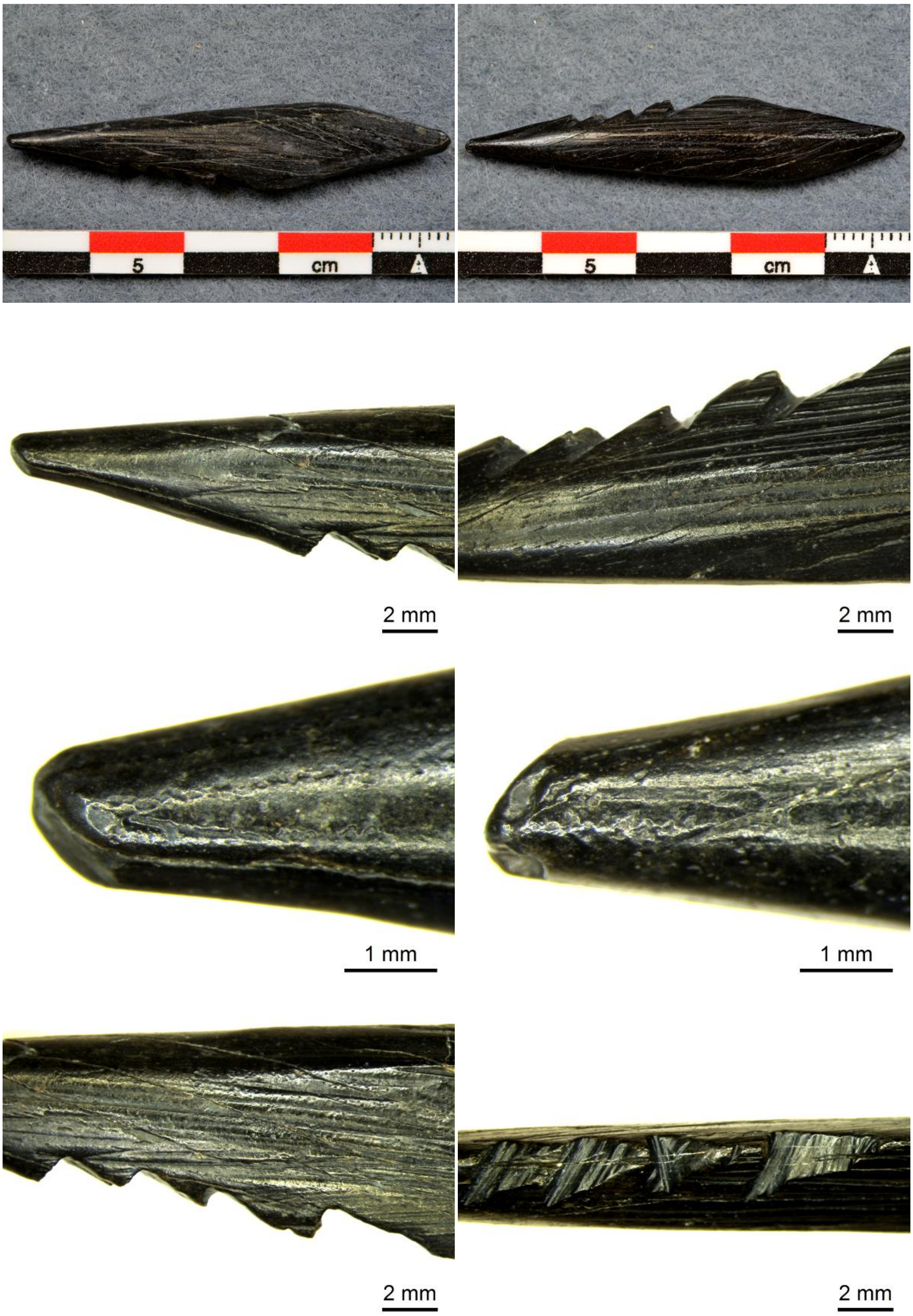
second barb was glued with velpon *'
Mansell: 5 YR, 3/2 → dark reddish brown



= breakage
↳ all seem to have occurred pre-depositional because of the less heavy weathering
= resin residue?
= smoother, shinier surface

- hafting V?

Archaeological point 14.84



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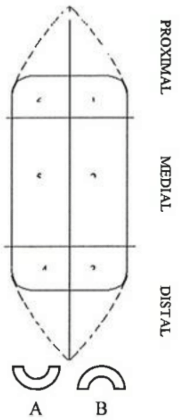


Date 04-06-2018 **Individual nr** 14-84

Analyst M. Spithoven **Site** Hoek van Holland

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

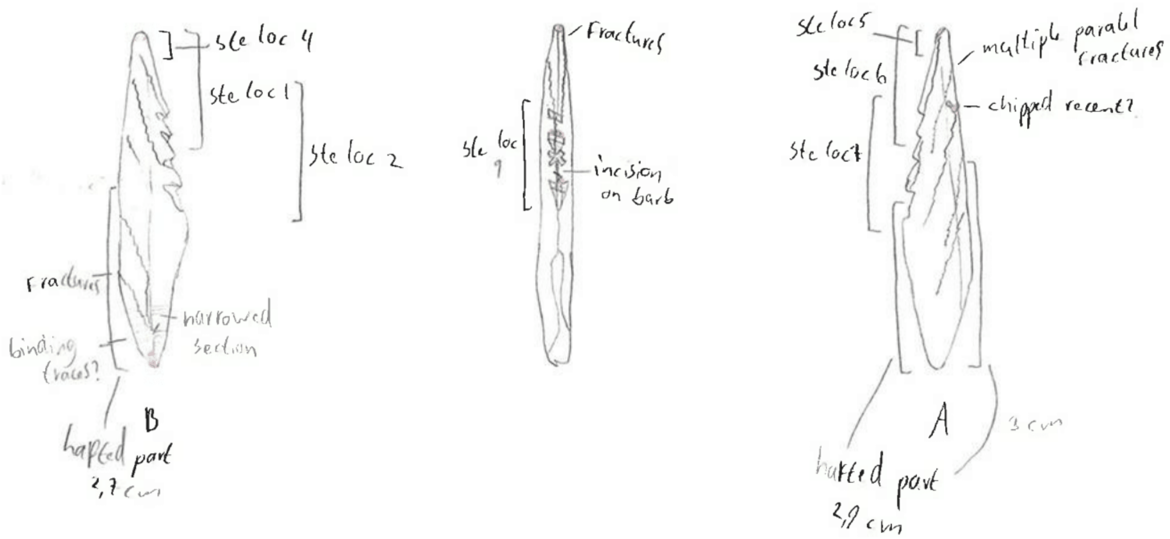
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

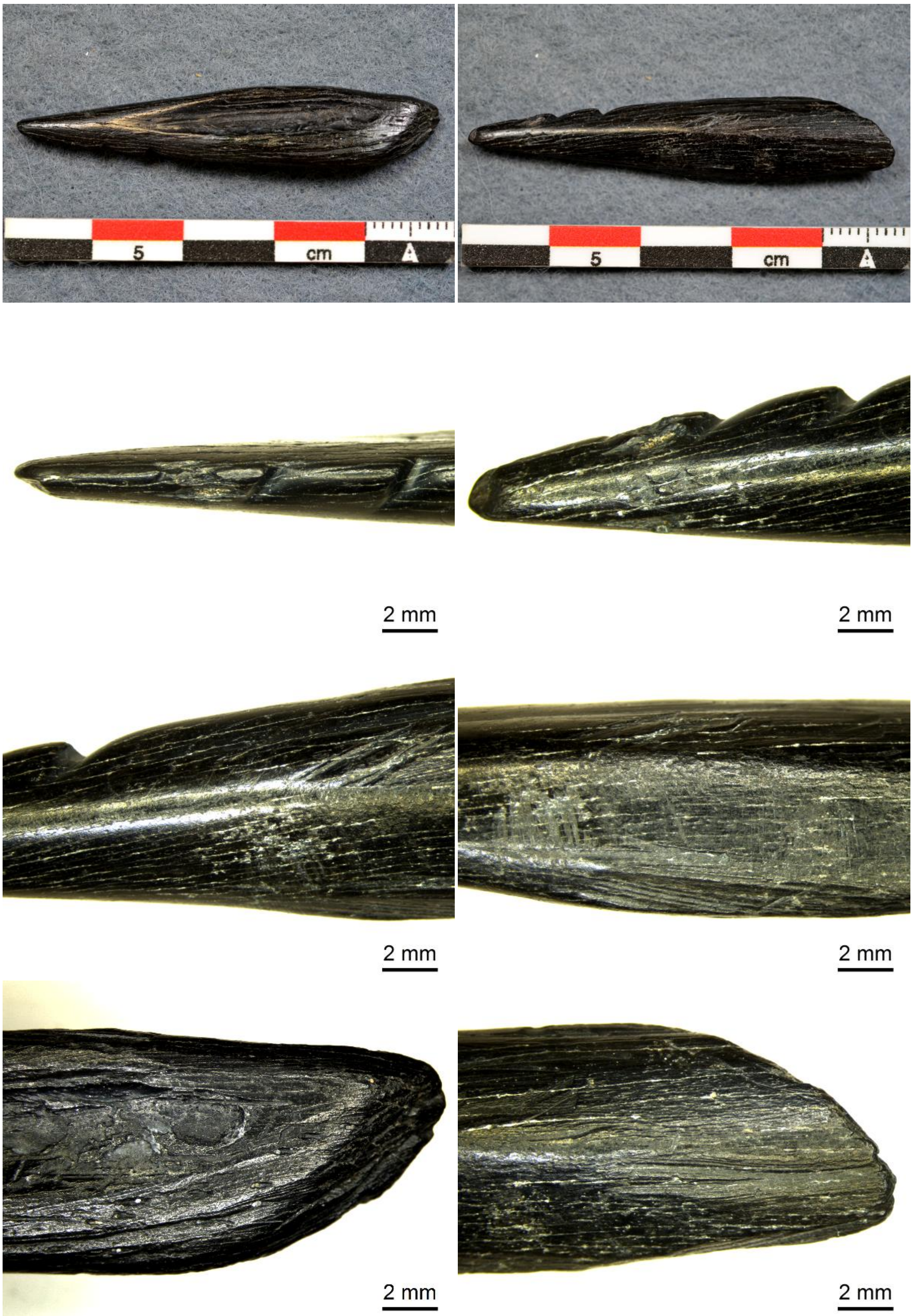
Munsell: black



■ = breakage

- hafting v

Archaeological point 14.87



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Date 04-06-2018 **Individual nr** 14-87

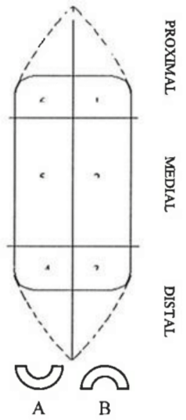
Analyst M. Spithoven **Site** Hoek van Holland

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soelers

Tool type: barbed point



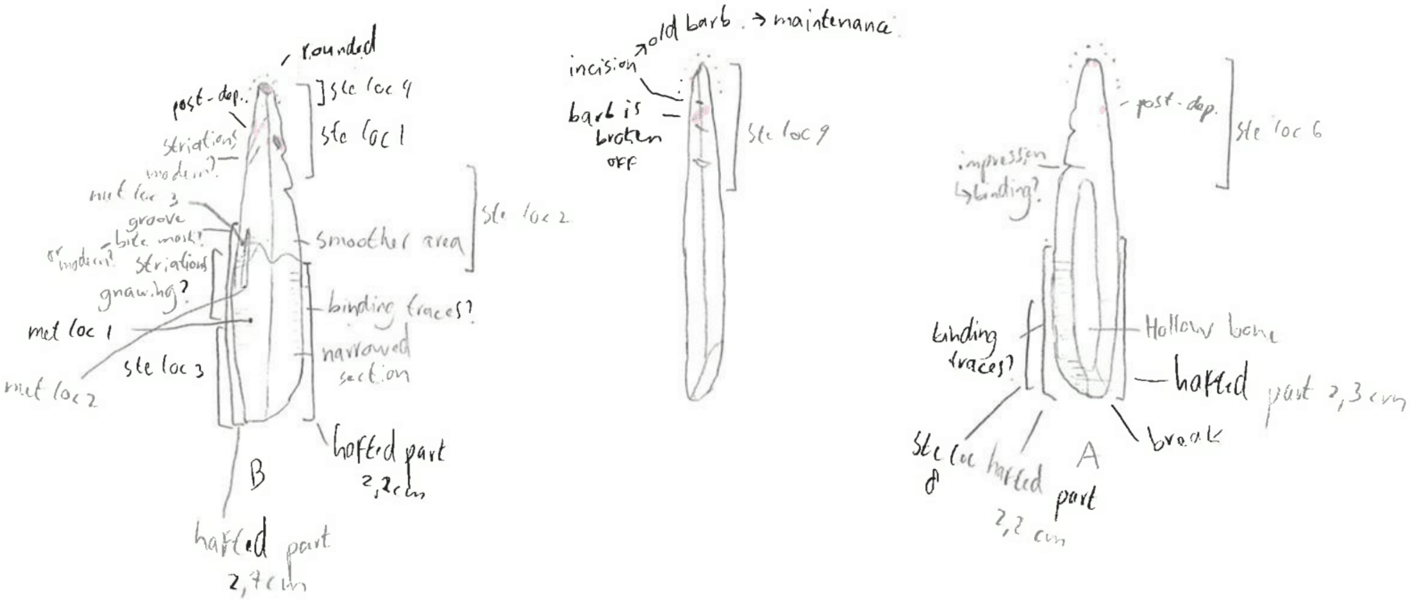
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

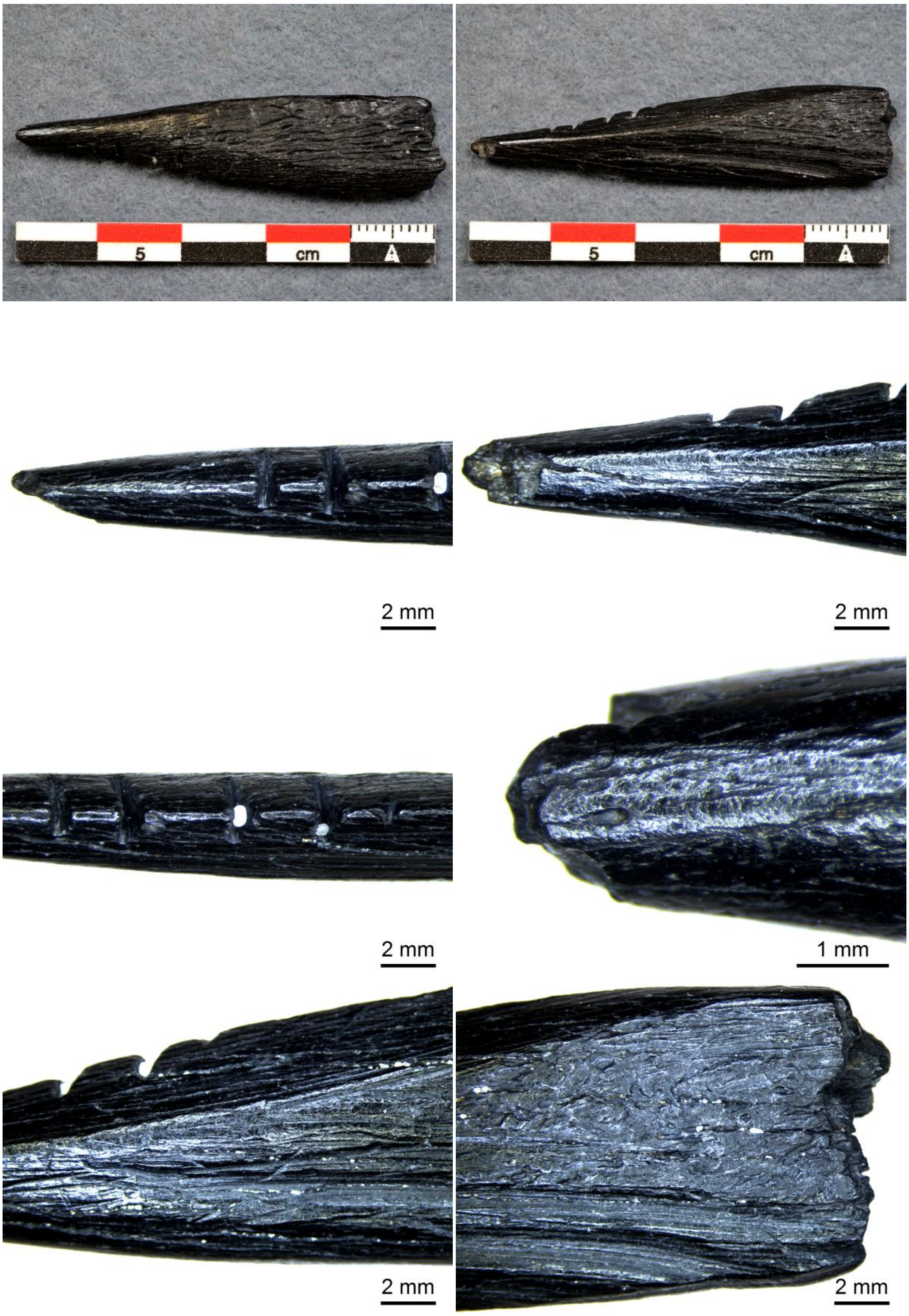
Munsell: black



▢ = breakage
▢ = smoother, more shiny surface

- hafting ✓

Archaeological point 14.88



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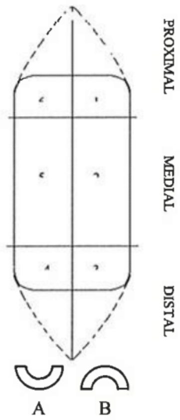


Date 01-06-2018 **Individual nr** 14-88

Analyst M. Spithoven **Site** Hoek van Holland

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

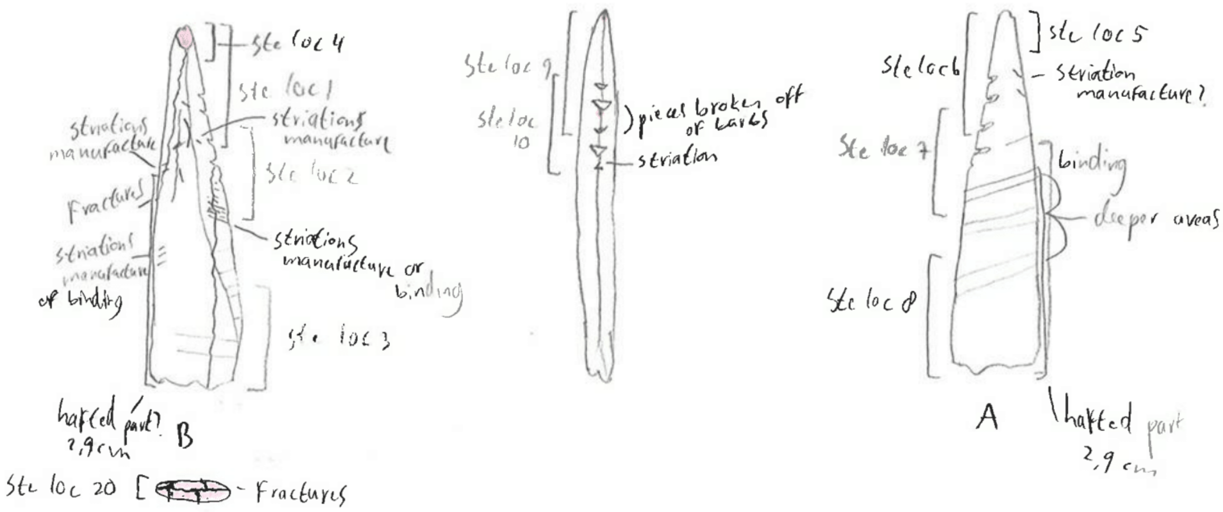
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

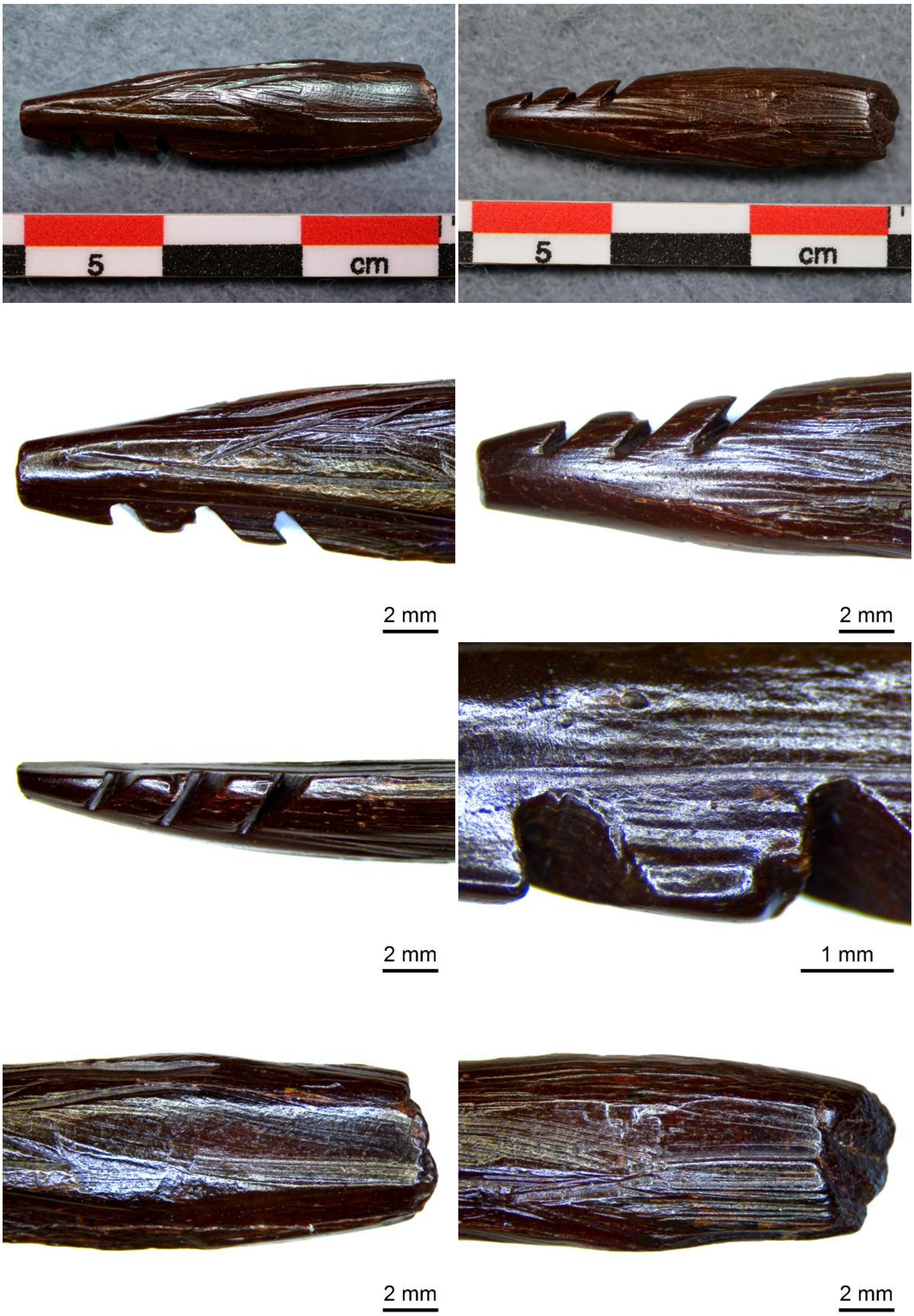
Photo/Video yes

Munsell: black



= breakage

Archaeological point 14.258



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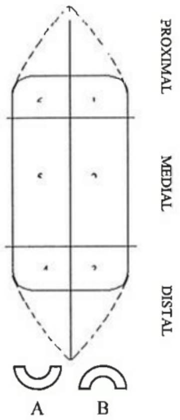


Date 29-05-2018 **Individual nr** 14-258

Analyst M Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soelers

Tool type: barbed point

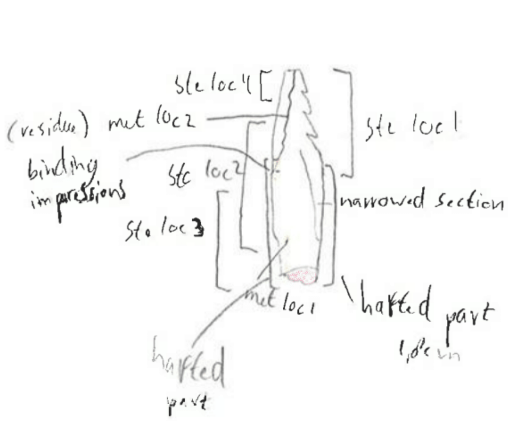
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

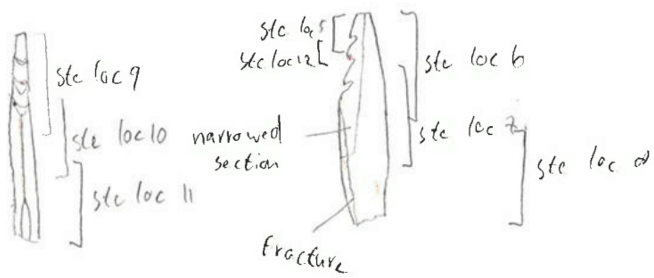
Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell 2,5 YR 2/4: dark reddish brown



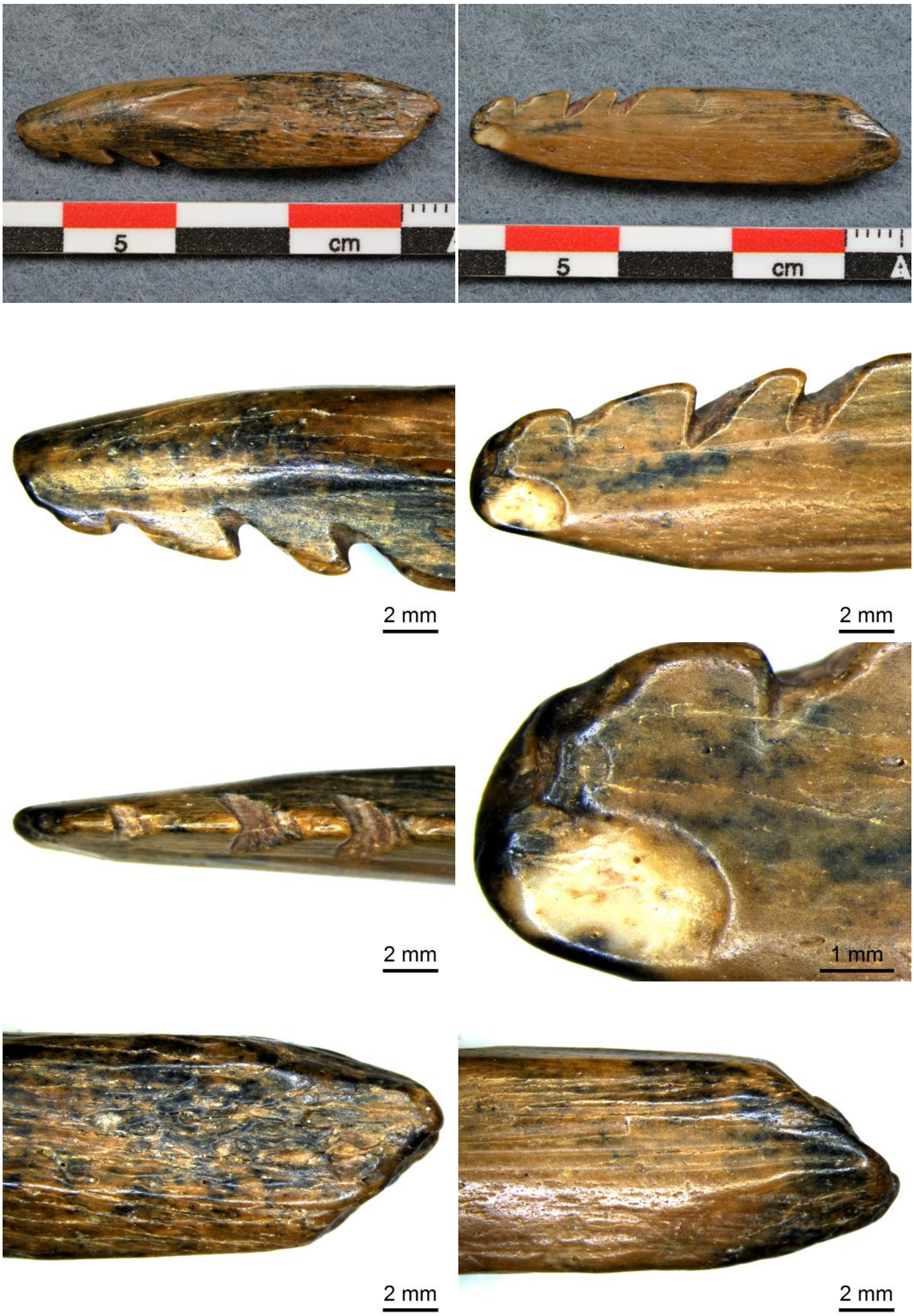


= breakage

= resin residue? / contamination → it has a orange color with rainbow shine and lies on top of the surface

- impact tip en butt base same break

Archaeological point 14.263



UH 1

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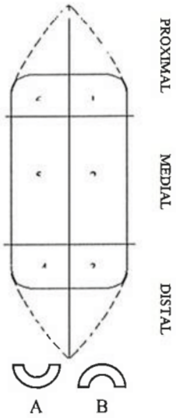


Date 30-05-2018 **Individual nr** 14-263

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

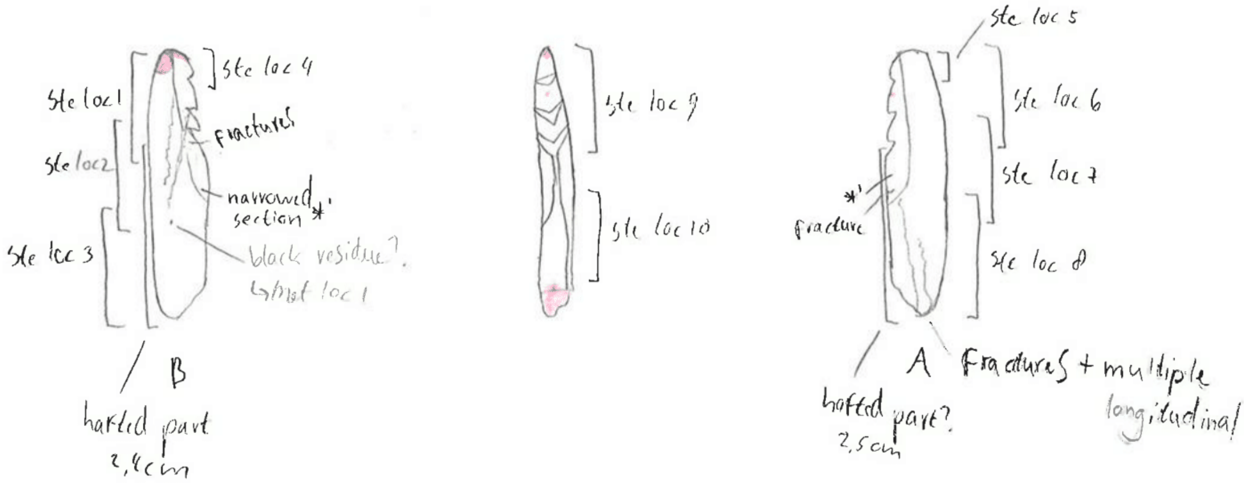
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

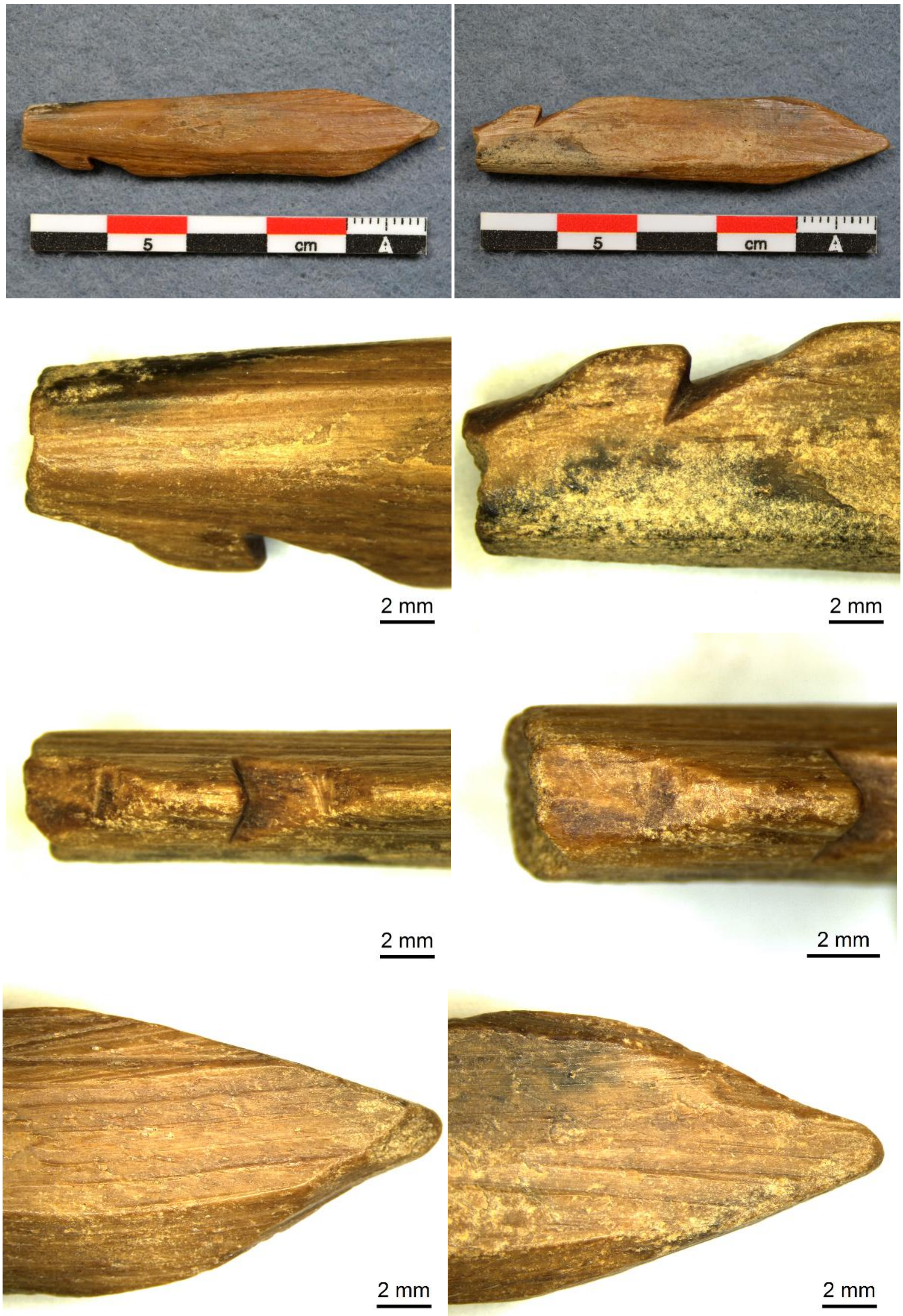
Munsell: 7,5 YR, 5/4, brown



☐ = breakage

~ hafting ∪

Archaeological point 14.278



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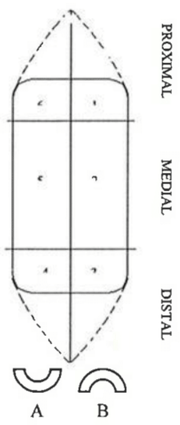


Date 31-05-2018 **Individual nr** 14-278

Analyst M Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

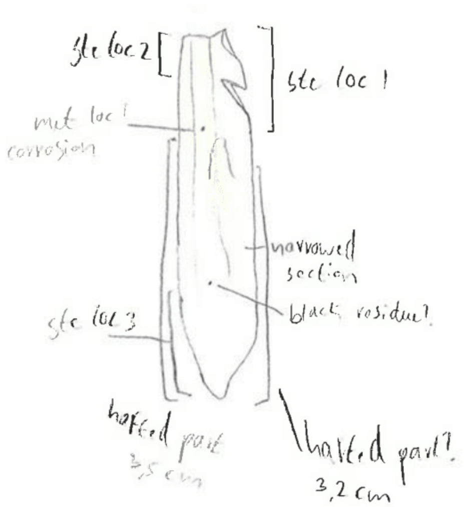
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	black				
macro wear					
directionality					

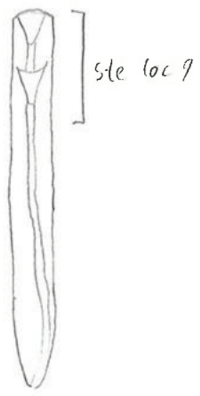
Cleaning desalted

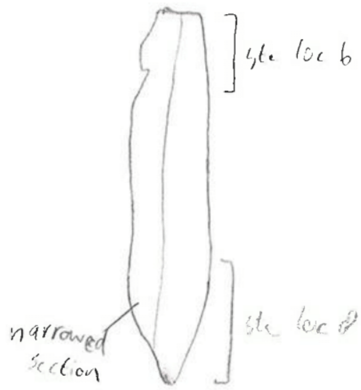
Taphonomy North Sea; beach

Photo/Video yes

Munsell: 10 YR, 5/4 → yellowish brown







▩ = breakage

□ = very corroded

- hafting V

Archaeological point 14.318

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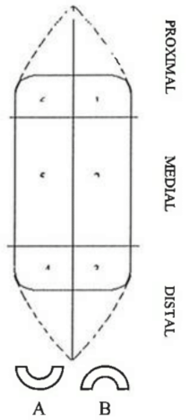


Date 31-05-2018 **Individual nr** 14-318

Analyst M.Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

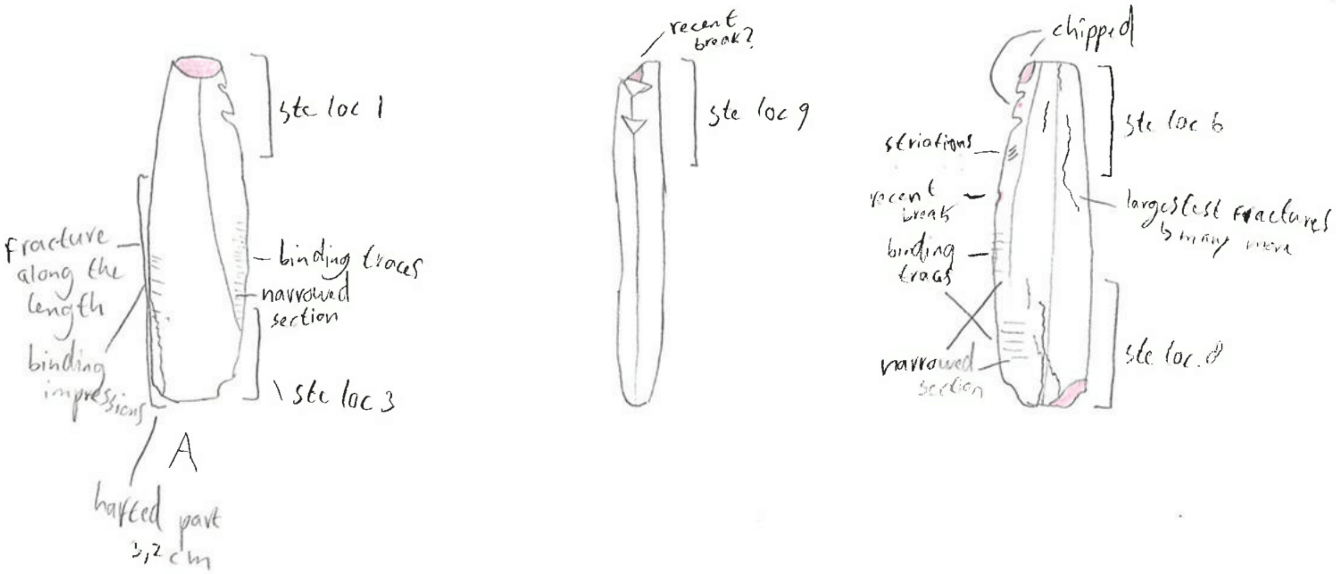
coordinate
extent
sec mod
edge angle
degree wear
motion
HP material
LP material
residue
macro wear
directionality

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell 7,5 YR, 4/4, brown/dark brown



□ = breakage

Archaeological point 14.324

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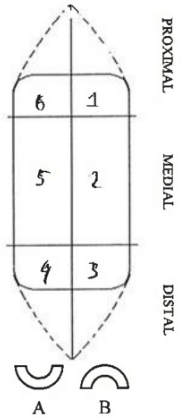


Date 29-05-2018 **Individual nr** 14-324

Analyst M. Spithoven **Site** Rockanje

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

Tool type: barbed point

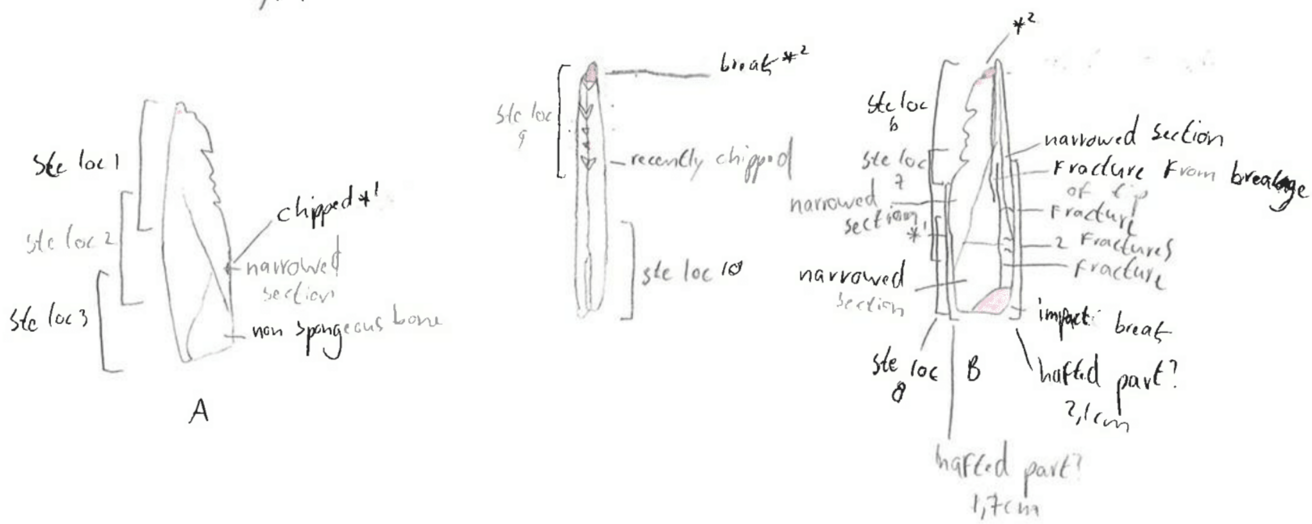
coordinate	mostly 6A				
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	yellow				
macro wear					
directionality					

Cleaning desalted

Taphonomy North sea; beach

Photo/Video yes

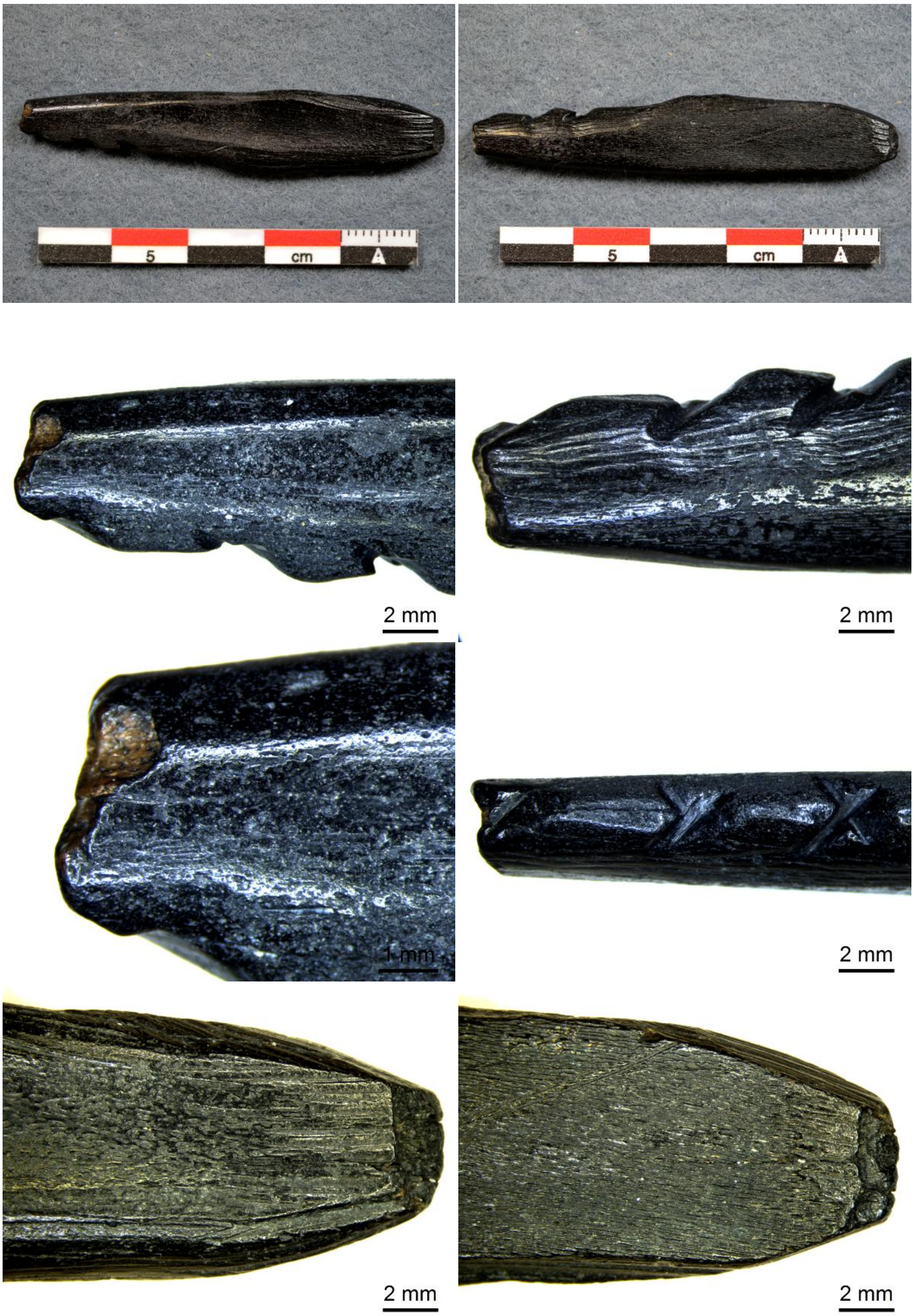
Munsell: 5 YR, 3/3 → dark reddish brown



▫ = breakage
▫ = narrowed section

- hafting U

Archaeological point 14.327



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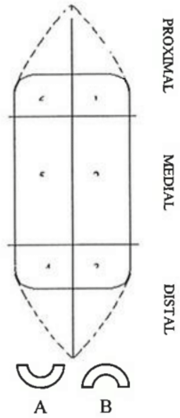


Date 01-06-2018 **Individual nr** 14-327

Analyst M. Spithoven **Site** Hoek van Holland

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Peter Soeters

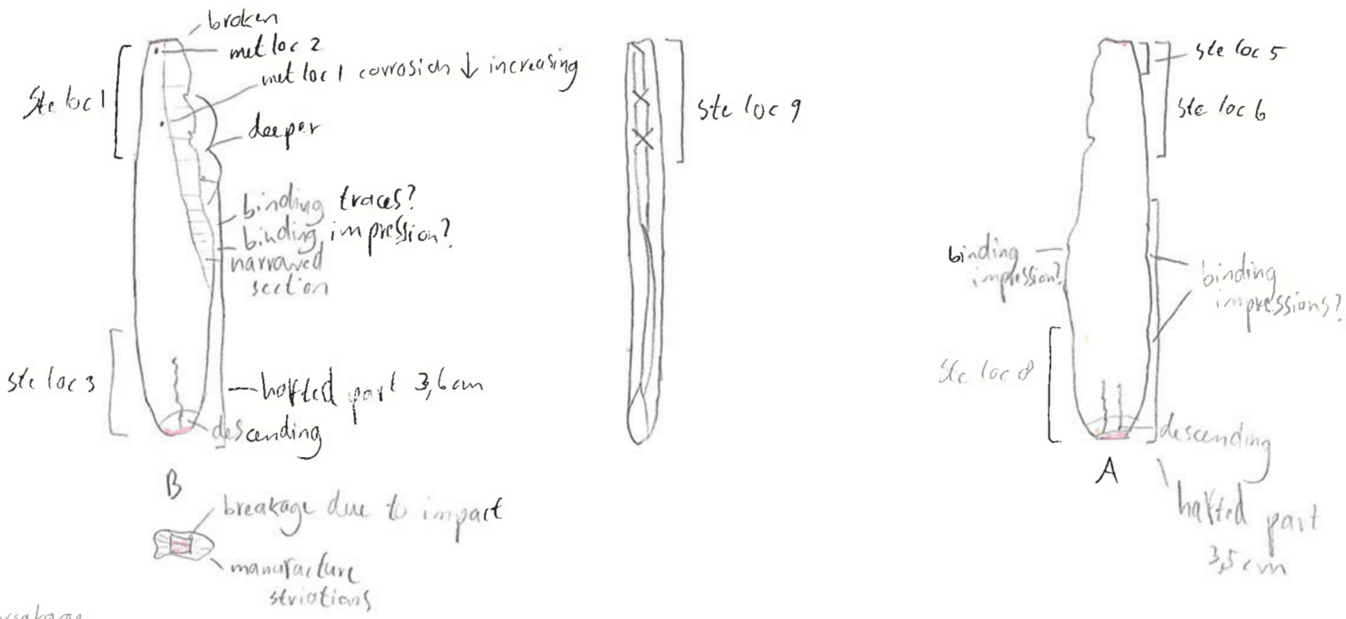
Tool type: barbed point

coordinate	A				
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue	resin?				
macro wear					
directionality					

Cleaning desalted

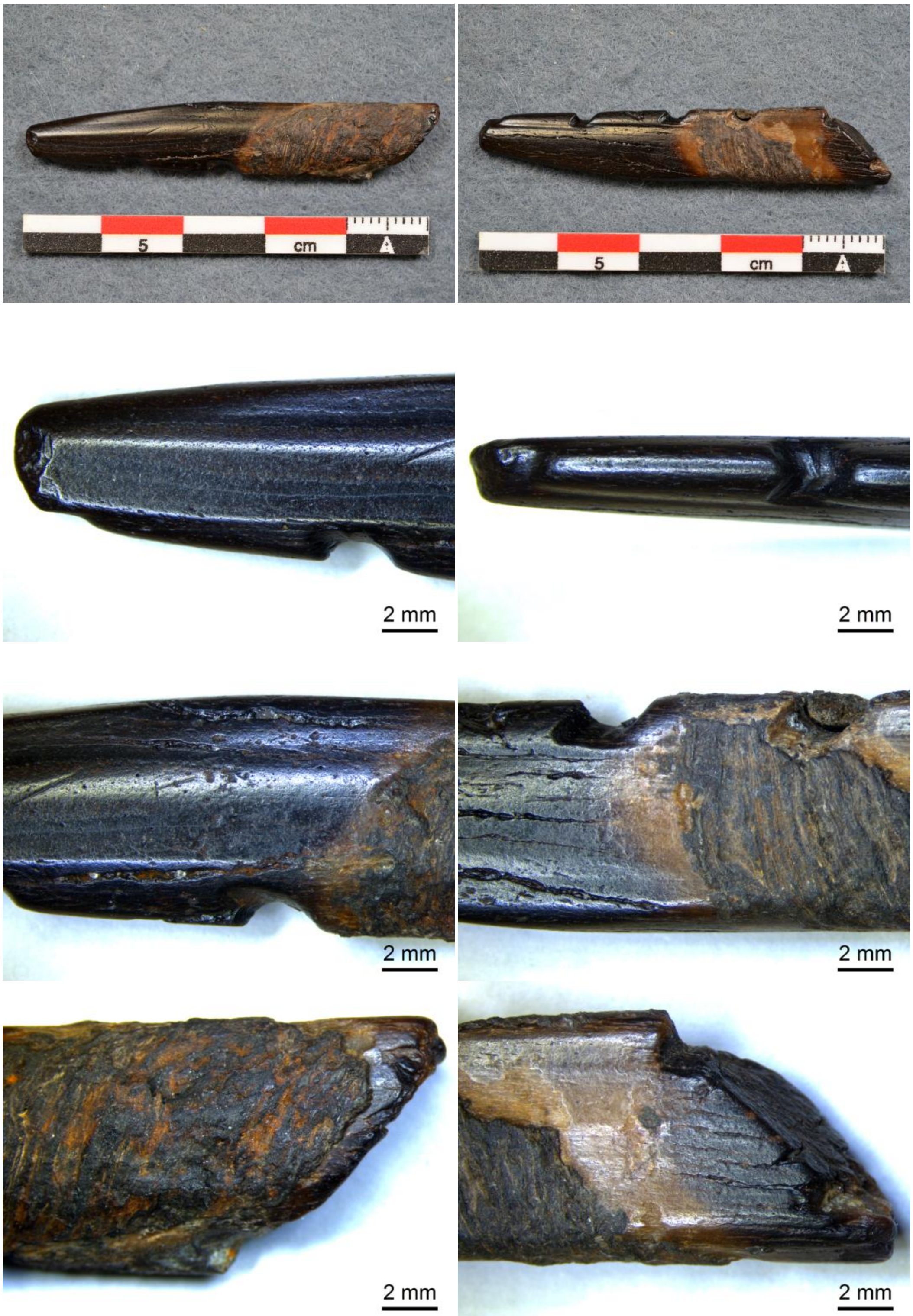
Taphonomy North Sea; beach

Photo/Video yes
Munsell: black

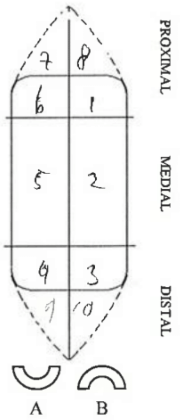


☐ = breakage
☐ = resin residue?
- hafting \/ + descending

Archaeological point 21.1



Use Wear Form Laboratory For Artefact Studies



Date 28-05-2018 **Individual nr** 21.1

Analyst M. Spithoven **Site** Maasvlakte 2

Raw material Bone Antler Teeth, Ivory, Horn

Species unknown **Skeletal part** unknown

Further specification collection Henk Houtgraaf

Tool type: barbed point

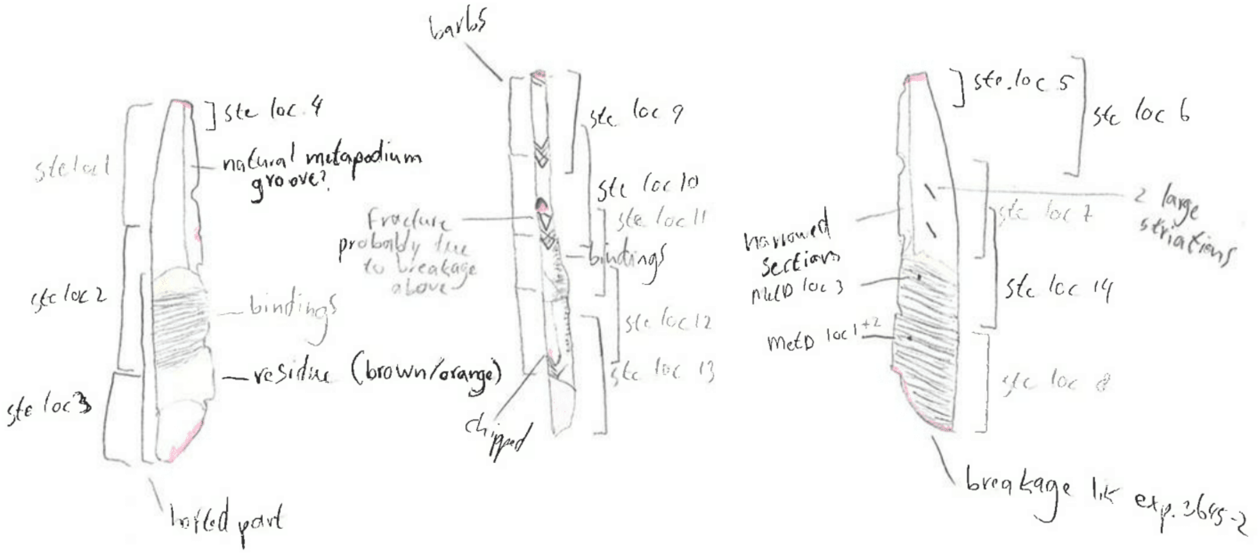
coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning desalted

Taphonomy North Sea; beach

Photo/Video yes

Munsell color: 5YR – 3/1 → very dark gray



residue brown/orange
breakage
hafted part = 2,6cm

Data Archaeological Points

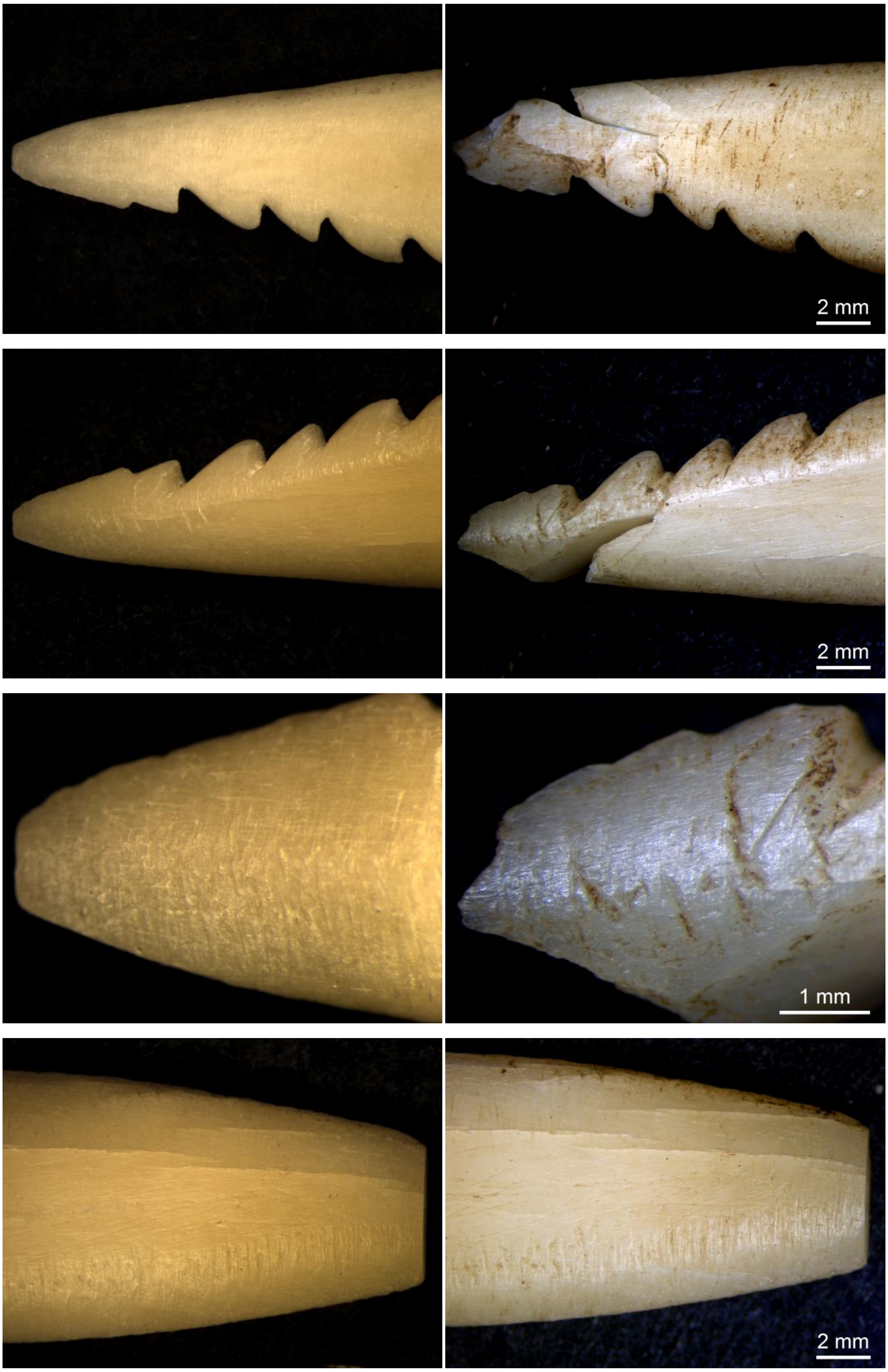
Collection Nr.	Find Nr.	Weight in mm	Length in mm	Max. Width in mm	Max. Thickness in mm	Nr. of Barbs	Shape Incisions	Lowest hafted part in mm	Highest hafted part in mm	Non-hafted part in mm	Non-hafted part %	Residue	Nr. of Broken Barbs	Nr. of Reworked Barbs	Degree of Wear Category	Discovery Site (beach of)
14	4	2,6	53,1	9,5	4,7	4	2	25	26	27,1	51%	Black (tar)	1	2	C	Rockanje
14	5	1,7	48,9	7,8	4,3	3	2	25	26	22,9	47%	Black (tar)	0	1	E	Rockanje
14	7	2,3	44,3	10,8	4,4	2	3	Unknown	Unknown	Unknown	Unknown	Black (tar)	0	0	C	Rockanje
14	10	1,7	30,8	8,8	4,3	2	2	18	Unknown	12,8	42%	Black (tar)	0	0	E	Rockanje
14	11	1,5	32,7	7,5	4,2	3	2	18	18	14,7	45%	Absent	0	0	E	Rockanje
14	13	1,4	34,8	9,1	4,2	3	2	15	20	14,8	43%	Absent	1	0	E	Rockanje
14	22	2,6	45	10,1	5,6	3	2	26	27	18	40%	Absent	0	0	D	Rockanje
14	24	2,2	38,7	11	4,2	4	2	21	25	13,7	35%	Absent	1	0	E	Rockanje
14	25	1,7	44,8	9,2	5,1	2	1	18	18	26,8	60%	Black (tar)	1	1	C	Rockanje
14	27	2,8	59,4	8,7	4,9	4	2	23	28	31,4	53%	Absent	0	1	E	Rockanje
14	29	2,3	37,6	9,8	5,4	2	2	21	22	15,6	41%	Absent	0	0	D	Rockanje
14	30	2,3	37,91	8,8	4,6	4	2	22	22	15,91	42%	Absent	3	1	E	Rockanje
14	33	1,7	42,73	9,23	4,1	3	2	25	Unknown	17,73	41%	Absent	0	2	B	Rockanje
14	37	2,6	56,73	9,25	5,44	4	1	28	Unknown	28,73	51%	Absent	0	2	B	Rockanje
14	39	2,6	51,36	9,02	5,03	3	2	27	30	21,36	42%	Black (tar)	0	0	C	Rockanje
14	47	1,1	37,71	9,29	3,06	3	2	20	20	17,71	47%	Black (tar)	0	2	D	Rockanje
14	56	0,9	28,93	6,57	3,39	3	2	16	16	12,93	45%	Absent	2	1	E	Rockanje
14	57	0,6	33,76	6,09	3,21	3	2	17	17	16,76	50%	Orange (rainbowglow)	1	0	C	Rockanje
14	84	1,8	47,03	8,61	4,41	4	4&5	27	29	18,03	38%	Absent	2	1	E	Hoek van Holland
14	87	1,9	46,79	9,15	4,56	2	2	22	27	19,79	42%	Absent	1	1	C	Hoek van Holland
14	88	2,7	50,63	11,62	3,8	5	2	29	29	21,63	43%	Absent	2	1	E	Hoek van Holland
14	258	1	30	7,37	3,63	3	2	18	18	12	40%	Orange (rainbowglow)	1	0	E	Rockanje
14	263	1,8	37,86	8,32	4,36	3	4&5	24	25	12,86	34%	Black (tar)	1	0	C	Rockanje
14	278	3,6	51,44	11,14	5,15	2	6	32	35	16,44	32%	Black (tar)	0	0	C	Rockanje
14	318	4,7	47,85	12,79	6,27	2	2	32	Unknown	15,85	33%	Absent	0	0	C	Rockanje
14	324	1,7	36,31	10,21	4,24	4	2	17	21	15,3	42%	Absent	2	0	E	Rockanje
14	327	2,3	55,8	10,93	4,56	2	5	35	36	19,8	35%	Orange (rainbowglow)	0	0	C	Hoek van Holland
21	1	2,5	50,9	9,6	4,5	3	6	26	26	24,9	49%	Black (tar)	2	0	C	Maasvlakte 2

Appendix B: Photos and Drawings of Experimental Points

Photos and drawings of the experimental points are presented below. Photos are divided into photos before the experiment and after the experiment. The photos are made with a Nikon D5100 camera, and a stereomicroscope.

Experimental point 3640

Before shooting experiment | After shooting experiment


2 mm
2 mm
1 mm
2 mm

Experiments usewear analysis
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Piece no. 3640
User name: M. Spithoven
Date: 04-01-2018

Tooltype : arrowhead-barbed point
Grainsize: fine medium coarse
Raw material: deer bone
Hafting: yes
Retouch: -
Edge angle:

Material: fish (salmon without organs) 2x, 1x ground (sea clay + clay-sand)

State: dry fresh soaked
Hardness: soft medium hard

Additives or pollution: tar
Type of surface worked on:

Motion: cutting sawing shaving scraping planing whittling graving boring piercing chopping adzing wedging pounding shooting

Contact surface: back, belly, ground (quartz stone)
Angle worked: +/- 90°
Loading: static dynamic
Depth of insertion (~~mm~~): 25cm; 36cm; 27,5cm
Duration (in min.):

Detailed description of experimental procedure and activity carried out:

Deer bone was sawn into pieces with a modern metal saw. Some of the edges were removed in the same way. After that one of the pieces was shaped with a brick and some sand. No water was used. The barbs have been made with flint blades and flakes.

point has been hafted with tar and cordage on wooden arrowshaft of 26gr. Arrow shot twice in salmon from 2m distance. Thereafter 1 shot in the sea clay (from Flevopolder) and in clay-sand underneath hitting a quartz stone.

Tool effectiveness (describe also its deterioration through time):

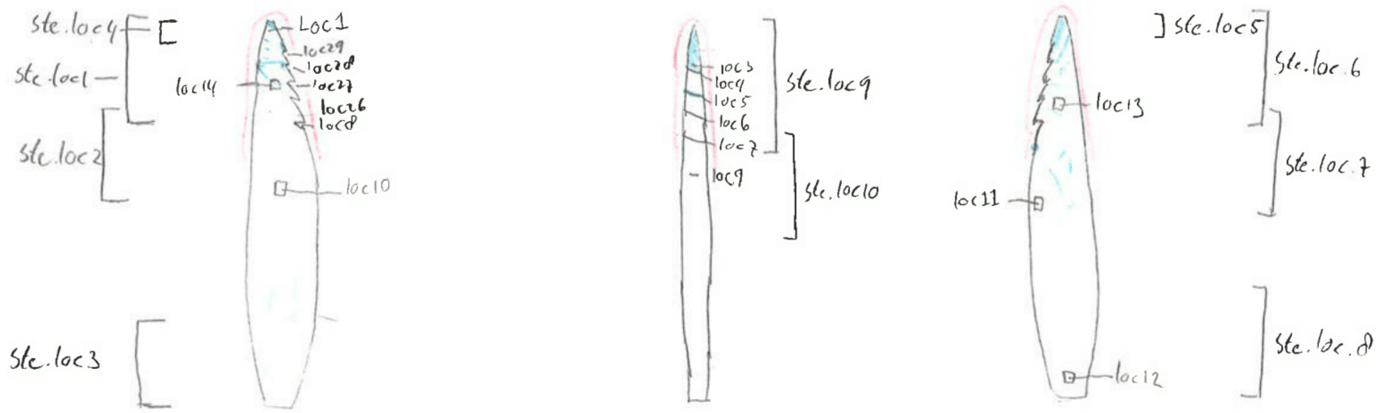
shots in fish no problems.
Shot against stone and tip broke

Cleaning procedures: soap alcohol acetone HCL KOH ultrasonic tank

Photographic documentation: yes

Piece no. 3640

Sketch of the way tool is handled and used.
Drawing (scale 1:1) of tool indicating used edge by red pencil and damage during work blue pencil:



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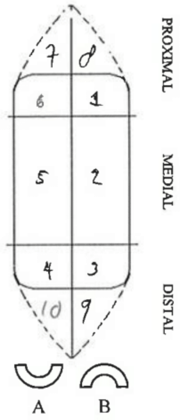


Date 26-04-2018 **Individual nr** 3640

Analyst M Spithoven **Site** experimental

Raw material Bone Antler Teeth, Ivory, Horn

Species red deer **Skeletal part** metapodium

Further specification

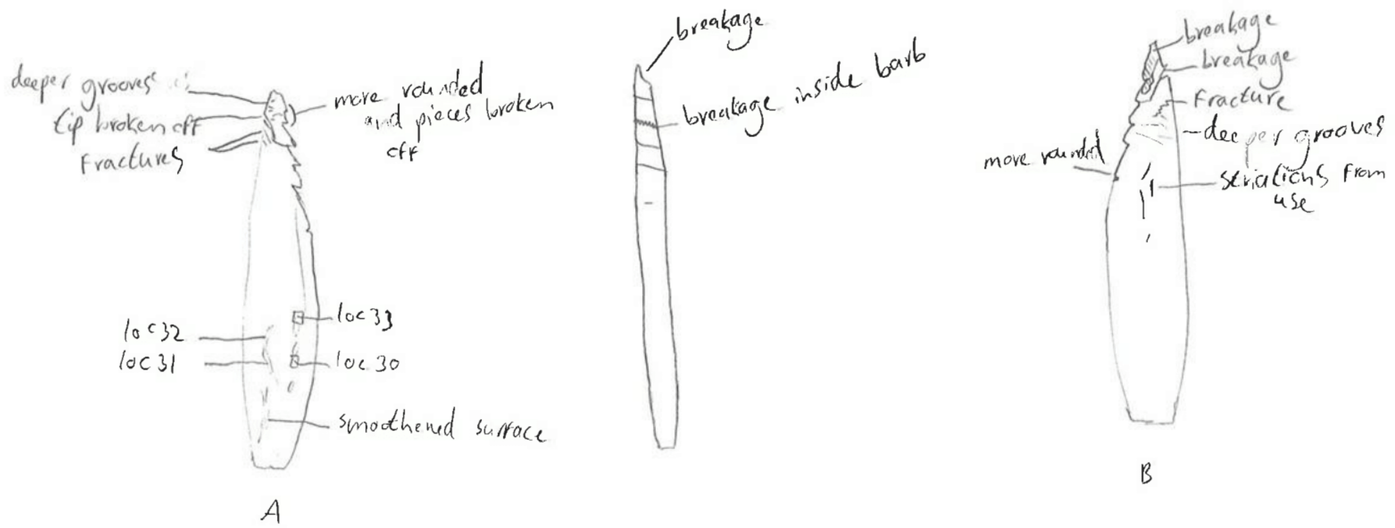
Tool type: arrowhead (barbed)

coordinate	A 7+6	B 2,3,9	B 8	B 8+1	
extent					
sec mod					
edge angle					
degree wear	a lot		a lot	a lot	
motion	projectile		projectile	projectile	
HP material					
LP material	grooves, chipping			grooves, striations, rounding	
residue		tar			
macro wear	breakage, frac-		breakages	fractures	
directionality	ture, rounding				

Cleaning handwash; ultrasonic tank; 96% alcohol

Taphonomy

Photo/Video yes

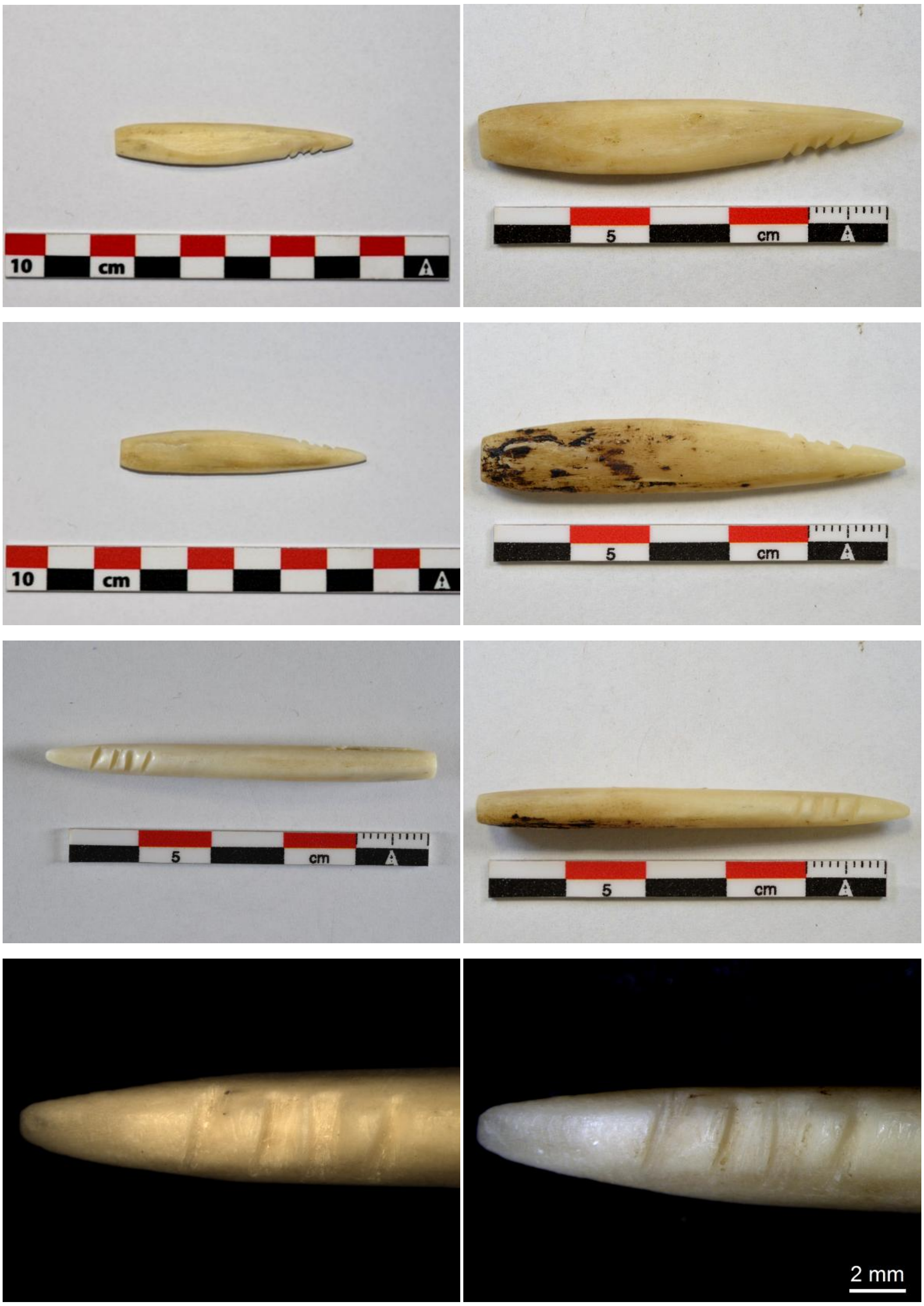


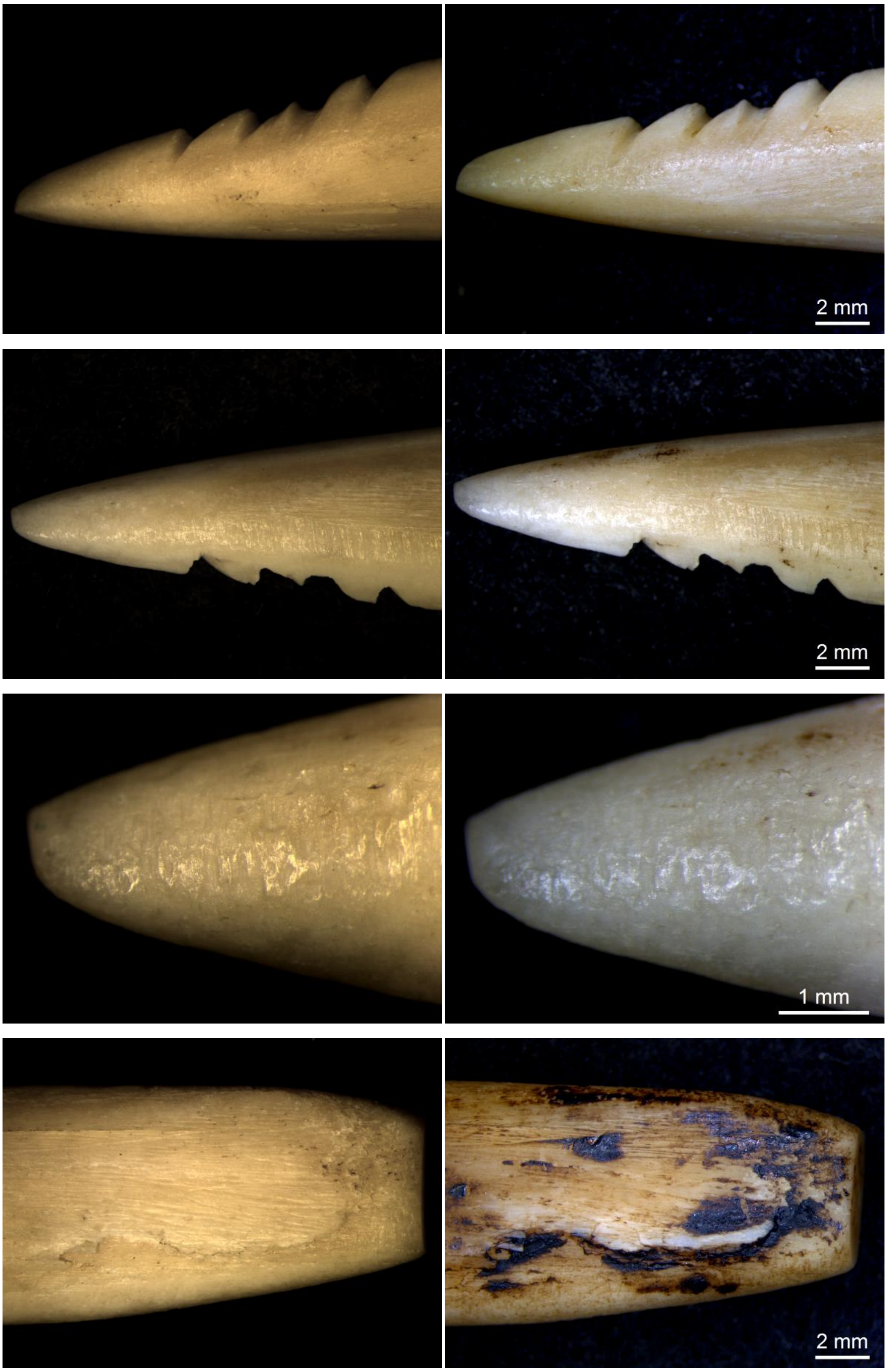
rounding everywhere causing the manufacture traces to disappear

Experimental point 3641

Before shooting experiment

After shooting experiment




2 mm
2 mm
1 mm
2 mm

Experiments usewear analysis

Piece no. 3641
User name: M. Spithoven
Date: 04-01-2018

Tooltype : arrowhead-barbed point
Raw material: deer bone
Retouch: ______________________

Grainsize: fine medium coarse
Hafting: yes______________________
Edge angle: ______________________

Material:fish (Salmon without organs)

State: dry fresh soaked
Hardness: soft medium hard

Additives or pollution: tar
Type of surface worked on: ______________________

Motion: cutting sawing shaving scraping planing whittling graving
boring piercing chopping adzing wedging pounding shooting

Contact surface: back, belly, tail
Loading: static dynamic
Duration (in min.): ______________

Angle worked: +/- 90°
Depth of insertion (~~mm~~): diverse

Detailed description of experimental procedure and activity carried out:

Deer bone was sawn into pieces with a modern metal saw. Some of the edges were removed in the same way. After that one of the pieces was shaped with a brick and some sand. No water was used. The barbs have been made with flint blades and flakes.

point has been hafted with tar and cordage on wooden arrow of 32gr. Arrow shot in Salmon 20 times from 2m distance.

Tool effectiveness (describe also its deterioration through time):

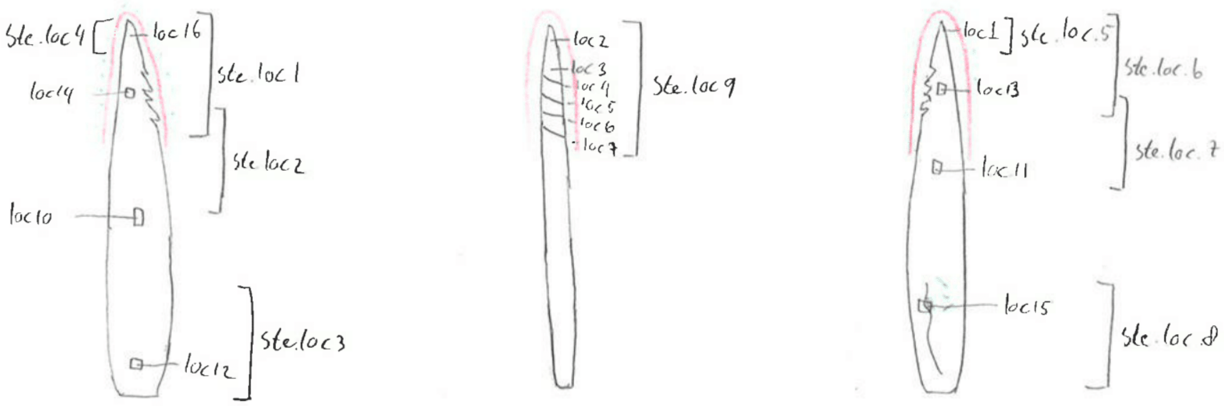
Very effective Little use wear

Cleaning procedures: soap alcohol acetone HCL KOH ultrasonic tank

Photographic documentation: yes______________________

Piece no. 3641

Sketch of the way tool is handled and used.
Drawing (scale 1:1) of tool indicating used edge by red pencil and damage during work blue pencil:



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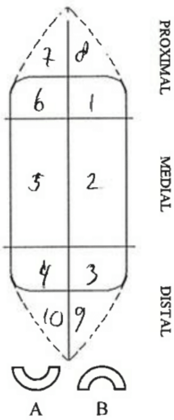


Date 26-04-2018 **Individual nr** 3641

Analyst M. Spithoven **Site** experimental

Raw material Bone Antler Teeth, Ivory, Horn

Species red deer **Skeletal part** metapodium

Further specification

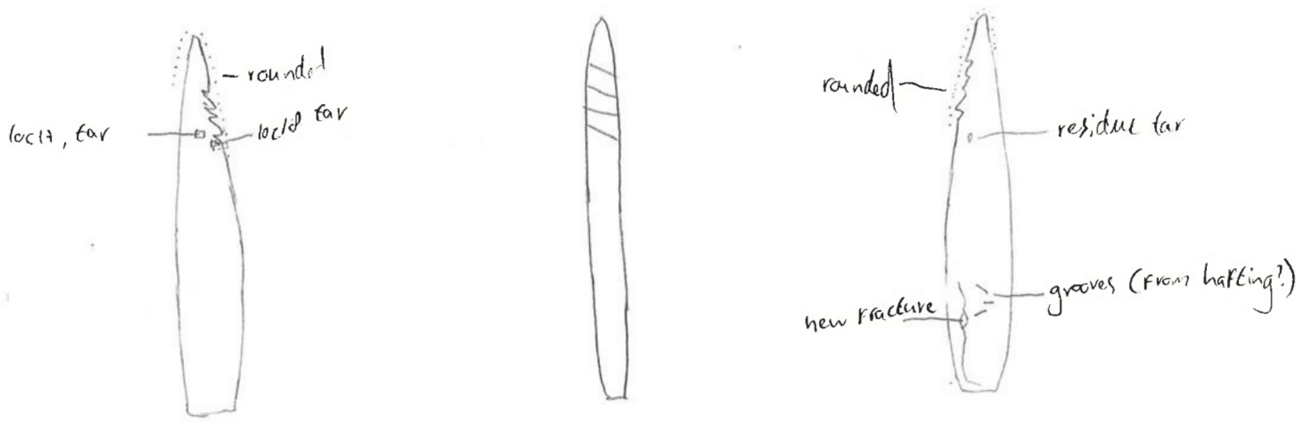
Tool type: barbed arrowhead (curated)

coordinate	B2,3,9	B3,9	7,8,6,1		
extent					
sec mod					
edge angle					
degree wear		Some			
motion					
HP material					
LP material		fracture, grooves	rounding		
residue	tar		fish mat./tar		
macro wear					
directionality		horizontal			

Cleaning handwash, ultrasonic tank

Taphonomy

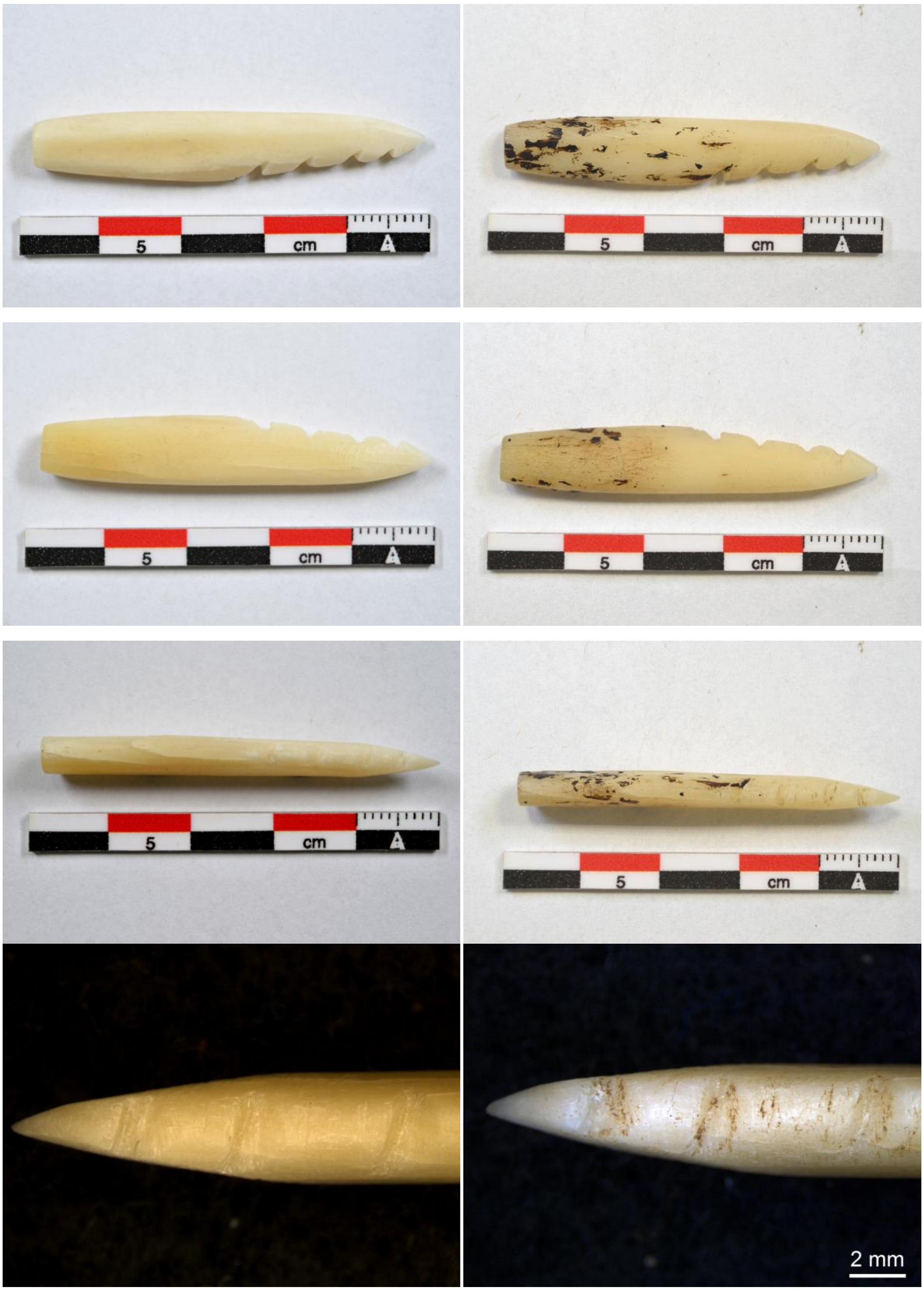
Photo/Video yes

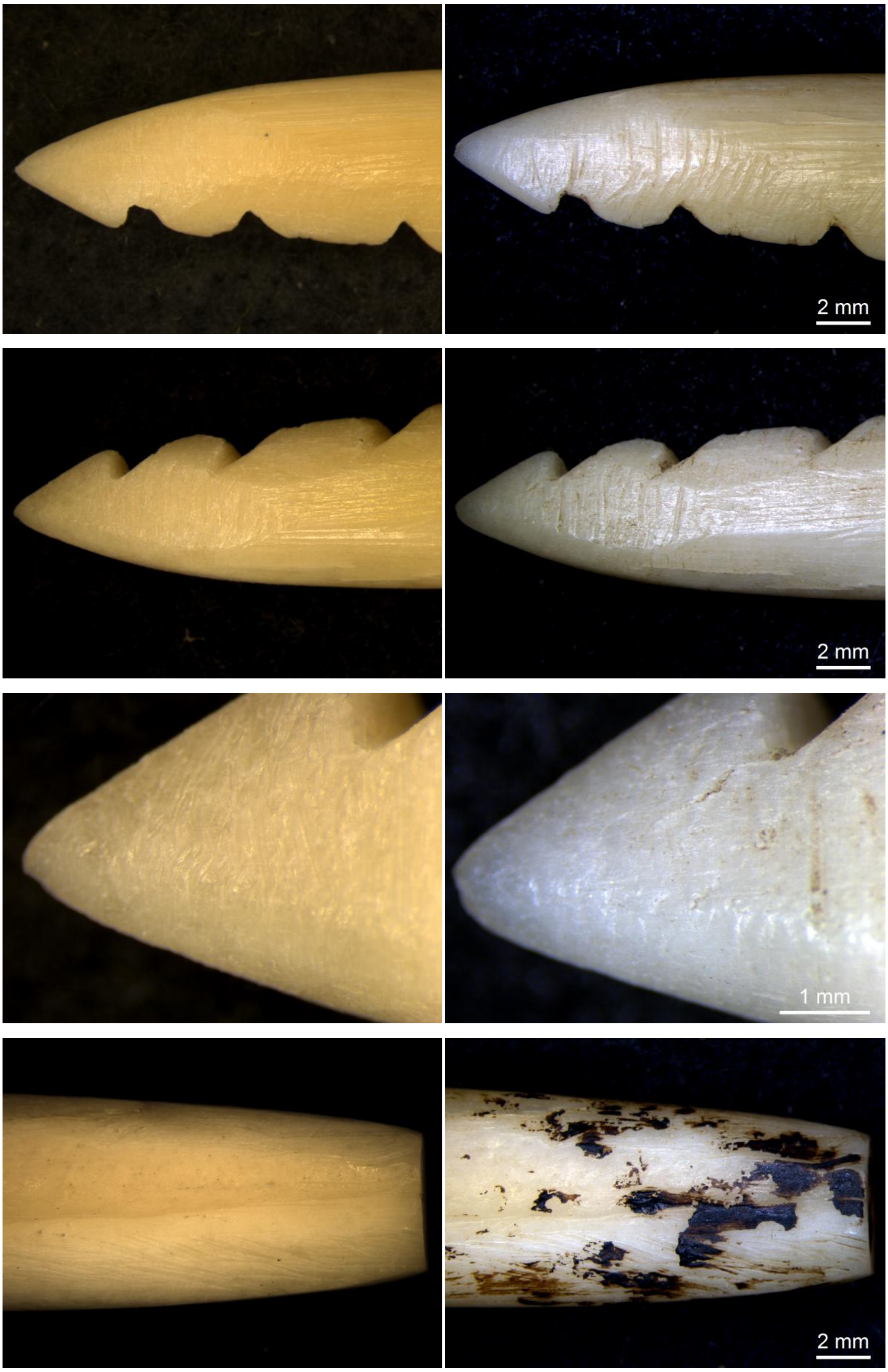


Experimental point 3642

Before shooting experiment

After shooting experiment




2 mm
2 mm
1 mm
2 mm

Experiments usewear analysis

Piece no. 364~~1~~2
User name: M. Spithoven
Date: 04-01-2018

Tooltype : arrowhead-barbed point
Raw material: deer bone
Retouch: __________

Grainsize: fine medium coarse
Hafting: yes__________
Edge angle: __________

Material:meat pork meat covered with deer skin

State: dry fresh soaked
Hardness: soft medium hard

Additives or pollution: tar
Type of surface worked on: __________

Motion: cutting sawing shaving scraping planing whittling graving boring piercing chopping adzing wedging pounding shooting

Contact surface: __________
Loading: static dynamic
Duration (in min.): __________

Angle worked: +/- 90°
Depth of insertion ~~(mm)~~: 13-22 cm

Detailed description of experimental procedure and activity carried out:

Deer bone was sawn into pieces with a modern metal saw. Some of the edges were removed in the same way. After that one of the pieces was shaped with a brick and some sand. No water was used. The barbs have been made with flint blades and flakes.

point has been hafted on wooden arrow with tar and cordage. Arrow weight 25gr. deer skin was filled with carbonades, tight together with rope and hung into a tree. Distance to target was 3m. After 4 shots point fell from shaft and was reshafted. 8 more times shot at target. Thereafter 2 shots in the clay-sand ground through grass.

Tool effectiveness (describe also its deterioration through time):

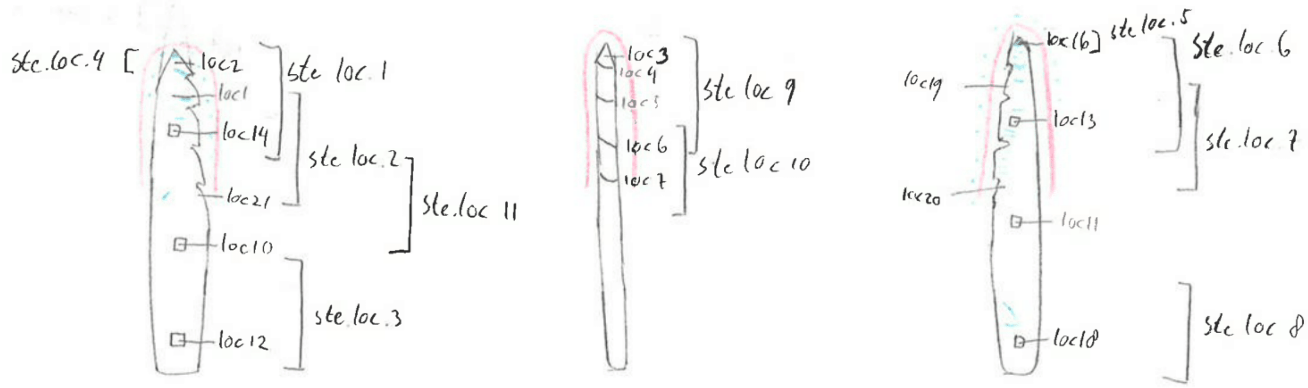
hafting not very effective, point effective, little use wear

Cleaning procedures: soap alcohol acetone HCL KOH ultrasonic tank

Photographic documentation: yes__________

Piece no. 364[redacted]2

Sketch of the way tool is handled and used.
Drawing (scale 1:1) of tool indicating used edge by red pencil and damage during work blue pencil:



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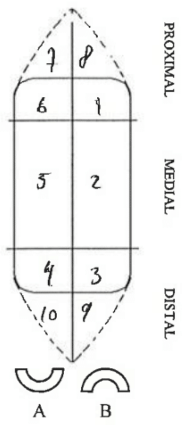


Date 26-04-2018 **Individual nr** 3642

Analyst M spithoven **Site** experimental

Raw material Bone Antler Teeth, Ivory, Horn

Species Red deer **Skeletal part** metapodium

Further specification ____

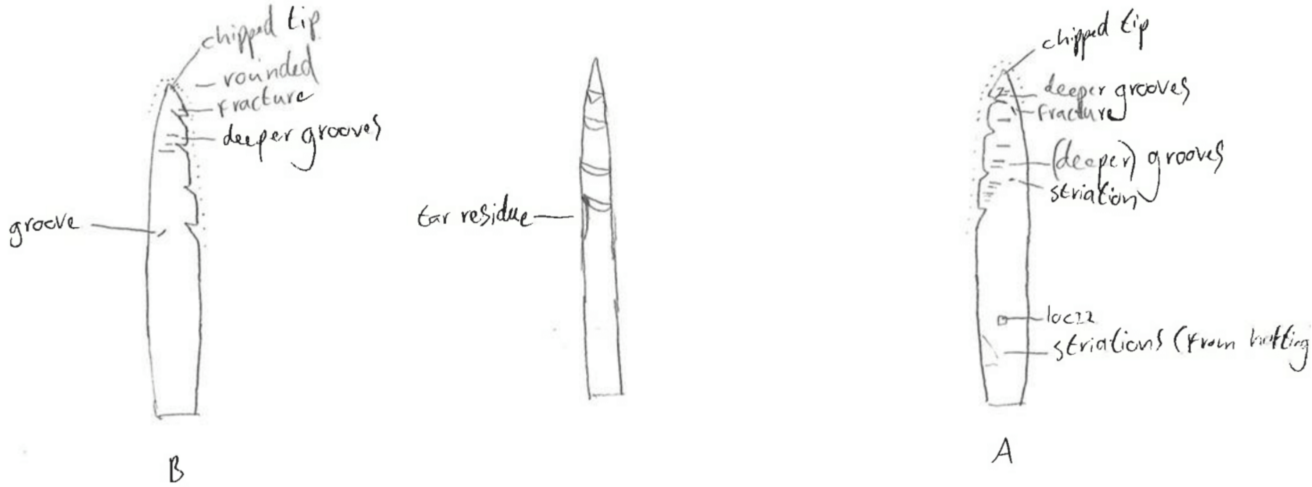
Tool type: barbed arrowhead (curved)

coordinate	B2,3,9	B8,1	A7,6,5	A9	
extent					
sec mod					
edge angle					
degree wear	little	some	a lot	little	
motion	projectile	projectile	projectile	projectile	
HP material					
LP material	groove	chipping rounding	chipping rounding	striations	
residue	tar	fracture, grooves	fracture, grooves, striations		
macro wear					
directionality					

Cleaning handwash, ultrasonic tank

Taphonomy ____

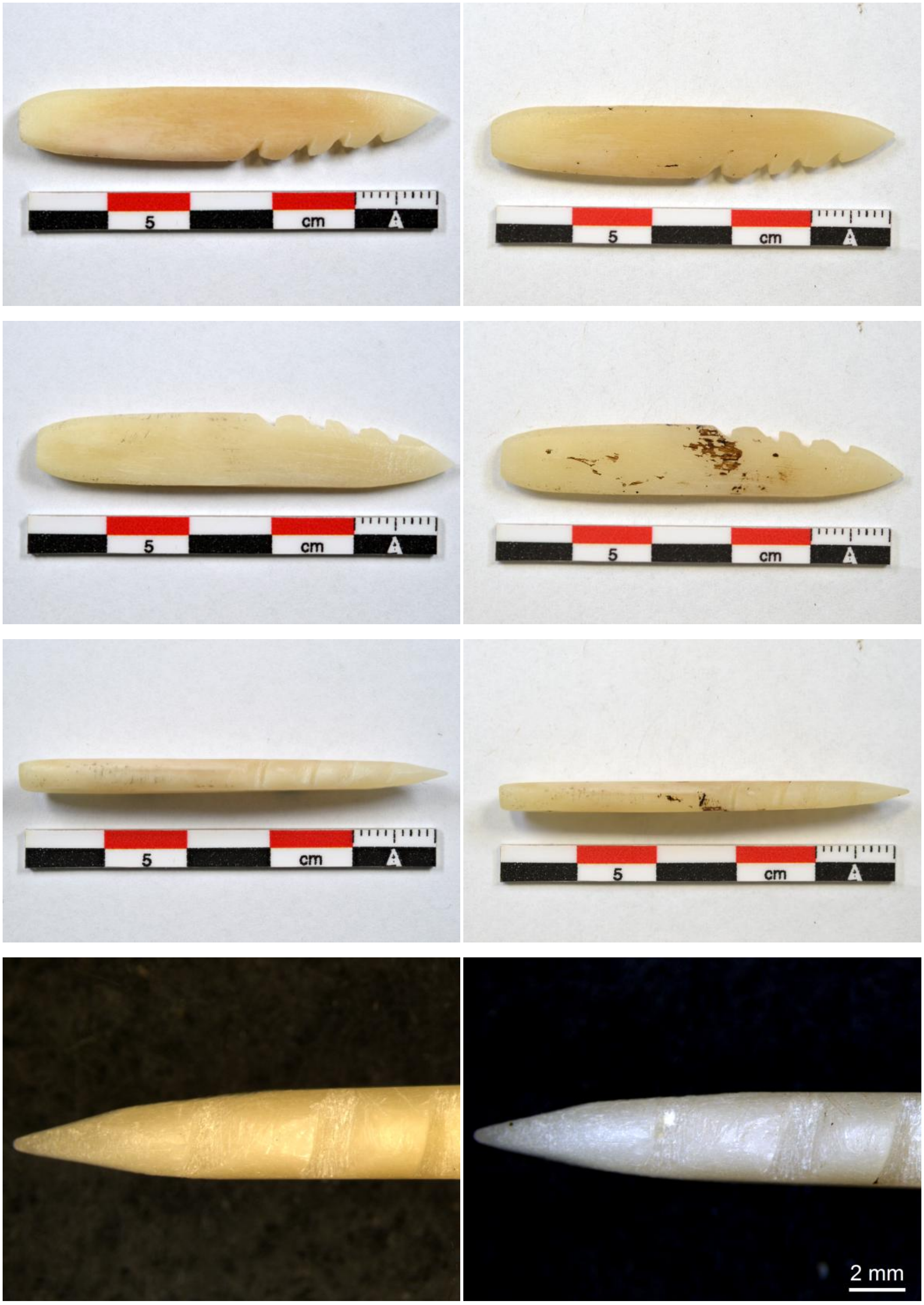
Photo/Video yes

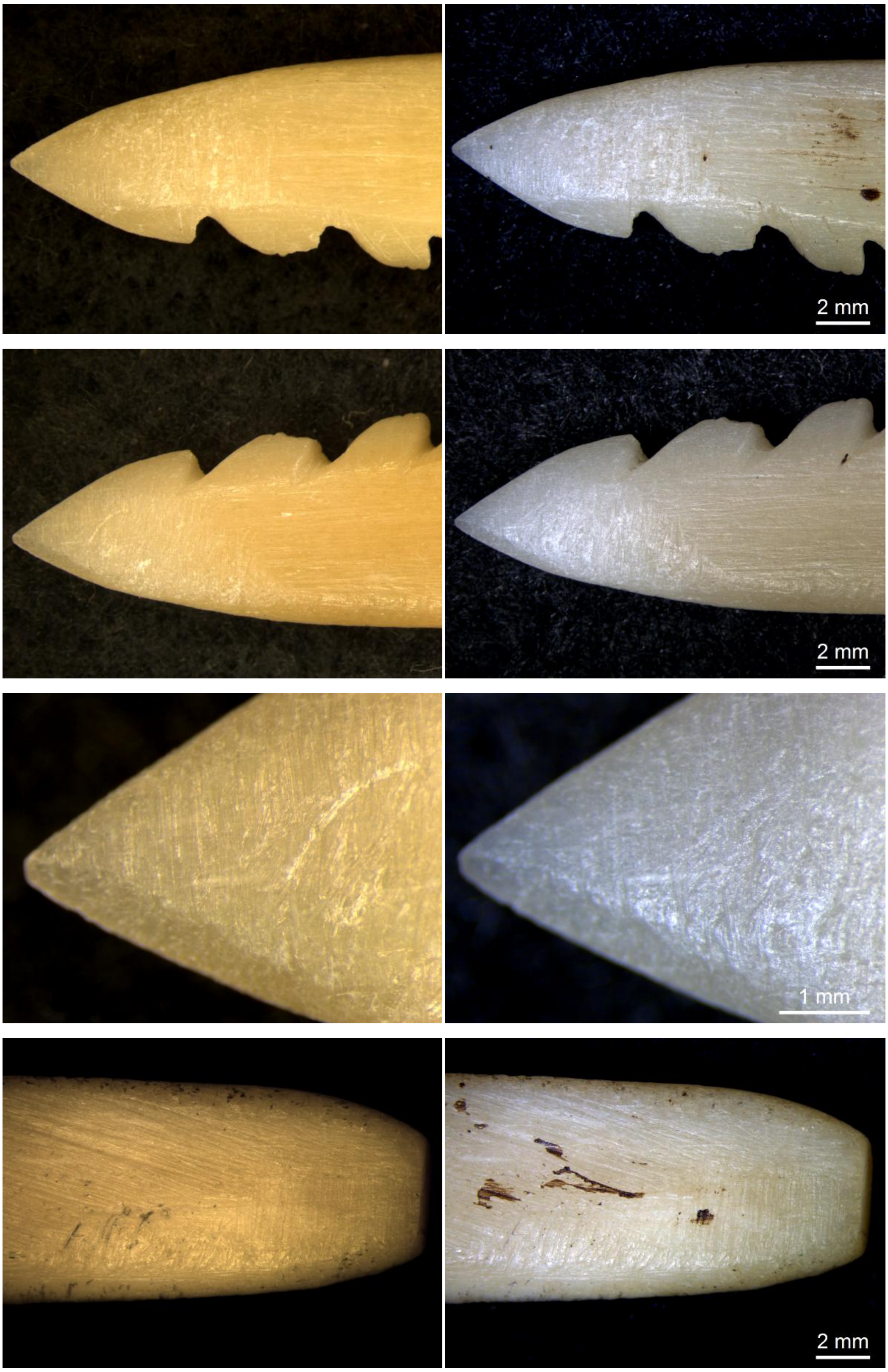


Experimental point 3643

Before shooting experiment

After shooting experiment




2 mm
2 mm
1 mm
2 mm

Experiments usewear analysis

Piece no. 3643
User name: M. Spithoven
Date: 04-01-2018

Tooltype : arrowhead-barbed point
Raw material: deer bone
Retouch: ______________________

Grainsize: fine medium coarse
Hafting: yes______________________
Edge angle: ______________________

Material:meat pork meat and deer skin

State: dry fresh soaked

Hardness: soft medium hard

Additives or pollution: tar
Type of surface worked on: ______________________

Motion: cutting sawing shaving scraping planing whittling graving
boring piercing chopping adzing wedging pounding shooting

Contact surface: ______________
Loading: static dynamic
Duration (in min.): ______________

Angle worked: +/- 90°
Depth of insertion (mm): ?

Detailed description of experimental procedure and activity carried out:

Deer bone was sawn into pieces with a modern metal saw. Some of the edges were removed in the same way. After that one of the pieces was shaped with a brick and some sand. No water was used. The barbs have been made with flint blades and flakes.

point has been hafted with tar and cordage on wooden arrowshaft of 29gr Arrow shot once in target from 3m distance shaft broke off where point was hafted. Tip of point looked chipped

Tool effectiveness (describe also its deterioration through time):

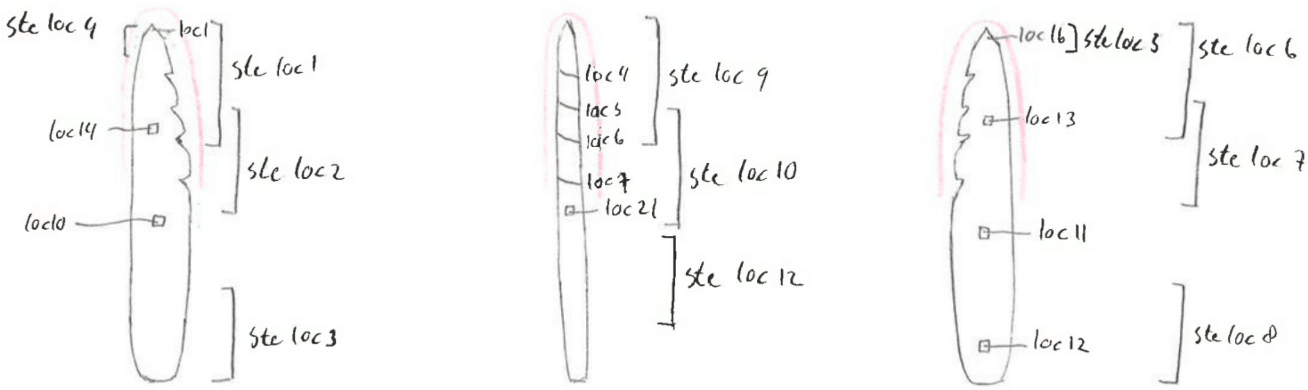
not very effective because shaft broke

Cleaning procedures: soap alcohol acetone HCL KOH ultrasonic tank

Photographic documentation: yes______________________

Piece no. 3643

Sketch of the way tool is handled and used.
Drawing (scale 1:1) of tool indicating used edge by red pencil and damage during work blue pencil:



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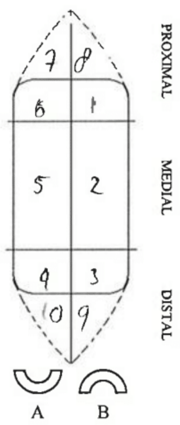


Date 30-04-2010 **Individual nr** 3643

Analyst M. Spithoven **Site** experimental

Raw material Bone Antler Teeth, Ivory, Horn

Species Red deer **Skeletal part** metapodium

Further specification

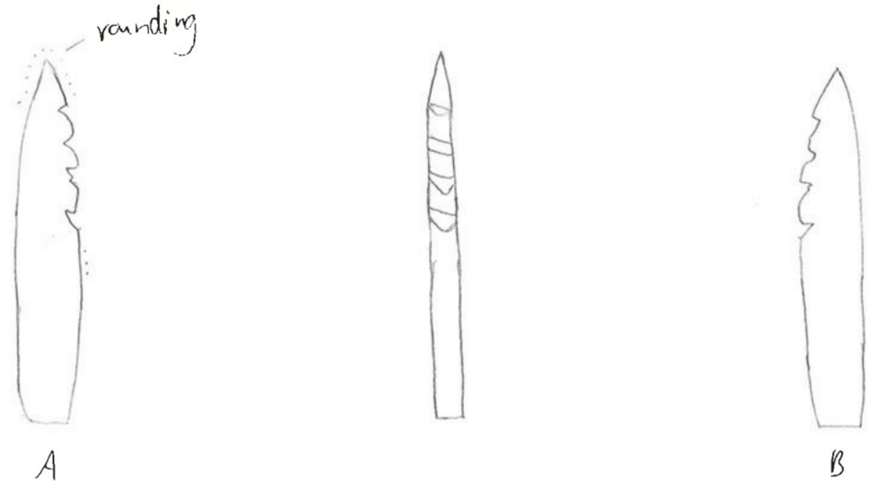
Tool type: barbed arrowhead (expedient)

coordinate	A 7(8)	B 5,2,9,3,10,4			
extent					
sec mod					
edge angle					
degree wear					
motion	projectile				
HP material					
LP material	rounding				
residue		tar			
macro wear					
directionality					

Cleaning handwash, ultrasonic tank

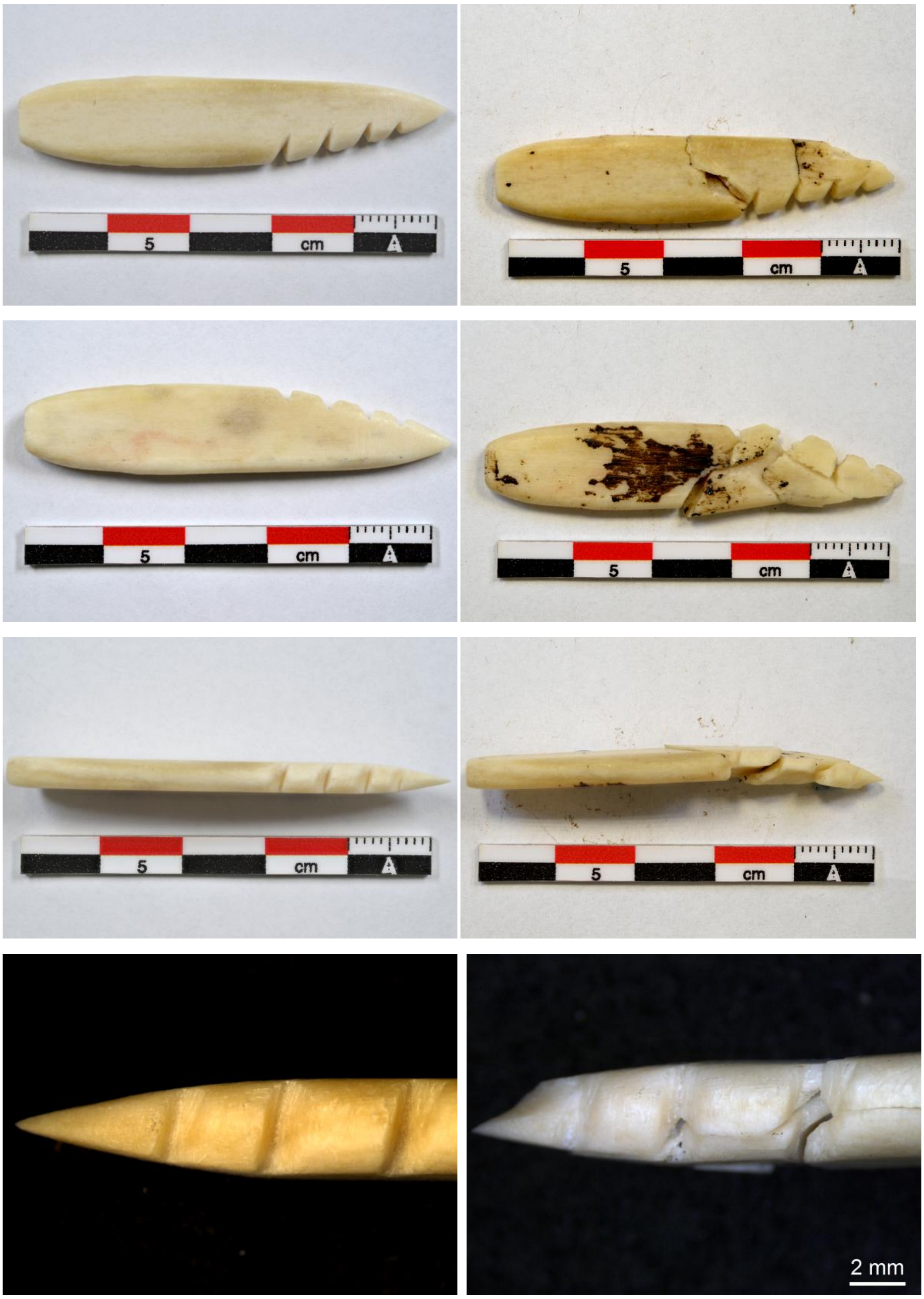
Taphonomy

Photo/Video yes



Experimental point 3644

Before shooting experiment After shooting experiment




2 mm
2 mm
1 mm
2 mm

Experiments usewear analysis

Piece no. 3644
User name: M. Spithoven
Date: 04-01-2018

Tooltype : arrowhead-barbed point
Raw material: deer bone
Retouch: ______

Grainsize: fine medium coarse
Hafting: yes______
Edge angle: ______

Material:bone (cow, mainly ribs) with pork meat covered with deer skin

State: dry fresh soaked

Hardness: soft medium hard

Additives or pollution: tar
Type of surface worked on: ______

Motion: cutting sawing shaving scraping planing whittling graving
boring piercing chopping adzing wedging pounding shooting

Contact surface: ______
Loading: static dynamic
Duration (in min.): ______

Angle worked: +/- 90°
Depth of insertion (mm): ?

Detailed description of experimental procedure and activity carried out:

Deer bone was sawn into pieces with a modern metal saw. Some of the edges were removed in the same way. After that one of the pieces was shaped with a brick and some sand. No water was used. The barbs have been made with flint blades and flakes.

Point has been hafted with tar and cordage on wooden arrow of 35gr incl. point. Arrow was shot once into the target and hit a bone resulting in many breakages

Tool effectiveness (describe also its deterioration through time):

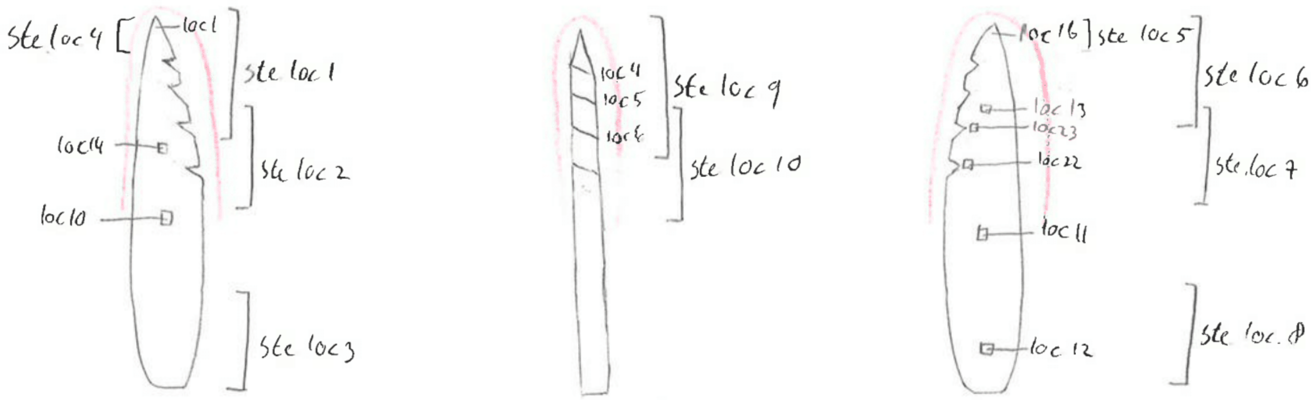
not very effective because it broke when hitting bone

Cleaning procedures: soap alcohol acetone HCL KOH ultrasonic tank

Photographic documentation: yes______

Piece no. 3644

Sketch of the way tool is handled and used.
Drawing (scale 1:1) of tool indicating used edge by red pencil and damage during work blue pencil:



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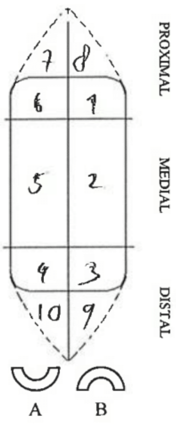


Date 01-05-2018 **Individual nr** 3644

Analyst M. Spithoven **Site** experimental

Raw material Bone Antler Teeth, Ivory, Horn

Species Red deer **Skeletal part** metapodium

Further specification

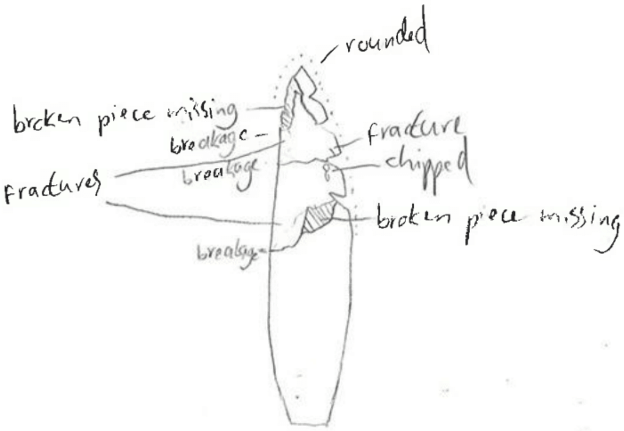
Tool type: barbed arrowhead (expedient)

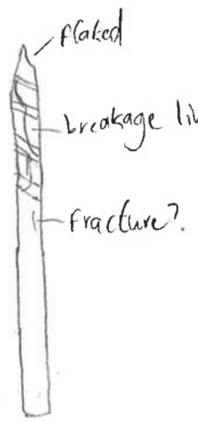
coordinate
extent
sec mod
edge angle
degree wear
motion
HP material
LP material
residue
macro wear
directionality

Cleaning handwash, ultrasonic tank, alcohol 96%, handsoap

Taphonomy

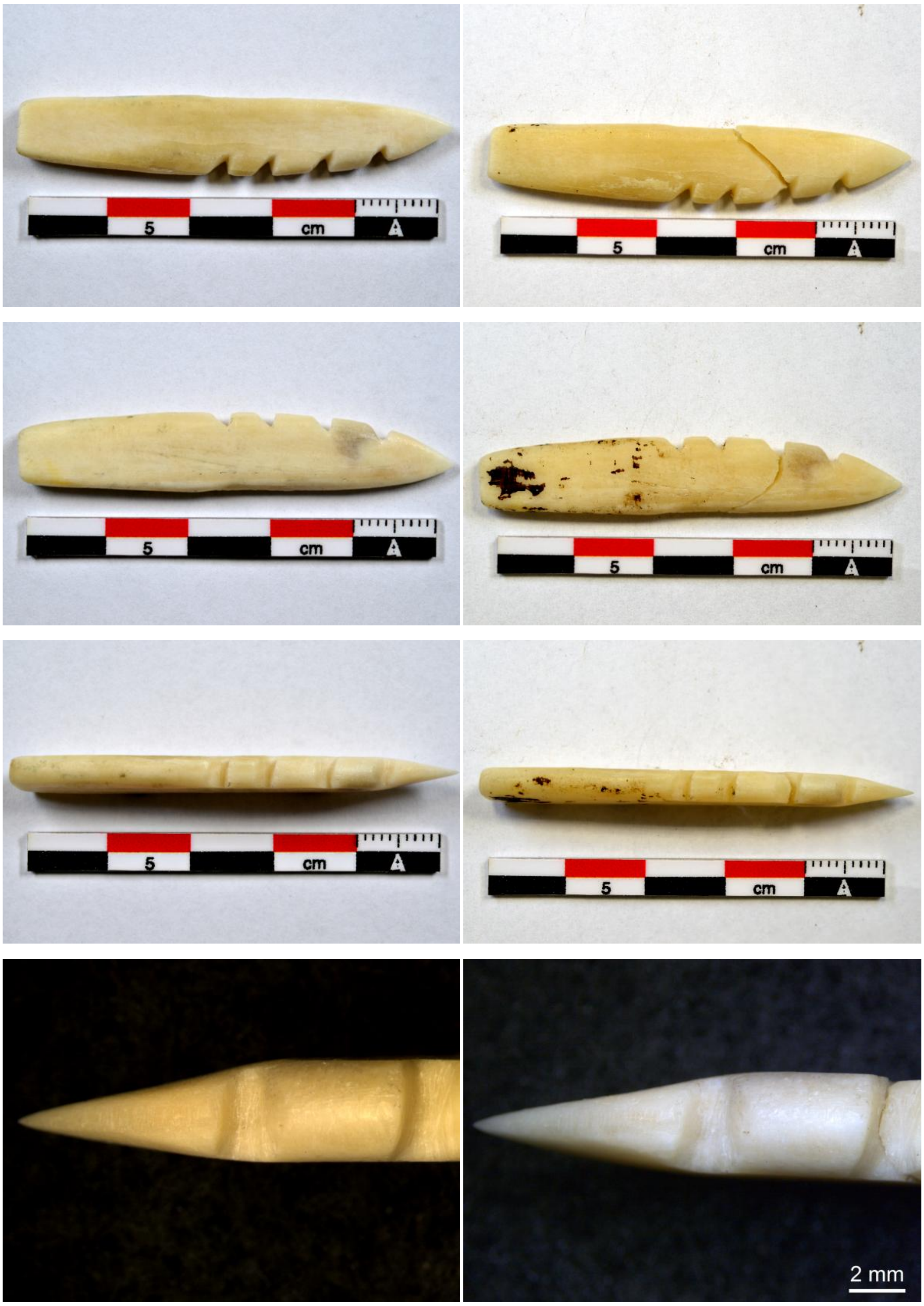
Photo/Video yes

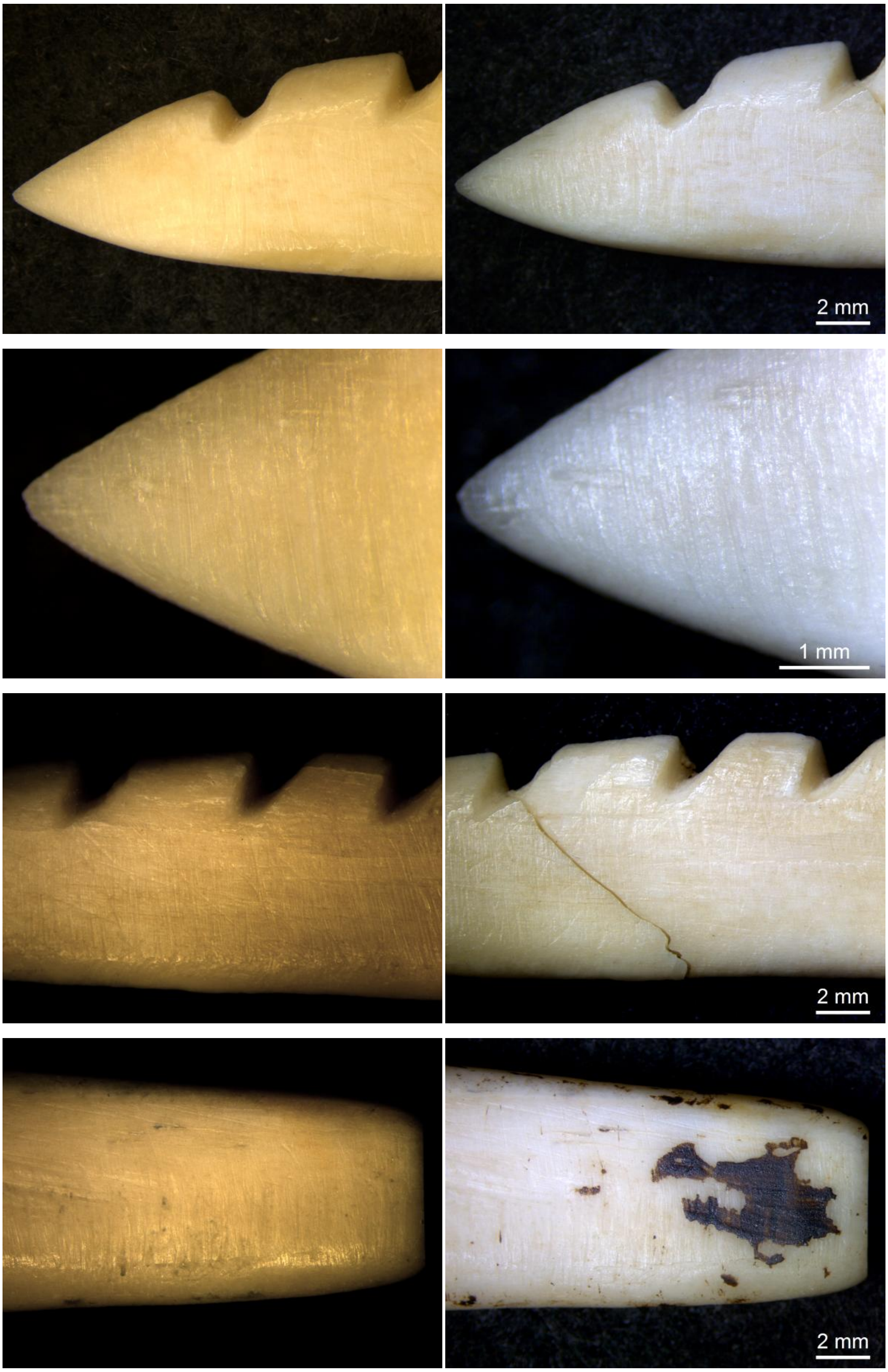




Experimental point 3645

Before shooting experiment | After shooting experiment




2 mm
1 mm
2 mm
2 mm

Experiments usewear analysis

Piece no. 3645
User name: M. Spithoven
Date: 04-01-2018

Tooltype : arrowhead-barbed point
Raw material: deer bone
Retouch: ______

Grainsize: fine medium coarse
Hafting: yes______
Edge angle: ______

Material:bone (cow) mainly ribs, pork meat, covered with deer skin

State: dry **fresh** soaked
Hardness: soft medium **hard**

Additives or pollution: tar
Type of surface worked on: ______

Motion: cutting sawing shaving scraping planing whittling graving boring piercing chopping adzing wedging pounding **shooting**

Contact surface: ______
Loading: static dynamic
Duration (in min.): ______

Angle worked: +/- 90°
Depth of insertion (~~mm~~): 0,5 cm, 12 cm

Detailed description of experimental procedure and activity carried out:

Deer bone was sawn into pieces with a modern metal saw. Some of the edges were removed in the same way. After that one of the pieces was shaped with a brick and some sand. No water was used. The barbs have been made with flint blades and flakes.

point has been hafted with tar and cordage on wooden arrowshaft of 29gr (incl. point). Arrow shot twice at target from distance of 3m. Point probably did not hit bone the first shot but hit at least 2 ribs the second shot. Broken off part was inside the target, not in a bone.

Tool effectiveness (describe also its deterioration through time):

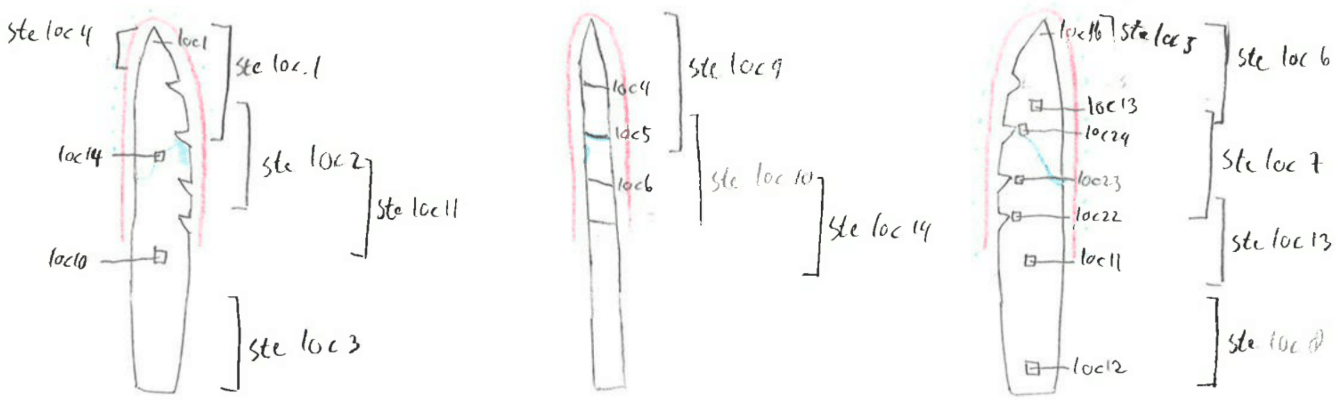
not very effective because point broke off at the second barb with the second shot.

Cleaning procedures: soap alcohol acetone HCL KOH **ultrasonic tank**

Photographic documentation: yes______

Piece no. 3645

Sketch of the way tool is handled and used.
Drawing (scale 1:1) of tool indicating used edge by red pencil and damage during work blue pencil:



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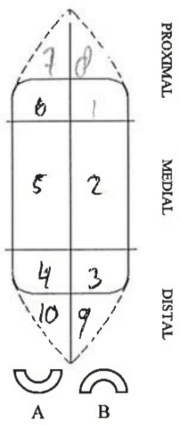

Date 30-09-2018 **Individual nr** 3645

Analyst M. Spithoven **Site** experimental

Raw material Bone Antler Teeth, Ivory, Horn

Species Red deer **Skeletal part** metapodium

Further specification ____

Tool type: barbed arrowhead (experiment)

coordinate					
extent					
sec mod					
edge angle					
degree wear					
motion					
HP material					
LP material					
residue					
macro wear					
directionality					

Cleaning hand wash, ultrasonic tank, alcohol 96%

Taphonomy ____

Photo/Video yes