Foraging Assemblages

Volume 1

Edited by Dušan Borić, Dragana Antonović, and Bojana Mihailović

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Volume 2

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Front Cover Illustration: Sculpted sandstone boulder named '*Progenitor*' (inv. no. 41) from Lepenski Vir (National Museum in Belgrade)
Back Cover Illustration: Lepenski Vir during excavations (Photograph courtesy of of Alan McPherron)

VOLUME I

60. Incremental growth line analysis of the European oyster (*Ostrea edulis*, Linnaeus, 1758) from the kitchen midden at Eskilsø, Denmark

Harry K. Robson, Søren A. Sørensen, Eva M. Laurie, and Nicky Milner

Eskilsø is one of a number of stratified Danish kitchen middens spanning the Late Mesolithic (Ertebølle) and the Early Neolithic (Funnel Beaker) periods, *c.* 5400–2800 cal BC. Oyster shell samples from seven *in situ* layers were taken from across the kitchen midden during its excavation in 2001. In total, 202 oysters were thin sectioned in order to ascertain seasonal consumption practices, and to assess changing shell size and age, which can be linked to increased human exploitation and/or environmental change. The hypothesis that a change in the seasonal exploitation of the oyster across the Mesolithic-Neolithic transition at the site was not proven. When compared with previous studies, these data demonstrate a rather complex situation regarding their exploitation at that time. Moreover, the data demonstrate that the seasonality of oyster consumption varied from site to site during the Late Mesolithic and Early Neolithic, and that oysters continued to play a role in diet well after the transition to agriculture *c.* 3950 cal BC.

Keywords: seasonality, Denmark, oyster, Mesolithic, Neolithic

Introduction

Roskilde Fjord has long been a focus of kitchen midden research in Denmark. During the late 1840s and early 1850s *The First Kitchen Midden Commission* carried out a number of excavations at some of the now famous localities including Bi-Lidt, Havelse Mølle, and Sølager. Later, in 1919, T. Mathiassen conducted a survey along the coast of the fjord and demonstrated that no less than 104 kitchen middens were preserved (Mathiassen 1919), and since then this number has increased to around 150.

Given the potential threats to the kitchen middens along the palaeoshorelines of fjords (*e.g.* Andersen 1989) a survey was conducted in the 1990s that resulted in the identification of more than 100 kitchen middens, the majority of which were small (*c.* 10–15 m in length), although occasionally larger ones were encountered (*c.* 100 m in length). Unfortunately, these investigations demonstrated that many of the sites have been disturbed by agriculture and/or construction work. The Eskilsø kitchen midden, located on the north-eastern coastline of a small islet (known as Eskilsø) in the Roskilde Fjord, North Zealand, East Denmark (Fig. 60.1), was selected for further analysis because it was under threat from

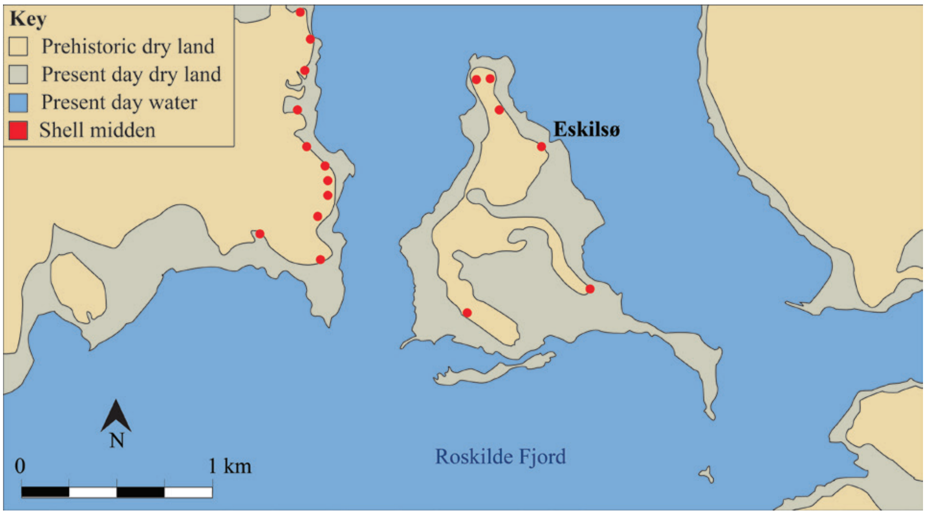

Fig. 60.1. Map showing the location of the Eskilsø kitchen midden.

agriculture. It is considered to be one of the smaller sites (Fig. 60.2); however, it contains both Late Mesolithic (*c.* 5400–3950 cal BC) and Early Neolithic (*c.* 3950–2800 cal BC) layers (Sørensen 2001). A partial excavation was undertaken by Søren A. Sørensen (S. A. S.) in order to evaluate its research potential.

The excavations showed that there was not one kitchen midden but in fact two closely spaced middens, one of which was entirely Neolithic in date. The older kitchen midden consisted of a stratified sequence with a Neolithic cultural layer at the top, in which there was a moderate amount of shell. In this layer only very small oyster shells were observed, which may in part be explained by environmental change, since a total extinction of the oyster followed in the fjord. This layer has been dated typologically to *c.* 3800–3500 cal BC. Under this layer a compacted shell layer was identified which consisted of oyster shells and material culture from the youngest Ertebølle culture (hereafter EBK). These deposits have been dated typologically to *c.* 4300–3800 cal BC. This shell layer was situated on top of a thick layer of sand and gravel from the middle and oldest EBK and within it scattered shells and material culture, including stone fireplaces, were observed. The cultural layers increased in thickness from west to east, from 0 cm at the top of the slope to 180 cm further to the east, around 15 m away, where the section ceased (Fig. 60.3). Here, the Neolithic layer was very disturbed, and there were only a few features in the form of stone fireplaces and a stone-lined boiling pit. In this area material culture dating from the Early Neolithic, represented by the Funnel Beaker culture (hereafter TRB), to the Late Neolithic, represented by the Pitted Ware and Single Grave cultures, were recovered. Owing to a very thick sequence, only a small part of the kitchen midden was excavated.

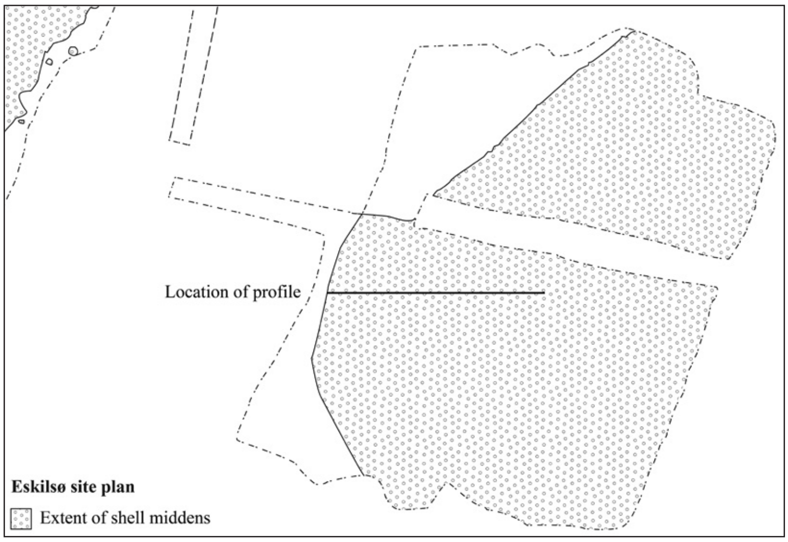

Fig. 60.2. Plan showing the extent of the kitchen midden and investigations at Eskilsø.

In the second (Neolithic) midden, the shell deposits were not compact, and fewer shells were encountered alongside cultural remains. In fact, a lower quantity of shell in Neolithic middens, compared to Mesolithic middens, is a pattern observed elsewhere in Denmark, for instance Vængesø III on the Helgenæs peninsula in east central Jutland (Robson 2015). This midden was completely excavated, but it had been severely damaged by agricultural activities and previous test pitting in the field. Nevertheless, a few pits were discovered and in some areas high frequencies of shells were found (Sørensen 2001).

Archaeomalacological analysis

Introduction

Analysis of the oyster shells was undertaken for the site in order to:

(i) determine the seasonality of oyster gathering and assess whether this was consistent or changed across the Late Mesolithic and into the Early Neolithic periods;
(ii) examine the age and size of the oyster shells through the midden sequence to see whether this was a product of intensive exploitation.

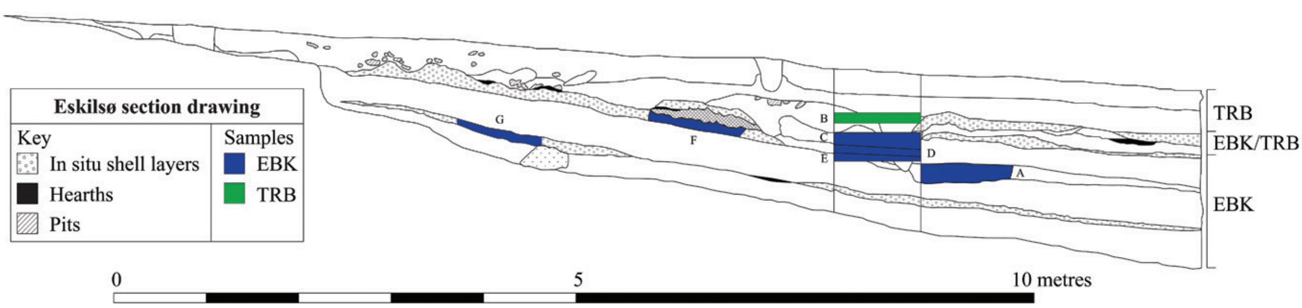

Fig. 60.3. Section through the Eskilsø kitchen midden. Note the location of sample B that is stratified above samples C, D, and E.

These questions have been examined for other Danish shell middens using well-established techniques (e.g. Milner 2002; Robson 2015).

Sampling

In 2001, during the excavation of the section through the kitchen middens (Figs. 60.2–3), 202 oyster shell samples were selected by S. A. S. from seven different *in situ* layers (Table 60.1). Initial sorting of the excavated material was undertaken in Denmark and they were then sent to Nicky Milner (N. M.) for analysis. The sampling strategy for the oyster shells was largely dependent upon the numbers available, taking into account the location of the shells within the kitchen midden, and how many thin sections could be made. Of the shells received, 130 were selected for thin sectioning. Of these, 110 came from deposits dating to the EBK, and 20 from the TRB layers.

Table 60.1. **Eskilsø sample reference numbers.**

Sample (layer)	Number of oyster shells catalogued	Number of oyster shells sampled	Culture
A	23	20	EBK
B (10 + 14)	63	20	TRB
C (11)	28	20	EBK
D (12)	15	15	EBK
E	27	20	EBK
F (2)	28	20	EBK
G (6)	18	15	EBK
Totals	**202**	**130**	

In general, the oysters from Eskilsø were fairly large and comparable with those from Havnø, Kalvø, Krabbesholm II, Lystrup Enge and Visborg (Laurie 2008; Milner 2001a, 2002, 2013; Milner and Laurie 2006, 2009; Robson 2015). In addition, it was very obvious that the shells reduced in size over time: those at the bottom of the midden sequence were much larger than those at the top.

Methods

The oysters were thin sectioned using the method developed and described by Milner (2001b, 2002). The thin sections were examined under polarized light at magnifications of x10 to x40 by two of us (E. L. and H. K. R). These were compared to a collection of thin sections made on modern shells, collected from four British locations each month over a period running from December 1995 to March 1997 (Milner 2001b). The annual lines were noted for each shell and counted, any other lines such as spawning lines were noted, and the last section of growth from the last line to the outer edge was examined in order to assess the season of death using the criteria shown in Table 60.2. In order to improve the reliability of the results, a blind test was undertaken by N. M. All identification numbers on the thin section slides were obscured using masking tape. The two analyses were compared and the results obtained are presented in Table 60.3. Agreement of over 90 percent was deemed high enough for the seasonality determinations to be valid for this analysis. Where disagreement occurred between testers the shells were reviewed by all parties and a final decision made.

Table 60.2. Season of death and identification criteria starting with line formation in the spring.

Season	Identifications
Spring	A line is present right on the edge and the edge dips down.
Spring/Summer	The shell shows a new line and a very thin band of new growth.
Summer	A band of growth between the last annual line and the shell edge.
Summer/ Autumn	A larger band of growth between the last annual line and the shell edge and a spawning line may be present.
Autumn	A large band of growth but not a full year.
Autumn/Winter	A large band of growth - almost a full year.
Winter	A large band of growth which looks like a full year but no dipping on the edge.
Winter/Spring	A darkening of the growth edge begins and dipping downwards on the edge.

Table 60.3. Initial and blind test analyses agreement percentage.

Total number of shells	Percentage agreed	Percentage disagreed
113	91.2	8.8

Results

Seasonality

Of the 130 thin sections, 102 could be read for the season of death (Table 60.4; Fig. 60.4). The other 28 thin sections were either unsuccessful during the thin section manufacturing process (for instance the shells or slides broke), or they were deemed as 'unreadable' for seasonality (for instance the edge was damaged, the structure was not clear enough or the hinge had been cut on a slant). During the process of thin sectioning every effort was made to avoid these problems, but it is inevitable that some shells are unreadable and this percentage (21.5 percent) is similar to the discard rate reported in a previous study (Milner 2002).

Overall, the patterning shows a peak of gathering in the winter/spring and spring seasons for both the EBK and

Table 60.4. Successful and unsuccessful thin section figures.

Sample	Unsuccessful thin sections	Unreadable thin sections	Readable thin sections	Totals
A	2		18	20
B	2	2	16	20
C	2	1	17	20
D	2	2	11	15
E	5		15	20
F	3	4	13	20
G	2	1	12	15
Totals	**18**	**10**	**102**	**130**

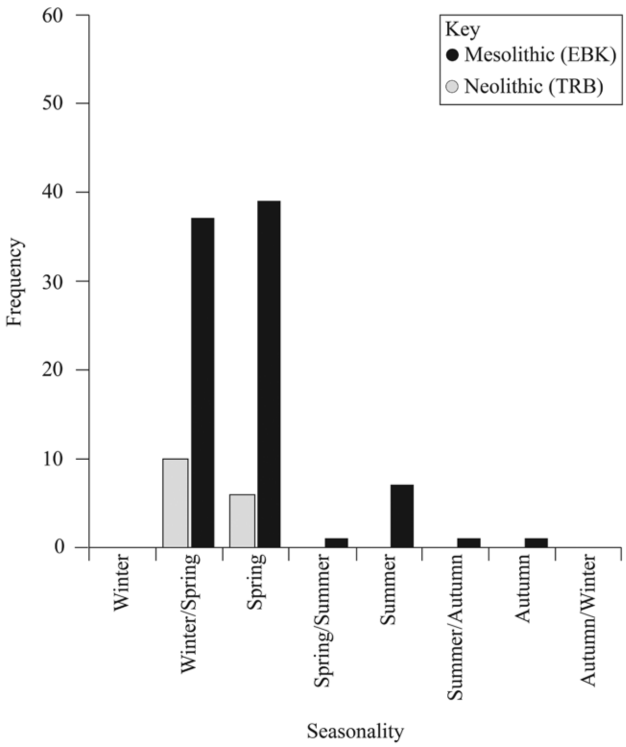

Fig. 60.4. Histogram showing the seasonality of oyster gathering for the EBK and TRB cultures.

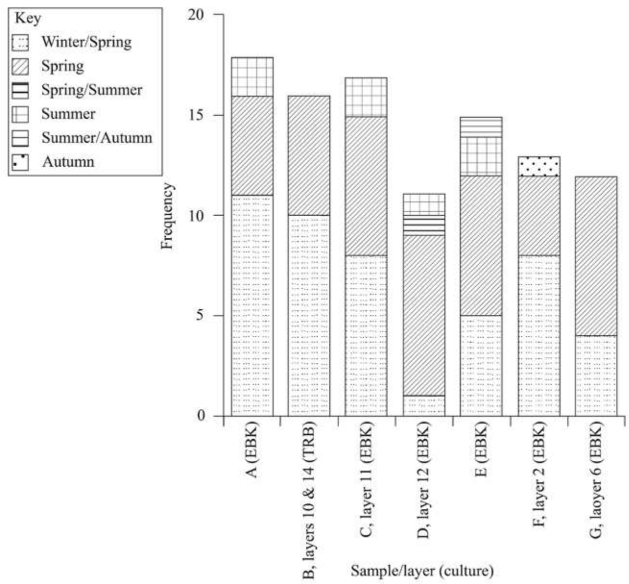

Fig. 60.5. Histogram showing the seasonality of oyster gathering that has been disaggregated according to sample/layer.

TRB periods. In addition, there are indications that oyster gathering also occurred on a smaller scale throughout most of the year, with the exception of winter during the Mesolithic. It should be noted that as growth slows down dramatically in autumn and winter these seasons are much harder to assess, but there are normally markers in the shell structure (Milner 2002) which have not been observed here. The lack of winter collection may be related to the fact that the water is much colder, perhaps even frozen over at some points during the winter making oyster gathering inaccessible, or at least less inviting. The fact that there is less of a spread of seasons in the Neolithic layers may be a product of the smaller numbers of oysters sampled: ideally similar sample sizes are required to compare periods, but this is not always possible because, in general, there are less Neolithic oysters available for thin sectioning.

The samples were also compared to determine whether there were any differences between layers (Fig. 60.5).

- Sample A dates to the EBK. Of the 20 thin sections from this sample, 18 produced seasonality data (Fig. 60.5). Here, the majority of oysters had been collected in the winter/spring and spring, with only two being harvested in the summer.
- Sample B dates to the TRB. Of the 20 thin sections from this sample, 16 produced seasonality data (Fig. 60.5). In this layer oyster collection occurred in the winter/spring and spring.
- Sample C was situated stratigraphically between Samples D and B in the midden sequence, and is dated to the EBK. Of the 20 thin sections from this sample, 17 produced seasonality data (Fig. 60.5). The period of oyster collection appears to have occurred during winter/spring and spring, with two shells representing a summer harvest; this is very similar to sample A.
- Sample D was taken from between Samples E and C and dates to the EBK. Of the 15 thin sections from this sample, 11 produced seasonality data (Fig. 60.5). Oyster collection mainly took place in the spring with one oyster harvested in winter/spring, spring/summer and summer respectively.
- Sample E is dated to the EBK. Of the 20 thin sections from this sample, 15 produced seasonality data (Fig.

60.5). The majority of the oysters in this layer were collected in the winter/spring and spring, with two in the summer and one in the summer/autumn.

- Sample F is thought to be contemporaneous with Samples C, D and E, and dates to the EBK. Of the 20 thin sections from this sample, 13 produced seasonality data (Fig. 60.5). Most of these oysters were harvested in the winter/spring and spring with one in the autumn.
- Sample G was taken from the western part of the profile. Stratigraphically, this layer is low down in the midden sequence and dates to the EBK. Of the 15 thin sections from this sample, 12 produced seasonality data (Fig. 60.5). Here harvesting occurred in the winter/spring and spring.

Comparison between layers does show that in the majority of samples, oyster gathering did persist beyond winter/spring and spring, into the summer and in two cases summer/autumn or autumn, albeit on a smaller scale.

Table 60.5. Summary statistics for the various samples from Eskilsø.

Sample	Hinge length (mm)		Age (years)	
	Sample size	Mean ± STDV (± 1σ)	Sample size	Mean ± STDV (± 1σ)
A	19	10.0 ± 4.2	18	7.4 ± 6.2
B	17	6.6 ± 1.1	16	3.4 ± 1.4
C	18	6.3 ± 2.0	17	4.3 ± 3.9
D	13	10.5 ± 4.7	11	7.4 ± 5.0
E	16	10.4 ± 4.3	15	9.1 ± 5.8
F	16	12.0 ± 3.8	13	11.7 ± 6.1
G	12	9.8 ± 3.5	12	8.2 ± 5.3

Size and age

In order to examine changing sizes of shell through the midden the shells were measured and aged. The length of the hinges were measured in mm using callipers and compared against the age of the shell that was ascertained by counting the annual lines. Measuring the hinge length can only be carried on shells that have complete hinges; it should be noted that although hinges can grow slightly skewed, the measurement gives an approximate length that enables a comparison to be carried out. The age counts can also only be carried out on hinges that have not been significantly broken, and which exhibit clear lines. Overall, 121 shells were measured and 104 could be aged (Table 60.5).

Figure 60.6 plots the mean hinge length per sample according to placement within the midden sequence. The largest shells were found in sample F (12.5 ± 3.8 mm, n=20), however, on the whole the oysters from the EBK have similar mean hinge lengths. The exception is sample C where oysters appear to be much smaller in size. These oysters are more comparable in size to those found in sample B, which is TRB in date. As sample C is higher up in the midden sequence, this suggests that at some point during the Mesolithic, oyster size reduced and this continued into the Neolithic. It is noteworthy that this does not appear to be happening at the Mesolithic/Neolithic transition.

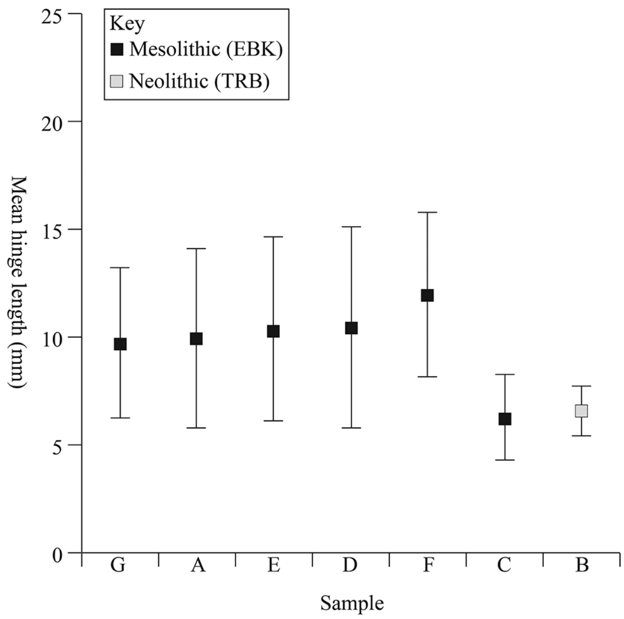

Fig. 60.6. Mean hinge length and standard deviations (±1σ) for the oysters from Eskilsø, plotted from lower down in the midden sequence, G, to higher up, B. The size of each sample group was >10 shells: G, n=12, A, n=19, E, n=16, D, n=13, F, n=16, C, n=18, B, n=17.

When the oyster size is plotted against age there is a positive correlation (Fig. 60.7). Overall the oysters in the EBK were older (7.9 ± 5.8 years, n=93) than those from the TRB (3.4 ± 1.4 years, n=16). This therefore shows that the oysters are getting both smaller and younger with age, which suggests that some pressure has been put on the natural population. This has also been seen for a number of other sites including Havnø, Krabbesholm II, and Norsminde (Milner 2013; Milner and Laurie 2009; Robson 2015). It has been hypothesized for these other sites that there is some form of environmental pressure, such as silting, which reduces the natural size of the population, which when coupled with human exploitation creates a decrease in age and size of the shells.

Discussion and conclusions

The seasonality data shows a strong peak of collection in the winter/spring or spring, a time when temperatures are rising and a growth line is formed in the hinge structure of the shell. This tends to be around March and April for the modern sample of oysters collected from around the

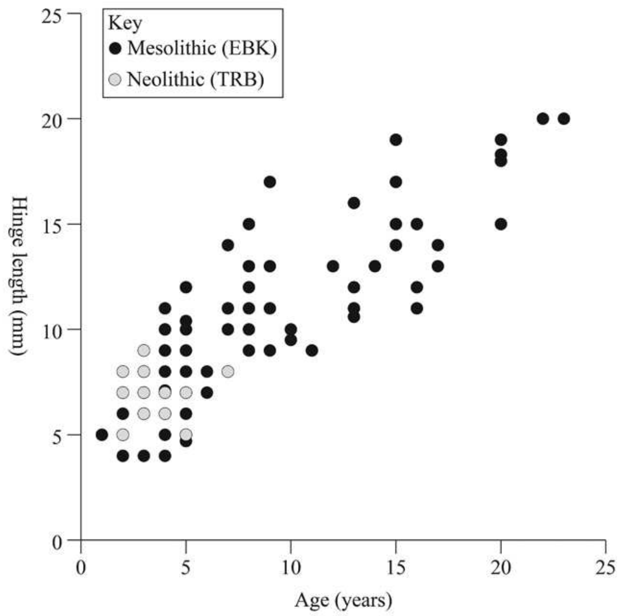

Fig. 60.7. Scattergraph plotting the ages (years) against hinge lengths (mm) obtained from oyster shell samples from Eskilsø (n=104).

British coastline (Milner 2002). It is possible that the higher level of collection in both the winter/spring and spring during both the Late Mesolithic and the Early Neolithic indicates a lean period for other resources, as suggested by Rowley-Conwy (1984, 2002) but equally there may be other environmental, social or cultural factors at play (Milner 2005). This gathering must have occurred around the time of extreme spring tides which, depending on the location of the natural oysters beds, can mean easier access when the tide is out. This pattern of a peak in spring gathering is typical of other middens we have studied. However, it is also noteworthy that oyster consumption appears to have occurred in other seasons as well, *i.e.* into the summer and possibly autumn. Again, this is seen at some other middens but not all, showing there is some variation in practice.

There is also little difference between the oyster gathering seasons between the Mesolithic and Neolithic periods; in the Neolithic the gathering occurs in late winter/spring and spring. There is no evidence of gathering in other seasons; however, as noted, the sample size is very small in comparison to the Mesolithic sample and potentially oysters might have been gathered in other seasons but a larger sample size would be needed to test this further.

The oysters also change in size through the midden but what is noteworthy here is that this happens within the Mesolithic layers: samples C (Mesolithic) and B (Neolithic) contain much smaller oysters. This change in size is fairly typical of kitchen middens which contain both Mesolithic and Neolithic layers of oysters, *i.e.* stratified kitchen middens, for instance Norsminde and Krabbesholm (Milner 2002, 2013; Milner and Laurie 2009; Robson 2015), however, it often occurs only within the Neolithic layers.

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