

Foraging Assemblages

Volume 1

Edited by Dušan Borić,
Dragana Antonović, and Bojana Mihailović



COLUMBIA UNIVERSITY
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Foraging Assemblages

Volume **2**

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Dragana Antonović, and Bojana Mihailović

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VOLUME I

	List of Contributors	ix
	Preface	xxv
	The Danube Gorges Mesolithic: The first fifty years (<i>Dušan Borić</i>)	xxvii
	Transitions – Beginnings	1
1	Introduction: Transitions – Beginnings (<i>Dušan Mihailović and Robert Whallon</i>)	3
2	Transition and tradition: Lithic variability in the cave of Vlakno, Croatia (<i>Dario Vujević and Mario Bodružić</i>)	5
3	Workspace organization of a Final Palaeolithic hunter-gatherer camp (<i>Anton A. Simonenko and Olesya I. Uspenskaya Aleksandrova</i>)	12
4	The problem of the Palaeolithic to Mesolithic transition on the Upper and Middle Don River (central Russia) (<i>Alexander N. Bessudnov and Alexander A. Bessudnov</i>)	20
5	Early Holocene human adaptation and palaeoenvironment of the north-western Caucasus (Elena V. Leonova, Olesya I. Uspenskaya, Natalia V. Serdyuk, Elena A. Spiridonova, Alexey S. Tesakov, Elena V. Chernysheva, Pavel D. Frolov, and Elena V. Syromyatnikova)	29
6	Early Mesolithic of northern Bohemia: 2015 excavations (<i>Jiří Svoboda</i>)	36
7	The last hunter-gatherers of South Arabia: A review of the Terminal Pleistocene and Early Holocene archaeological record (<i>Yamandú Hieronymus Hilbert</i>)	45
	Colonization	53
8	Introduction: Colonization	55
9	First Mesolithic occupations at high altitudes in Vercors (Isère, France): The case studies of Les Coins I, Roybon, and Gerland (<i>Alexandre Angelin and Régis Picavet</i>)	57
10	The Mesolithic site of Borovskoye 2 in light of the Pre-Boreal habitation in Karelia (<i>Sergey Lisitsyn, Alexey Tarasov, Nataliya Tsvetkova, and Stanislav Belsky</i>)	64
11	The Mesolithic of Fontanella rockshelter (Vilafranca, eastern Mediterranean Iberia) and the last hunters-gatherers of northern Valencian country (<i>Dídac Román, Inés Domingo, and Jordi Nadal</i>)	74
	Landscapes	83
12	Introduction: Landscapes (<i>Dušan Borić</i>)	85
13	The missing landscapes and territories of Mesolithic Portugal (<i>Ana Cristina Araújo and Ana Maria Costa</i>)	88
14	A comparative perspective on Mesolithic assemblages from different landscapes in Bohemia (<i>Katarína Kapustka, Jan Eigner, and Matthew Walls</i>)	94
15	The Early Mesolithic of the Piave River basin: Mountain tops, riverbanks, and seashores? (<i>Federica Fontana, Davide Visentin, and Stefano Bertola</i>)	102
16	Integrating communities and landscape: A wetland perspective from the Lower Rhine area (<i>Luc W. S. W. Amkreutz</i>)	110

17	Tracing raw materials: Procurement strategies and movements in the Early Mesolithic, a case study from Larvik, south-eastern Norway (<i>Guro Fossum</i>)	118
18	Local or imported? Tracking the provenance of flint raw materials of the Mesolithic habitants of Estonia and northern Latvia with the help of geochemical methods (<i>Kristiina Johanson, Aivar Kriiska, Jaan Aruväli, Peeter Somelar, Kaarel Sikk, and Liina Sepp</i>)	123
19	The Upper Dee Tributaries Project: Finding the Mesolithic in the mountains of Scotland (Shannon M. Fraser, Gordon Noble, Graeme Warren, Richard Tipping, Danny Paterson, Wishart Mitchell, Ann Clarke, and Caroline R. Wickham-Jones)	129
20	Surviving Doggerland (<i>Caroline R. Wickham-Jones</i>)	135
21	A Mesolithic moment in time: The Drumnaglea Cache (<i>Peter Woodman† and Sarah Close</i>)	142
22	Transient campsites, logistic campsites, and the cumulative taphonomy of Malham Tarn site A: A persistent place in the northern Pennines (<i>William A. Lovis and Randolph E. Donahue</i>)	148
	Settlement	157
23	Introduction: Settlements, dwellings, pits, and middens – still very far from a theory of everything! (<i>Ole Grøn and Nuno Bicho</i>)	159
24	Of space and time: The non-midden components of the Cabeço da Amoreira Mesolithic shell mound (Muge, central Portugal) (<i>João Cascalheira, Nuno Bicho, Célia Gonçalves, Daniel García-Rivero, and Pedro Horta</i>)	162
25	Looking for the ‘Asturian’ dwelling areas: New data from El Alloru and Sierra Plana de la Borbolla (Asturias, Spain) (<i>Pablo Arias, Miriam Cubas, Miguel Ángel Fano, Esteban Álvarez-Fernández, Ana Cristina Araújo, Marián Cueto, Patricia Fernández Sánchez, Eneko Iriarte, Inés L. López-Dóriga, Sara Núñez, Christoph Salzmann, Carlos Duarte, Felix Teichner, Luis C. Teira, and Paloma Uzquiano</i>)	169
26	Habitation areas in Asturian shell middens and site formation processes: Mazaculos II cave (La Franca, Asturias, northern Iberia) and the new sites of El Total III and El Mazo (<i>Manuel R. González Morales</i>)	177
27	Mesolithic settlement patterns and occupation of central and eastern Cantabria (Spain) (<i>Mercedes Pérez-Bartolomé</i>)	184
28	Domestic life by the ocean: Beg-er-Vil, c. 6200–6000 cal BC (<i>Grégor Marchand and Catherine Dupont</i>)	191
29	Mesolithic pit-sites in Champagne (France): First data, key issues (<i>Nathalie Achard-Corompt, Emmanuel Ghesquiere, Christophe Laurelut, Charlotte Leduc, Arnaud Remy, Isabelle Richard, Vincent Riquier, Luc Sanson, and Julia Wattez</i>)	198
30	Some observations on the archaeological record of the (Late) Mesolithic in the northern Netherlands (<i>Marcel J. L. Th. Niekus</i>)	202
31	Life on the lake edge: Mesolithic habitation at Star Carr (<i>Nicky Milner, Chantal Conneller, Barry Taylor, Mike Bamforth, Julian C. Carty, Shannon Croft, Ben Elliott, Becky Knight, Aimée Little, Harry K. Robson, Charlotte C. A. Rowley, and Maisie Taylor</i>)	210
32	Late Mesolithic shallow pithouse from Sąsieczno 4 (central Poland) (<i>Grzegorz Osipowicz</i>)	216
33	Mesolithic complexes on the right bank of the Vyatka River (the middle Volga Basin) (<i>Tatyana Gusentsova</i>)	223
34	Mesolithic hearth-pits and cooking-pits in western Sweden and south-eastern Norway: When, where, how, and a bit about why (<i>Robert Hernek</i>)	227
35	Mesolithic ‘ghost’ sites and related Stone Age problems with lithics (<i>Ole Grøn and Hans Peeters</i>)	233
36	Sømmevågen. A Late Mesolithic–Early Neolithic settlement complex in south-western Norway: Preliminary results (<i>Trond Meling, Hilde Fyllingen, and Sean D. Denham</i>)	240
37	Mesolithic settlement on Utsira, western Norway: Mesolithic hunter-gatherers in transition as reflected by dwellings and site patterns (<i>Arne Johan Nærøy</i>)	246
38	Mesolithic dwellings from Motala, Sweden (<i>Ann Westermarck</i>)	252

Regional Identities	259
39 Introduction: Regional identities (<i>Rick Schulting</i>)	261
40 Holocene foraging in the Dinaric Alps: Current research on the Mesolithic of Montenegro (<i>Dušan Borić, Emanuela Cristiani, Ljiljana Đuričić, Dragana Filipović, Ethel Allué, Zvezdana Vušović-Lučić, and Nikola Borovinić</i>)	264
41 New perspectives on the Mesolithic of the Sado Valley (southern Portugal): Preliminary results of the SADO MESO project (<i>Pablo Arias, Mariana T. Diniz, Ana Cristina Araújo, Ángel Armendariz, and Luis C. Teira</i>)	274
42 The 'Asturian' and its neighbours in the twenty-first century: Recent perspectives on the Mesolithic of northern Spain (<i>Pablo Arias, Esteban Álvarez-Fernández, Miriam Cubas, Miguel Ángel Fano, María J. Iriarte-Chiapusso, Mercedes Pérez Bartolomé, and Jesús Tapia</i>)	281
43 The Mesolithic in the northwest of the Iberian Peninsula (Galicia, Spain): The state of art (<i>Eduardo Ramil Rego, Natividad Fuertes Prieto, Carlos Fernández Rodríguez, Eduardo González Gómez de Agüero and Ana Neira Campos</i>)	289
44 The last foragers in the north-east of the Iberian Peninsula: New evidence of human occupation during the seventh/sixth millennia cal BC (<i>Antoni Palomo, Igor Bodganovic, Raquel Piqué, Rafel Rosillo, Xavier Terradas, Marta Alcolea, Marian Berihuete, and Maria Saña</i>)	295
45 The Late Mesolithic of the south-western coast of Portugal: The lithic industry of Vale Marim I in focus (<i>Joaquina Soares, Niccolò Mazzucco, and Carlos Tavares da Silva</i>)	301
46 The temporality of the Mesolithic in southern France (<i>Thomas Perrin</i>)	308
47 Re-evaluating the old excavation from Pinnberg, Germany (<i>Daniel Groß, Steffen Berckhan, Nadine Hauschild, Anna-Lena Räder, and Anne Sohst</i>)	312
48 Exploring early Ertebølle: Results of preliminary assessments at a submerged site in the Kiel Bay (Baltic Sea, Germany) and its potential (<i>Julia Goldhammer, Annika B. Müller, Laura Brandt, Steffen Wolters, and Sönke Hartz</i>)	318
49 Identifying regional practices in cave use during the Mesolithic in south-western Britain (<i>Caroline Rosen</i>)	324
50 About time for the Mesolithic near Stonehenge: New perspectives from Trench 24 at Blick Mead, Vespasian's Camp, Amesbury (<i>David Jacques, Tom Lyons, Barry Bishop, and Tom Phillips</i>)	330
51 Secrets of Blue Maiden: The archaeology of a virgin island in the Baltic Sea (<i>Kenneth Alexandersson, Anna-Karin Andersson, and Ludvig Pappmehl-Dufay</i>)	337
52 Mesolithic site locations in the river valleys of Karelia, west of Ladoga Lake, Russia (<i>Hannu Takala, Mark. M. Shakhnovich, Aleksey Yu. Tarasov, and Anssi Malinen</i>)	345

VOLUME II

People in Their Environment	355
53 Introduction: People in their environment (<i>Clive Bonsall and Vesna Dimitrijević</i>)	357
54 Late Glacial to Early Holocene environs and wood use at Lepenski Vir (<i>Ethel Allué, Dragana Filipović, Emanuela Cristiani, and Dušan Borić</i>)	359
55 Plant use at the Mesolithic site of Parque Darwin (Madrid, Spain) (<i>Marian Berihuete Azorín, Marta Alcolea Gracia, Raquel Piqué i Huerta, and Javier Baena Preysler</i>)	367
56 A tale of foxes and deer, or how people changed their eating habits during the Mesolithic at Vlakno cave (Croatia) (<i>Siniša Radović, Victoria Pía Spry-Marqués, and Dario Vujević</i>)	374
57 Coastal resource exploitation patterns and climatic conditions during the Early Mesolithic in the Cantabrian region (northern Iberia): Preliminary data from the shell midden site of El Mazo (<i>Asier García-Escárzaga, Igor Gutiérrez-Zugasti, David Cuenca-Solana, Adolfo Cobo, and Manuel R. González-Morales</i>)	382

58	How ‘marine’ were coastal Mesolithic diets? (<i>Rick J. Schulting</i>)	389
59	The seasonality of hunting during the Mesolithic in southern Scandinavia (<i>Ola Magnell</i>)	398
60	Incremental growth line analysis of the European oyster (<i>Ostrea edulis</i> , Linnaeus, 1758) from the kitchen midden at Eskilsø, Denmark (<i>Harry K. Robson, Søren A. Sørensen, Eva M. Laurie, and Nicky Milner</i>)	404
61	Skellerup Enge: Evidence for a distinctive subsistence economy in western Denmark during the early Ertebølle (<i>Kenneth Ritchie, Søren H. Andersen, and Esben Kannegaard</i>)	410
62	Hunting beyond red deer: Exploring species patterning in Early Mesolithic faunal assemblages in Britain and north-western Europe (<i>Nick J. Overton</i>)	416
63	Size estimations of sturgeons (<i>Acipenseridae</i>) from the Mesolithic-Neolithic Danube Gorges (<i>Ivana Živaljević, Igor V. Askeyev, Dilyara N. Shaymuratova (Galimova), Oleg V. Askeyev, Sergey P. Monakhov, Dušan Borić, and Sofija Stefanović</i>)	422
	Technology	429
64	Introduction: Technology (<i>Federica Fontana, Emanuela Cristiani, and Dušan Mihailović</i>)	431
65	<i>Couteaux de Rouffignac</i> : A new insight into an old tool (<i>Davide Visentin, Sylvie Philibert, and Nicolas Valdeyron</i>)	434
66	The lithic assemblage of the Mesolithic station of Alp2 (pre-alpine mountain range of Chartreuse, northern French Alps): Preliminary data (<i>Jocelyn Robbe</i>)	440
67	The First and Second Mesolithic of La Grande Rivoire (Vercors range, Isère, France): A diachronic perspective on lithic technology (<i>Alexandre Angelin, Thomas Perrin, and Pierre-Yves Nicod</i>)	444
68	Techno-functional approach to a technological breakthrough: The Second Mesolithic of Montclus rockshelter (Gard, France) (<i>Elsa Defranould, Sylvie Philibert, and Thomas Perrin</i>)	452
69	The late microblade complexes and the emergence of geometric microliths in north-eastern Iberia (<i>Dídac Román, Pilar García-Argüelles, Jordi Nadal, and Josep Maria Fullola</i>)	457
70	Mesolithic raw material management south of the Picos de Europa (northern Spain) (<i>Diego Herrero-Alonso, Natividad Fuertes-Prieto, and Ana Neira-Campos</i>)	464
71	New perspectives on Mesolithic technology in northern Iberia: Data from El Mazo shell midden site (Asturias, Spain) (<i>Natividad Fuertes-Prieto, John Risetto, Igor Gutiérrez-Zugasti, David Cuenca-Solana, and Manuel R. González Morales</i>)	470
72	The conical core pressure blade concept: A Mesolithic <i>chaîne opératoire</i> (<i>Tuija Rankama and Jarmo Kankaanpää</i>)	476
73	Middle and Late Mesolithic microblade technology in eastern Norway: Gradual development or abrupt change? (<i>Svein Vatsvåg Nielsen and Torgeir Winther</i>)	482
74	Shaori II: An obsidian workshop in Javakheti, Georgia (<i>Dimitri Narimanishvili, Petranka Nedelcheva, and Ivan Gatsov</i>)	490
75	Finding, shaping, hiding: Caching behaviour in the Middle Mesolithic of south-eastern Norway (<i>Lucia Uchermann Koxvold</i>)	495
76	Hafting flake axes: Technological and functional aspects of an assemblage from north-western Norway (<i>John Asbjørn Havstein</i>)	499
77	Quantifying Irish shale Mesolithic axes/adzes (<i>Bernard Gilhooly</i>)	505
78	Technology of osseous artefacts in the Mesolithic Danube Gorges: The evidence from Vlasac (Serbia) (<i>Emanuela Cristiani and Dušan Borić</i>)	512
79	Antler in material culture of the Iron Gates Mesolithic (<i>Selena Vitezović</i>)	520
80	Tools made from wild boar canines during the French Mesolithic: A technological and functional study of the collection from Le Cuzoul de Gramat (France) (<i>Benjamin Marquiebielle and Emmanuelle Fabre</i>)	526

81	Lost at the bottom of the lake. Leister prongs from the Early and Middle Mesolithic (<i>Lars Larsson, Björn Nilsson, and Arne Sjöström</i>)	535
82	Late Glacial and Early Holocene osseous projectile weaponry from the Polish Lowlands: The case of a point from Witów (<i>Justyna Orłowska</i>)	540
Social Relations, Communication, Mobility		547
83	Introduction: Social relations, communication, mobility (<i>Chantal Conneller</i>)	549
84	Role of personal ornaments: Vlakno cave (Croatia) (<i>Barbara Cvitkušić and Dario Vujević</i>)	551
85	Marine shells as grave goods at S'Ormu e S'Orku (Sardinia, Italy) (<i>Emanuela Cristiani, Rita T. Melis, and Margherita Mussi</i>)	558
86	Visual information in Cabeço da Amoreira, Muge (Portugal): Shell adornment technology (<i>Lino André and Nuno Bicho</i>)	567
87	Neighbours on the other side of the sea: Late Mesolithic relations in eastern Middle Sweden (<i>Jenny Holm</i>)	574
88	Sedentary hunters, mobile farmers: The spread of agriculture into prehistoric Europe (<i>T. Douglas Price, Lars Larsson, Ola Magnell, and Dušan Boric</i>)	579
Rites and Symbols		585
89	Introduction: Rites and Symbols (<i>Judith M. Grünberg and Lars Larsson</i>)	587
90	A portable object in motion – Complex layers of meaning embedded in an ornamented sandstone-object from the Late Mesolithic site of Brunstad (Norway) (<i>Almut Schülke</i>)	590
91	Net patterns in Mesolithic art of north-western Europe (<i>Tomasz Płonka</i>)	595
92	Protective patterns in Mesolithic art (<i>Peter Vang Petersen</i>)	602
93	Mesolithic engraved bone pins: The art of fashion at Téviec (Morbihan, France) (<i>Éva David</i>)	610
94	Final destruction and ultimate humiliation of an enemy during the Mesolithic of southern Scandinavia (<i>Erik Brinch Petersen</i>)	619
95	Archaeological remains of Mesolithic funerary rites and symbols (<i>Judith M. Grünberg</i>)	622
96	Buried side by side: The last hunter-gatherers of the south-western Iberian Peninsula through the lens of their mortuary practices (<i>Rita Peyroteo-Stjerna</i>)	629
97	Depositions of human skulls and cremated bones along the River Motala Ström at Strandvägen, Motala (<i>Fredrik Molin, Sara Gummesson, Linus Hagberg, and Jan Storå</i>)	637
98	Human–animal symbolism within a ritual space in the Mesolithic wetland deposit at Kanaljorden, Motala (<i>Fredrik Hallgren, Sara Gummesson, Karin Berggren, and Jan Storå</i>)	644
99	What are grave goods? Some thoughts about finds and features in Mesolithic mortuary practice (<i>Lars Larsson</i>)	649
100	Mesolithic companions: The significance of animal remains within Mesolithic burials in Zvejnieki and Skateholm (<i>Aija Macāne</i>)	655
101	Pit or grave? 'Emptied' graves from the cemetery at Dudka, Masuria, north-eastern Poland (<i>Karolina Bugajska</i>)	660
102	Beware of dogs! Burials and loose dog bones at Dudka and Szczepanki, Masuria, north-eastern Poland (<i>Witold Gumiński</i>)	668
103	Shamans in the Mesolithic? Re-analysis of antler headdresses from the North European Plain (<i>Markus Wild</i>)	678
104	Birds in ritual practice of eastern European forest hunter-gatherers (<i>Ekaterina Kashina and Elena Kaverzneva</i>)	685

Transitions – Endings	693
105 Transitions – Endings: Introduction (<i>T. Douglas Price</i>)	695
106 Modelling the empty spaces: Mesolithic in the micro-region of central Serbia (<i>Vera Bogosavljević Petrović and Andrej Starović</i>)	699
107 How North Iberia was lost? The Early Neolithic in Cantabrian Spain (<i>Miguel Ángel Fano and Miriam Cubas</i>)	706
108 Debating Neolithization from a Mesolithic point of view: The Sado Valley (Portugal) experience (<i>Mariana Diniz, Pablo Arias Cabal, Ana Cristina Araújo, and Rita Peyroteo-Stjerna</i>)	713
109 The Caucasian route of Neolithization in the Pontic-Caspian region (<i>Alexander Gorelik, Andrej Tsybriy, and Viktor Tsybriy</i>)	720
110 The Late Mesolithic and Early Neolithic of the Kama region, Russia: Aspects of the Neolithization process (<i>Evgeniia Lychagina</i>)	727
111 The Late Mesolithic in western Lesser Poland: Spectators or participants in the Neolithization? (<i>Marek Nowak, Mirosław Zajac, and Justyna Zakrzeńska</i>)	733
112 Wetland sites in a dry land area. A survey for Late Mesolithic and Early Neolithic sites in and around the Zwischenahner Meer Lake, Germany (<i>Svea Mahlstedt</i>)	740
113 Forager-farmer contacts in the Scheldt Basin (Flanders, Belgium) in the late sixth-early fifth millennia BC: Evidence from the site of Bazel-Sluis (<i>Erwin Meylemans, Yves Perdaen, Joris Sergeant, Jan Bastiaens, Koen Deforce, Anton Ervynck, and Philippe Crombé</i>)	746
114 Ritual continuity between the Late Mesolithic Ertebølle and Early Neolithic Funnel Beaker cultures (<i>Søren Anker Sørensen</i>)	750
115 Continuity and change: hunters and farmers in the Mesolithic-Neolithic transition, Östergötland, eastern middle Sweden (<i>Tom Carlsson</i>)	756
116 The Mesolithic-Neolithic transition in South Norway: Cylindrical blade technology as an indicator of change (<i>Dag Erik Færø Olsen</i>)	763
Representing and Narrating the Mesolithic	771
117 Introduction: Representing and Narrating the Mesolithic (<i>Nicky Milner</i>)	773
118 Mesolithic movie stars: Analyzing rare film archives of the Muge excavations from the early twentieth century (<i>Ana Abrunhosa and António H. B. Gonçalves</i>)	776
119 Elusive, perplexing, and peculiar? Presenting the Mesolithic to twenty-first century audiences (<i>Don Henson</i>)	785
120 Public perceptions and engagement with the Jomon and the Mesolithic (<i>Don Henson</i>)	789
121 Building Mesolithic: An experimental archaeological approach to Mesolithic buildings in Ireland (<i>Graeme Warren</i>)	796
Index	805

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

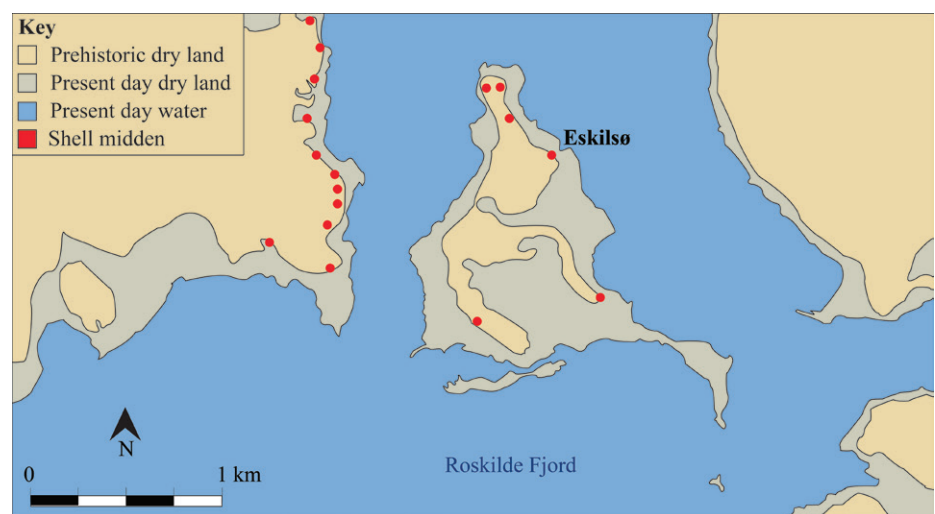


Fig. 60.1. Map showing the location of the Eskilsø kitchen midden.

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.

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

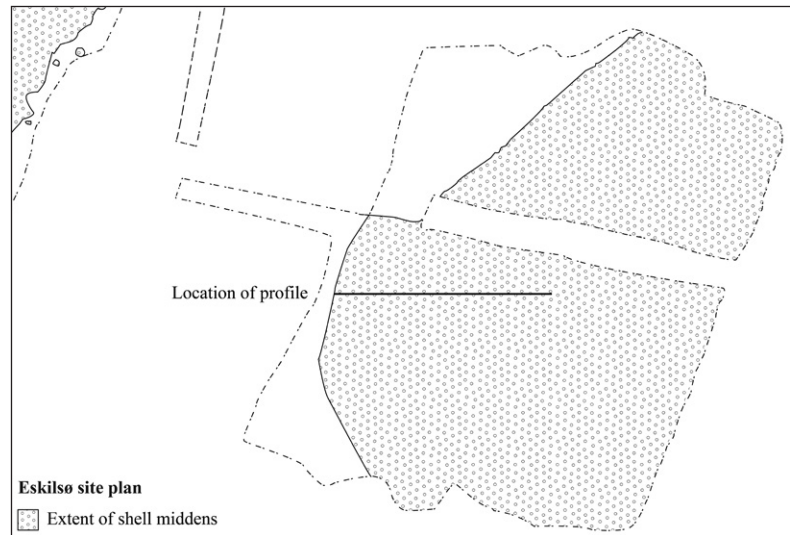


Fig. 60.2. Plan showing the extent of the kitchen midden and investigations at Eskilsø.

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.

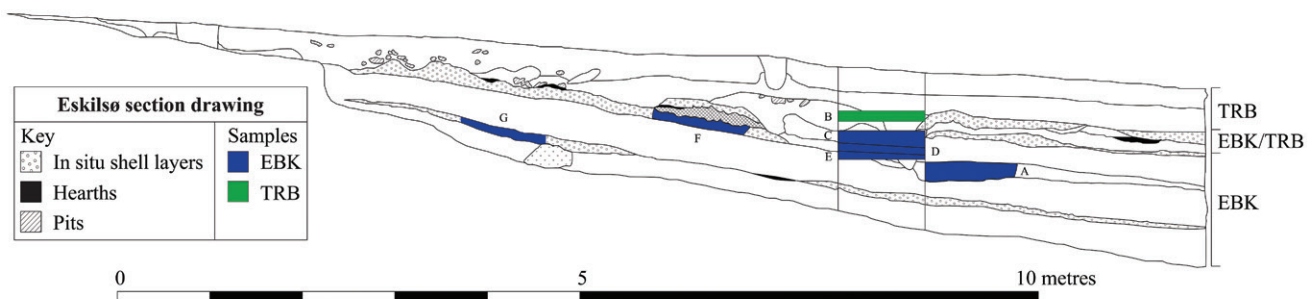


Fig. 60.3. Section through the Eskilsø kitchen midden. Note the location of sample B that is stratified above samples C, D, and E.

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

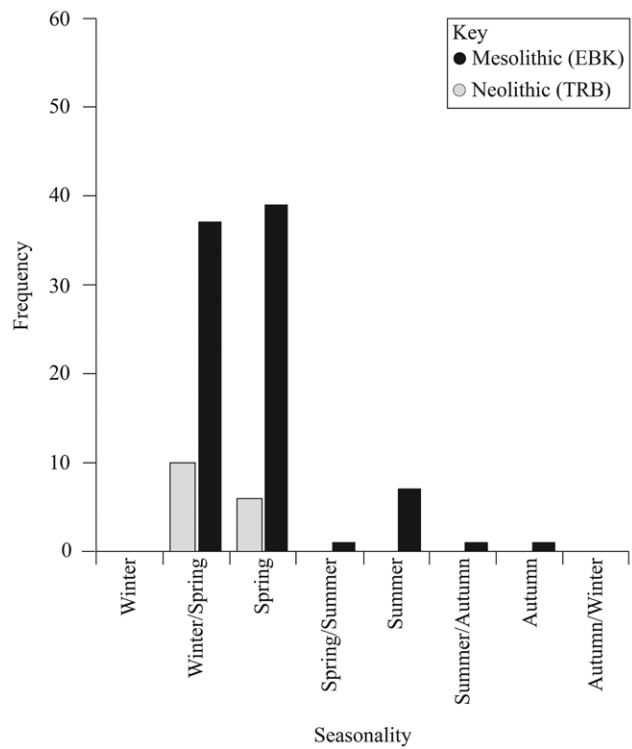


Fig. 60.4. Histogram showing the seasonality of oyster gathering for the EBK and TRB cultures.

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

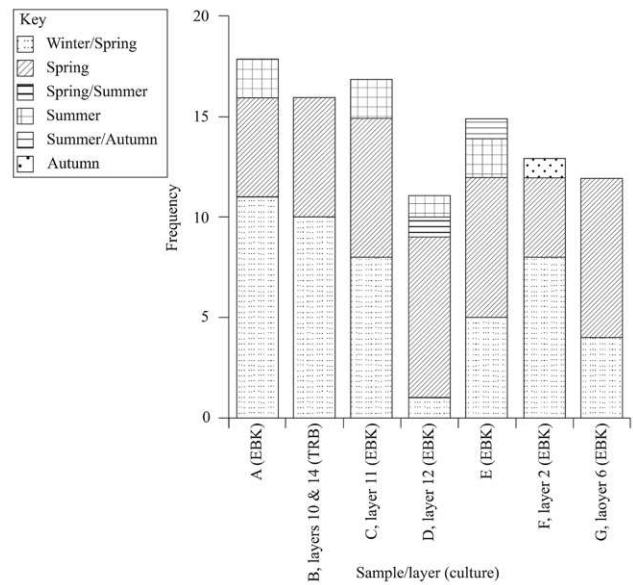


Fig. 60.5. Histogram showing the seasonality of oyster gathering that has been disaggregated according to sample/layer.

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 \pm STDV ($\pm 1\sigma$)	Sample size	Mean \pm STDV ($\pm 1\sigma$)
A	19	10.0 \pm 4.2	18	7.4 \pm 6.2
B	17	6.6 \pm 1.1	16	3.4 \pm 1.4
C	18	6.3 \pm 2.0	17	4.3 \pm 3.9
D	13	10.5 \pm 4.7	11	7.4 \pm 5.0
E	16	10.4 \pm 4.3	15	9.1 \pm 5.8
F	16	12.0 \pm 3.8	13	11.7 \pm 6.1
G	12	9.8 \pm 3.5	12	8.2 \pm 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 \pm 3.8 mm, n=20), however, on the whole the oysters from the EBK

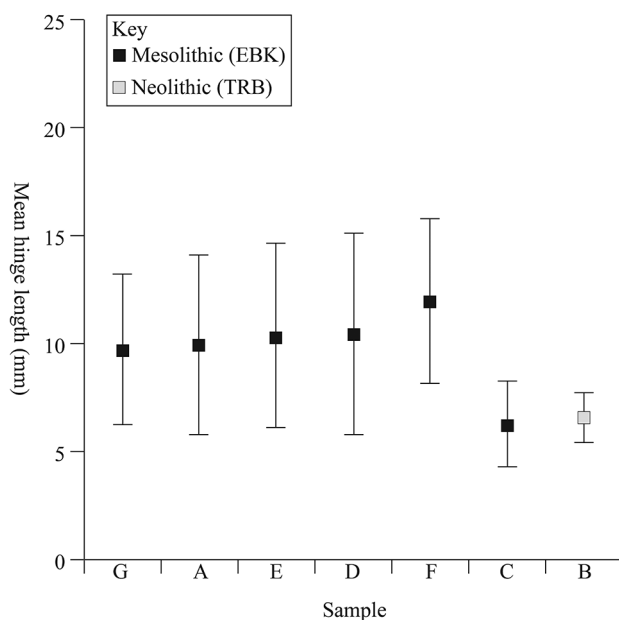


Fig. 60.6. Mean hinge length and standard deviations ($\pm 1\sigma$) for the oysters from Eskilsø, plotted from lower down in the midden sequence, G, to higher up, B. The size of each sample group was >10 shells: G, n=12, A, n=19, E, n=16, D, n=13, F, n=16, C, n=18, B, n=17.

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.

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 \pm 5.8 years, n=93) than those from the TRB (3.4 \pm 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

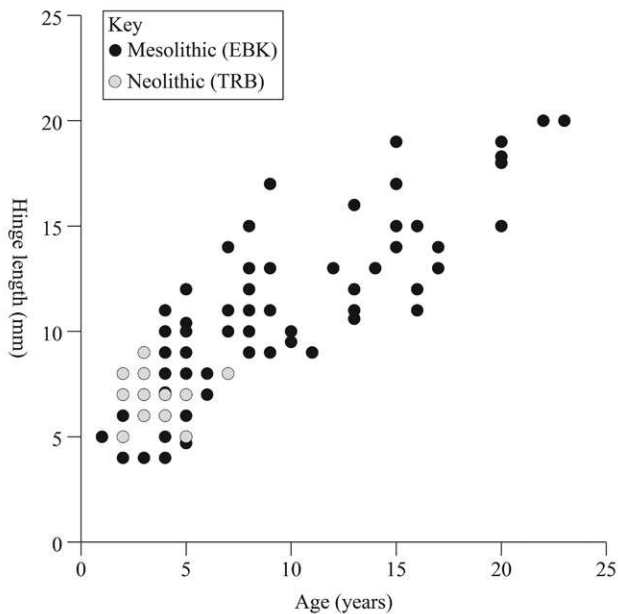


Fig. 60.7. Scattergraph plotting the ages (years) against hinge lengths (mm) obtained from oyster shell samples from Eskilsø (n=104).

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.

Acknowledgements

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