The Jortveit farm wetland: A Neolithic fishing site on the Skagerrak coast, Norway

S. V. Nielsen and P. Persson

Department of archaeology, Museum of Cultural History, University of Oslo, Oslo, Norway

ABSTRACT
In 1931, several osseous and lithic artefacts, as well as fish and whalebones, were discovered in the wetland at the Jortveit farm in Southern Norway. In 2018–19, a small-scale excavation at the original find location took place and a series of AMS-dates were produced. The excavation identified a mud profile with exceptional preservation conditions. At ~125–130 cm depth, the mud contained unburnt fish and whale bones, burnt wooden sticks and lithic artefacts. AMS-dates of stray finds and samples retrieved during the excavation date to the period roughly between 3700–2500 cal BCE, i.e. Scandinavian Early and Middle Neolithic Periods. Nearly all bones belong to the Atlantic bluefin tuna (Thunnus thynnus). The results are compared to local climate and landscape reconstructions, and the question of marine adaptation in the Neolithic is discussed. We find that the Jortveit site represented a patch in the landscape for specialized marine adaptation in the Neolithic.

KEYWORDS
Atlantic bluefin tuna; Orcinus orca; toggling harpoon; barbed harpoon; fishhook; excavation; wetland; Neolithic

Introduction

The question of economic adaptation in the Scandinavian Early and Middle Neolithic Periods (3900-2350 cal BCE) has been a subject of debate within Norwegian Neolithic research, and opinions have shifted due to changing empirical realities. With reference to the scarce evidence of farming and husbandry before the Late Neolithic/Early Bronze Age, doubt has been shared about there ever having been a ‘Neolithic’ Period in Norway (Prescott 1996). Conversely, evidence of ritual behaviour has led others to argue that specific regions of Eastern Norway were fully integrated in the north group of the Funnel Beaker Culture (3900-2800 cal BCE), though evidently adapted to a new landscape previously inhabited by a hunter-fisher-gatherer population (Bakker 1979; Glørstad and Solheim 2015; Glørstad and Sundström 2014; Østmo 2007). Others again, have stressed the numerous and well-documented coastal and high-mountain hunter-fisher-gatherer settlements in Southern Norway where occupations often persisted throughout the Neolithic. These have been interpreted as indicative of an affluent – and primarily – forager economy in the Early and Middle Neolithic (Bergsvik 2012; Solheim 2012).
Based on excavations recently conducted at the Jortveit wetland site on the central Ska-ggerak Coast, this paper presents new insights on coastal adaptation in Southern Norway during the Early and Middle Neolithic. A small-scale excavation took place at Jortveit in 2018-19, and a selection of artefacts discovered in the early twentieth century have now been AMS-dated. We find that in a period of the Neolithic, when farming was practiced in large parts of Scandinavia, a specialized marine adaptation emerged at Jortveit that was focused on the seasonal exploitation of Atlantic bluefin tuna (*Thunnus thynnus*). This practice was probably more widespread along the Skagerrak and the western Swedish coast than indicated by the Jortveit site alone. However, though fishing is the main activity currently documented at Jortveit, the finds also demonstrate contact with farming communities. We argue that it is conceivable, based on the tool inventory, that the introduction of farming in Scandinavia was a background, or maybe even a prerequisite for the type of coastal adaptation that took place at Jortveit and along the Skagerrak Coast.

**Background**

**Site History**

At the Homborsund Peninsula on the central Skagerrak Coast in Southern Norway (58.27 °N, 8.5 °S), there is today a wetland area (35 ha) sheltered against the Skagerrak Sea on all sides except via a narrow sound in the northwest (Figure 1). In 1931, local farmers drained the wetland on the Jortveit farm and discovered osseous and lithic tools mixed with fish and whalebones inside stinking mud at ∼170 cm depth (Bjørn 1932) (Figures 2 and 3). Guided by scholars via mail, the archaeological artefacts were transported to the Museum of Cultural History in Oslo, and the zoological samples to the Museum of Natural History in Oslo. In the years that followed, more artefacts appeared coincidentally both in the ditches at Jortveit and on dry land at nearby farms (Figure 4). Though the Jortveit assemblage, particularly the osseous artefacts, achieved high status in Norwegian research due to its exceptional preservation (Bakka 1973; Gaustad 1961; Gjessing 1945, 1941a, 1941b; Hagen 1967; Magnus and Myhre 1976; Østmo 2008), investigations at Jortveit never continued. Thus, the true age and function of the site remained unexplored.

**The Bay Formation at Jortveit**

In order to understand the function of the Jortveit site today, it is necessary to take into account the sea level history of the area, as relative sea levels in Norway have changed drastically throughout the Holocene. The Skagerrak Coast is a c. 140 km straight coastline from the southern tip of Norway to the Oslo fjord in the northeast. It forms an archipelago dominated by skerries, deep, narrow sounds, and a generally hilly terrain with occasional wetlands, e.g. marshes, ponds and minor lakes. Together, these elements form a landscape referred to in Norwegian as ‘skjaergaard’ (Romundset 2018, 465).

Surveys and excavations have identified hundreds of Mesolithic and Neolithic sites along the Skagerrak Coast (Nielsen et al. 2016, 2013; Reitan and Sundström 2018). A vast majority of them were shore bound during occupations in the Stone Age, but they have since risen from the seashore due to post-glacial land uplift (isostacy) (Romundset 2018, 475, Figure
3.2.12). Based on previous sea level studies in adjacent areas (e.g. Midtbø, Prøsch-Danielsen, and Helle 2000; Romundset 2018), it is probable that the Jortveit wetland transformed from an open sea bottom and into a sheltered lagoon around $\sim 3900/3800$ cal BCE (Figure 1). It stayed a lagoon until sometime after $\sim 500$ cal BCE, when it turned brackish due to continued isostatic uplift. The wetland eventually rose from the sea and changed into a fresh water marsh under which the prehistoric seabed was preserved.

Archaeological artefacts from 1931.

Inside the prehistoric seabed at Jortveit, three bone points were discovered in 1931 (Figure 2). Two of them are of the toggling harpoon type (Figure 3), similar in shape and function to late historical iron harpoons (‘skutel’) used in tuna and basking shark (Cetorhinus maximus) fishing in Norway (Kalland 2014). The toggling harpoons from Jortveit also bear resemblance to socket harpoons known from Inuit material culture (Helmer 1991; McCartney 1984; Tuck 1970), as well as harpoons discovered at Neolithic lake-
Figure 2. Archaeological and zoological finds from the Jortveit wetland site. These finds were discovered 1.7 m deep in a drainage ditch in 1931 in the northern end of the wetland. Top row: Neolithic flint arrowheads of different types (Beckers’ type A-C), and a fragment of a slate arrowhead (D). Middle row: Osseous fish hook (E), toggling harpoons (F), single row barbed harpoon (G), wooden torch (H), vertebrae from Atlantic bluefin tuna (Thunnus thynnys) (I), lower jaw from orca (Orcinus orca) (J).
dwellings in Central Europe (Torke 1993). Prehistoric parallels to the Jortveit toggling harpoons in Norway are from Skipshelleren (layer 3-4), a rock shelter site located in Vikafjorden in Straume on the western coast, where two toggling harpoons occurred in mixed cultural layers (Bøe 1934, 60; Rosvold et al. 2013 with references).

The third bone point from Jortveit is a single row barbed harpoon, broken at the base. Similar harpoons occurred also at Skipshelleren and in the child burial at Bjønnhammaren, a rock shelter site located on the island Tustna on the northwestern coast (Haug 2011). These barbed harpoons resemble Middle Neolithic harpoons found in Denmark, Southern Sweden and the Eastern Baltic, and date the period to ∼3000-2450 cal BCE (Becker 1951; Iversen 2010; Löugas, Kriiska, and Maldre 2007; Oldeberg 1952 Abb. 266). The latter often have a perforated base, thus indicating how the harpoon from Jortveit might have looked like before it broke in prehistoric times (Andersen 1972; Becker 1951, 160–161).

The fishhook from Jortveit also has contemporary parallels in Denmark and Sweden (Becker 1951), and it differs in shape from known Mesolithic fishhooks from Southern Norway (Bergsvik and David 2015). A characteristic trait on the Jortveit fishhook type is the oblique wrapping detail and their relatively large size. Similar hooks were found at Skipshelleren (Bøe 1934) and the open-air site Slettabø (layer 2) on the southwestern coast (Skjølsvold 1977). Radiocarbon dates from both sites confirm a Middle Neolithic Age (for a discussion of layer 2 at Slettabø, see Glørstad 1996).

Figure 3. Toggling harpoons found coincidentally by laymen at Jortveit. These artefacts were deposited and encapsulated inside the soft-bottom seabed between 3700 and 2500 cal BCE. The harpoon to the left dates directly to 3635–3369 cal BCE (Table 1).
Figure 4. Selection of lithic artefacts found coincidentally at farms surrounding the wetland area at Jortveit. Top row: fragment of polygonal stone battle-axe (Zápotocký Type KIII) and a knuckle shaped grinding stone from the Espevig farm (No. 3 in Figure 1). Bottom row: polished flint axe with hollowed edge from the Granly farm (No. 8 in Figure 1) and a trihedral flint projectile point presumably recovered from a wetland context at the Amtedal farm (No. 2 in Figure 1).
The lithic points of flint and slate (or shale) from Jortveit are typical for the Early and Middle Neolithic (3900-2350 cal BCE) in this region (Bergsvik 2002; Nærøy 1994; Nielsen, Persson, and Solheim 2019). The flint arrowheads follow Becker’s (1951) typology of Pitted Ware Culture projectiles from tanged points with direct retouch (i.e. types A and B) to heavily retouched trihedral points (type C). The single slate point is broken but shows parallel sides, rhombic cross section, and a facetted base, which is typical for the Middle Neolithic in Southern Norway (Bergsvik 2002; Olsen 1992; but see Gjessing 1942, 163, 170).

Zoological Samples from 1931

The 1931 zoological samples from Jortveit belong to one Atlantic bluefin tuna and one killer whale, or orca (Orcinus orca). The six tuna vertebrae indicate an age of >13 y (Gunn et al. 2008; Lee, Prince, and Crow 1983), and size estimation is roughly ~150 kg and ~160 cm fork length, which classify the individual as a ‘big tuna’ in accordance to modern fishery standards (Hamre 1957). Tuna bones also occurred at the Neolithic sites Skipsheileren in Norway (Olsen 1976), and at Ånneröd (Alin 1955), Gröninge (Särlvik 1976), Sandhem (Jonsson 2007), and Hakeröd (Jonsson 2002) in Western Sweden, as well as at Stora Förvar on Gotland (Ericson 1989; Knape and Ericson 1983). Tuna bones are known to appear occasionally on Late Mesolithic (Ertebølle) coastal settlements in Southern Scandinavia, such as at Italiensvej in Eastern Denmark and Tägerup in Southwestern Sweden (Enghoff, MacKenzie, and Nielsen 2007; Karsten and Knarrström 2003).

The orca from Jortveit is represented by a broken, lower left mandible. Age and size estimation based on single mandibles is problematic, but the preserved row of teeth (360 mm) itself indicate roughly 5-9 m length and a maximum weight of ~4000 kg (Clark, Odell, and Lacinak 2000; Heyning and Dahlheim 1988). Striking points and cut marks indicate intentional breaking, perhaps for marrow extraction. Bones from orca were also documented at the Neolithic site Rörvik (Henrici 1936; Kaelas 1973) in Western Sweden, and again at Stora Förvar on Gotland (Ericson 1989; Knape and Ericson 1983). It could be mentioned that Clark (1947, 100) listed one orca vertebrae from Lindö on Langeland in Denmark, a site Becker (1951, 157–180) came to consider a typical Funnel Beaker Culture site. Bones from orca do not appear on Mesolithic sites in Norway, but a few depictions in rock art have been documented (Jaksland 2005, 101, Fig. 17; Mikkelsen 1977, 152). As was the case with tuna, bones from orca appear occasionally on Ertebølle sites, such as the skull fragment from Lystrup Enge (Aaris-Sørensen et al. 2010), the rib bone from Ertebølle (Clark 1947), and the tooth from Vængesø III (Adersen 2018, 186).

Results

The 2018–19 Excavations at Jortveit

In 2018-19, six trenches dug along the northern drainage ditch at Jortveit showed shifting stratigraphy from north to south (Figure 5). In the northernmost trenches, a shell layer (Mutilus edulis, Ostre edulis) occurred below ~40 cm of modern cultivation (shell layer described in Bakke 1933). At 80-100 cm depth, the shell layer changed from a domination
of oysters into a variation of small and fragmented shell species, with a few rocks in the transition. In the southern trenches, i.e. trench 2 and 6, a layer of marine mud occurred below the modern cultivation and a subsequent ∼50 cm thick layer of silty clay.

At the depth level ∼125-130 cm, the mud in trench 2 and 6 was filled with unburnt fish bones and wooden sticks, some of which were burnt. We refer to this horizontally deposited horizon as ‘the bone layer’. Inside the bone layer, wood samples (Betula) and primarily unburnt fish bones (Thunnus thynnus, Gadus morhua) were collected for age estimation. The presence of marine mud covered by silty clay in the soil profile indicate the presence of a soft-bottom lagoon before the area was isolated due to isostacy. When the osseous

---

**Figure 5.** Soil profiles (above) at the Jortveit wetland site documented in 2018-19, and (below) topographic cross sectional model of the wetland and the surrounding area. (Map source: www.hoydedata.no).
and lithic tools were deposited in this layer, the lagoon at Jortveit was \( \sim 11.9 \) m deep. However, as the research have shown that wetlands tend to compress after isolation and drainage (Coles 1988), it is conceivable that the mud at Jortveit was even thicker and the lagoon shallower than suggested here. If the artefacts’ height above sea level was measured correctly in 1931, which we have no reason to dispute, then the wetlands have subsequently sunken at least \( \sim 40 \) cm.

**AMS-Dates**

Four samples collected in 1931 and seven samples retrieved in-situ from the ‘bone layer’ in 2018–19 were AMS-dated (Table 1, Figure 6). The quantity of preserved collagen in bones falls during degradation (Hedges, Millard, and Pike 1995). As collagen content is an important variable in sample extraction from osseous artefacts for \(^{14}\)C-dating, we measured collagen content in the 1931 artefacts from very small samples before extracting samples large enough for \(^{14}\)C-dating. This was done in order to ensure that a proper amount of collagen was extracted for dating. We used fourier-transform infrared spectroscopy (FTIR) (Perkin Elmer Spectrum 400 FT-IR/FT-NIR Spectrometer) to measure the collagen content of each sample three times before calculating a mean value. Relatively low amounts of collagen were found (Table 1). The toggling harpoon had mean content of 11.1% and the barbed harpoon 12.2%, while the tuna and orca contained even lesser amounts, 6.9% and 8.5% respectively. The variations observed here could be due to different storage facilities of archaeological versus zoological finds after 1931.

The dated wood and charcoal samples were retrieved from the ‘bone layer’ at \( \sim 125-130 \) cm depth (\( \sim 135-130 \) cm above 2019 sea level) in profile 2 and 6. A piece of wood from of the torch (Figure 2H) found in 1931 was also dated. Raw BP ages were calibrated in OxCal (v4.3.2) using the IntCal 13 atmospheric curve (Bronk Ramsey 2017; Reimer et al. 2013). In Figure 6, the orca and tuna ages were calibrated with an Atlantic marine reservoir effect (MRE) \( (380 \pm 30 \) y) taken into account (Mangerud et al. 2006). Alternatively, as tunas probably migrated from the Mediterranean (see below), the tuna BP ages could be calibrated with a Mediterranean MRE \( (390 \pm 85 \) y) (Siani et al. 2000), but the calibrated ages are in every case very similar.

To summarize, the AMS-dates indicate a continuous activity in and around the lagoon at Jortveit between roughly 3700 and 2500 cal BCE. Unfortunately, the youngest dates

---

### Table 1. AMS-dates from the Jortveit site.

| Lab ID    | BP  | SD | Cal BCE   | \( \delta C_{13} \) | FTIR (C %) | mg C | Sample ID     | Sample depth (cm) | Artefact/species          |
|-----------|-----|----|-----------|--------------------|------------|------|---------------|---------------------|--------------------------|
| LuS-13504 | 4935| 45 | 3889-3641 | –12.6              | 6.9        | 2.1  | PMO232.239    | Stray find            | Thunnus thynnus          |
| LuS-14883 | 4890| 40 | 3767-3635 | –27.0              | 1.6        | 1.6  | C61777/F20    | 125–130              | Wood/Betula              |
| LuS-13505 | 4885| 55 | 3791-3531 | –12.9              | 8.5        | 1.6  | PMO232.238    | Stray find            | Orcinus orca             |
| LuS-13503 | 4715| 45 | 3635-3369 | 12.2               | 0.4        | 0.4  | C25035b       | Stray find            | Toggling harpoon         |
| LuS-13897 | 4695| 40 | 3631-3369 |                | 1.6        | 1.6  | PMO232.237    | Stray find            | Torch/wood               |
| LuS-14885 | 4620| 40 | 3520-3138 | –12.0              | 1.1        | 1.1  | F15/TUN003    | 125–130              | Thunnus thynnus          |
| LuS-14886 | 4555| 40 | 3488-3101 | –14.0              | 1.3        | 1.3  | F15/TUN004    | 125–130              | Thunnus thynnus          |
| LuS-14887 | 4555| 40 | 3488-3101 | –13.0              | 1.1        | 1.1  | F15/TUN005    | 125–130              | Thunnus thynnus          |
| LuS-14884 | 4480| 40 | 3349-3026 | –28.0              | 2.1        | 2.1  | C61777/F21    | 125–130              | Charcoal                 |
| LuS-13896 | 4240| 40 | 2920-2679 |                | 1.1        | 1.1  | C61323/7      | 125–120              | Wood/Betula              |
| LuS-13895 | 4135| 40 | 2875-2582 |                | 1.3        | 1.3  | C61323/7      | 125–120              | Charcoal/Betula          |
| LuS-13502 | 4050| 75 | 2878-2356 | 11.1               | 0.2        | 0.2  | C25035a       | Stray find            | Barbed harpoon           |

---

To summarize, the AMS-dates indicate a continuous activity in and around the lagoon at Jortveit between roughly 3700 and 2500 cal BCE. Unfortunately, the youngest dates

---
(LuS-13502, LuS-13895) hit a plateau in the calibration curve, resulting in a large range of possible dates. Thus, it is conceivable, considering our prior knowledge of the site, that activity ended around 2800 cal BCE, but we nonetheless suggest a conservative estimate of 2500 cal BCE.

**Local Climate Reconstruction**

The mid-4th millennium BCE (Figure 7) marks the end of the Holocene Climatic Optimum (HCO), which involved a drop of temperature in Northern Europe, and thus the start of the Subboreal Period (3700–450 cal BCE) (Seppä et al. 2009; Velle et al. 2005). In Southern Norway, this transition is visible in a reactivation of glacier formation (e.g. Jostedalsbreen) and a lowering of the tree limit around 3300–3100 cal BCE (Eide et al. 2006; Karlén and Kuylenstierna 1996; Mayewski et al. 2004; Nesje and Kvatne 1991). Effects on temperatures were regionally specific in Scandinavia, and estimated mean July temperatures from lake basins close to Jortveit (Figure 8B and C) do not show strong deviations in this period (Eide et al. 2006; Nesje et al. 2005; Seppä et al. 2009). However, in Eastern Norway and Western Sweden, the vegetation history show a decline of linden (Tilia) followed by elm (Ulmus) in the period 3900–3500 cal BCE (Henningsmoen and Høeg 1985; Wieckowska-lüth, Kirleis, and Doerfler 2017). Temperature reconstruction from Lake Trehörningen and a humification index from Kortlandamossen in Western Sweden also show a trending temperature drop in this period (Antonsson and Seppä 2007; Borgmark 2005; Seppä et al. 2009).
Figure 7. Local climate reconstruction based on climate records from Norway, Sweden and Denmark, and selected archaeological data. Sources given in the main text. Dark grey vertical column marks the temporal limits of the radiocarbon dates from Jortveit.
Estimations of mean sea surface temperatures (SST) also mirror the end of the climatic optimum. In the period 4000–3500 cal BCE, a drop in SST is recorded for the Norwegian Sea (Calvo, Grimalt, and Jansen 2002). Sediment analyses on Northern Jutland have identified a 'high-energy environment' and a strengthening of the Jutland current in the period 4300–3500 cal BCE (Conradsen and Heier-Nielsen 1995; Gyllencreutz 2005; Jiang, Björck, and Svensson 1998; Leth 1996). This impact on sea currents also changed the morphology of the coastal strip of Northern Jutland and eventually formed the Skagen spit-system.

Figure 8. Location of Neolithic sites mentioned in the text with bones from bluefin tuna (dots), orca (circles), and with constructed fish weirs (triangle). 1: Skipshelleren, 2: Jortveit, 3: Alveberget, 4: Ånnerød, 5: Sandhem, 6: Rørvik, 7: Hakeröd, 8: Gröninge, 9: Stora Förvar, 10: Nekselø, 11: Smakkerup Huse, 12: Sankt Klaravej, 13: Ølby Lyng, 14: Oleslyst: 15; Oreby Rende. A: Jostedalsbreen, B: Grostjorna, C: Dalane, D: Lake Trehörningen, E: Kortlandamossen, F: Skagen. The presumed migratory route of bluefin tuna is drawn after Tiews (1963). Places where orcas were caught by Norwegians in the period 1938–1967 drawn after Jonsgård and Lyshoel (1969, Figure 1). Sea currents in the Skagerrak Sea drawn after Conradsen and Heier-Nielsen (1995, Figure 1).
around 3500 cal BCE (Johannessen and Nielsen 2006; Petersen 1991). SST in the Central Skagerrak Sea did not change markedly, while the northeastern part of Skagerrak experienced a drastic ∼5-6 °C drop in the period 4300–3400 cal BCE (Butruille et al. 2017; Krossa et al. 2017). According to Krossa et al. (2017, 1595), this drop in temperature probably documents ‘the onset of a longer-lasting disconnection between the SST evolution in the Northeast and West-Central Skagerrak’. Changes in sea currents are also documented in the Southwestern Baltic sea through increased surface water salinity and inflow of saline water in the period 4000–3000 cal BCE, indicating ‘enhanced primary productivity’ (Binczewska et al. 2018, 307, for an alternative interpretation see Warden et al. 2017).

These climatic trends correlate with long-term changes in the archaeological record. In Western Norway, an increased utilization of marine mammals on coastal hunter-fishergatherer sites occur after 3500 cal BCE, which also marks the transition from the Early to the Middle Neolithic in that region (Hufthammer 1997). Demographic frequency studies have identified a loss of signal of cultural carbon in the period 3400–3100 cal BCE in both Southern Norway and Southern Sweden, and the rise of hunter-fishergatherer societies, e.g. the Pitted Ware Culture (Nielsen, Persson, and Solheim 2019). In Eastern Norway, ∼3500 cal BCE correlates with a shift in settlement locations from inland towards the coast and marine resources (Nielsen, Persson, and Solheim 2019). Large areas of Denmark were cultivated by 3700 cal BCE (Warden et al. 2017), but a boom in radiocarbon dates from stationary fish weirs occur at ∼3500 cal BCE on the Danish islands (Fischer 2007). In the Baltic Sea Region, this boom coincides with an increased exploitation of marine mammals, particularly the low Arctic harp seal (Phoca groenlandica) by members of the Pitted Ware Culture (Fornander, Eriksson, and Lidén 2008; Storå 2002; Storå and Ericson 2004).

Thus, although local mean July temperatures and local SST (Central Skagerrak Sea) seem to have been stable when fishing activity took place at Jortveit, environmental changes have been documented in neighbouring regions of Scandinavia. Of particular relevance to Jortveit is the increase of the Jutland current and evidence pertaining to high primary productivity in the Southeastern Baltic Sea. On this background, it is conceivable that coastal dwellers on the Skagerrak Coast were already accustomed to sea travels and exploitation of select marine species (Figure 8). These would evidently include large fish species such as bluefin tuna and toothed whales. Both tuna and orca subsist largely on herring and mackerel, and such species often occur together with tuna and orca on Neolithic settlements (e.g. discussion of Stora Förvar in Knape and Ericson 1983).

Discussion

Coastal Adaptation in the Neolithic

The climate data paint a background picture of the Central Skagerrak Coast as a relatively stable environment in the mid-4th mill BCE, when evidence of tuna fishing and whaling appear in the archaeological record at Jortveit. The reconstructed cultural landscape surrounding the site indicate the presence of a hunter-fishergatherer community centred on a productive patch in the landscape. Though dated to the Early and Middle Neolithic, there is no direct evidence of a Neolithic economy at Jortveit, nor is there such evidence from any known contemporary coastal site in Southern Norway. Directly dated kernels
(Hordeum vulgare, Triticum dicoccum) from the site Kvastad A2, located in the hinterland some kilometres northeast of Jortveit, show that crops were indeed grown in the region when the fishing at Jortveit took place (Reitan, Sundström, and Stokke 2018). It is probable that the dwellers on the Homborsund Peninsula were aware of such farming practices and perhaps even took part in it on a seasonal basis. The occurrence of a polygonal battle-axe close to Jortveit and the toggling harpoons found in the wetland do show contact with farming societies. As shown by Zápotocký (1992), the Scandinavian polygonal battle-axe types with a bent neck, such as the type Killi axe that occur close to Jortveit (Figure 4, top row left), originate in the Pfyn and Mondsee groups of the Early Funnel Beaker Culture. The few finds of the characteristic toggling harpoons known from Central Europe seem to indicate a similar diffusion route for these tools as well (Torke 1993). It is on this archaeological background we argue that the Neolithization of Southern Scandinavia, and the social networks it formed, was a prerequisite for the type of coastal adaptation emerging at Jortveit.

A dependency on marine resources in Scandinavia during the Neolithic has been a subject of debate (Fischer 2007, 2002; Schulting 2015). Almgren (1906) first noticed the preserved seal bones at Neolithic settlements in Eastern Sweden, such as Åloppe in Uppland. Some decades later, Becker (1951) synthesized the many Neolithic coastal hunter-fisher-gatherer sites in Denmark, Sweden and Norway as a single phenomenon, namely the Grubekeramisk kultur (Pitted Ware Culture). Becker considered the two contemporary Neolithic groups, the Funnel Beaker Culture and the Pitted Ware Culture, as separate cultures and populations with unique historical trajectories. Based on δ13C-values from human skeletons, Tauber (1986) argued for a diet based on nearly 100% agriculture products among Neolithic farmers, i.e. Funnel Beaker Culture, as a contrast to Mesolithic foragers with a diet heavily based on marine resources. This was challenged by Fischer (2007), with reference to Neolithic fish bones of fresh water species with δ13C-values equal to terrestrial food sources (−20.9 to −26.7%). The question of marine orientation in Denmark then shifted from whether people ate fish at all, to which species were actually consumed.

In Western Sweden, Sjögren (2003) found a similar pattern as Tauber from stable isotopes in human and dog bones; a mixed diet in the Early Neolithic followed by a clear terrestrial diet in the Early Middle Neolithic, and then a clear marine diet in the Pitted Ware Culture. In Eastern Sweden, Lidén (1996) initially found continued exploitation of marine resources in the Neolithic regardless of cultural affiliation, i.e. Funnel Beaker Culture versus Pitted Ware Culture. However, the dependency of aquatic resources was highest in coastal regions, and conversely terrestrial sources were highest in inland contexts, a pattern subsequent studies have confirmed (Fornander, Eriksson, and Lidén 2008). However, a connection between Funnel Beaker Culture and terrestrial food sources, and between Pitted Ware Culture and aquatic food sources, is also strengthened by recent studies (Eriksson et al. 2008).

Studies of Neolithic pottery groups, such as the well-known Fagervik sequence on the east coast of Sweden, have also found a continuous sequence from Early Funnel Beaker Culture pots to ‘typical’ Pitted Ware (Larsson 2009). In Southern Norway, Hinsch (1955) argued that a population of farmers with origins in Southern Scandinavia settled in Eastern Norway in the Early Neolithic but that some centuries later, this society had collapsed and the population mixed with the local foragers (a process referred to as a de-
Neolithisation) – the outcome of which was the Pitted Ware Culture. In a recent study, Nielsen, Persson, and Solheim (2019) identified population fluctuations correlating with the de-Neolithisation period, but these were not connected with changes in economic strategies. With the exception of a few hinterland and possibly farming related sites in the eastern region of Norway, nearly all Neolithic occupation sites from this period are associated with the exploitation of wild resources.

An Archaeology of Patches

From an anthropological viewpoint, a change in subsistence strategy from terrestrial to aquatic, or vice versa, would not have happened coincidentally in the past. This is mainly because adaptive strategies are presumed to be dependent on a range of cultural and natural factors (Erlandson and Rick 2010; Kelly 2013). Hunter-gatherer societies found to be heavily dependent on aquatic resources often dwell in geographically small but highly populated territories, as was probably the case at Jortveit and more generally along the Skagerrak Coast during the Neolithic. This state of population density is due to the low availability of terrestrial meat sources within the local ecological system. Low availability of terrestrial meat sources restricts how a society can depend on meat, since hunting in cold areas, in global terms, often require relatively large territories (Kelly 2013, 46). Hence, the presence of a population adapted to a marine environment, such as at Jortveit, attest to low availability of terrestrial meat compared to the more easily available marine resources. It could therefore be hypothesized that such communities would have the technology and expertise to harvest enough marine resources to feed a relatively large population.

The ‘skjaergaard’ landscape formation along the Skagerrak Coast produces a patchy landscape enabling great ecological and thus cultural diversity (Price and Brown 1985; Wiens 1976; Winterhalder 1980; Yesner 1980). When discussing how societies with mixed farming and fishing economies would have found time devoted to foraging, hunting and fishing, Bulbeck (2013, 570) noted that communities ‘differ from each other in their subsistence pursuits based on the resource patches to which they have access, and their skills in recognizing and harvesting the edible resources contained in those patches’. At Jortveit and in the surrounding area, the hunter-fisher-gatherers, perhaps acquainted with farming communities, discovered the potential gain in seasonal tuna fishing and whaling. The technology enabling fisheries focused on large fish species (i.e. toggling harpoons) was probably acquired through trading networks or intermarriage relations. When applied within the patch, this technology probably boosted the size of their returns. Following this line of thought, the Jortveit lagoon represented a microenvironment for specialized foraging, a form of ‘cultivated landscape’ (Terrell et al. 2003) where high return rates were accomplished during the right season. In other seasons, fractions of the community could seek different activities, such as hinterland hunting or even farming near the coast (Reitan, Sundström, and Stokke 2018, 557).

Fishing with Toggling Harpoons at Jortveit

Considering the evidence of foraging at Jortveit, it is perhaps not correct as some Norwegian historians have suggested (Kalland 2014, 13), that the importance of whaling...
in prehistory decreased after the introduction of farming. The Jortveit site, in addition to a number of contemporary sites in Southern Norway and Sweden (Figure 8), supports the opposite view, namely that both tuna fishing and whaling represented good return rates for stationary communities in the Neolithic. The evidence of tuna fishing and whaling at Jortveit even implicates the presence of complex marine technologies (Erlandson, Rick, and Braje 2009), the exact shape of which we have yet to discover.

Even though it is tempting to interpret the ‘bone layer’ at Jortveit as representing waste from butchering and cleansing of fish, historical accounts do suggest a different scenario, namely that the tuna bones (or some of them) could be a direct result of failed catches. In the mid-twentieth century AD, the feeding migration of tuna from the Mediterranean started after spawning in April, May and June, and they appeared on the Norwegian Coast from July to October (Tiews 1963). Though the ethnography of tuna fishing in Northern Europe is limited – the first accounts of tuna (norw: størje) fishing with toggling harpoons in Norway date to 1762 (reviewed in Lindquist 1994) – an account from the southwestern coast of Norway is informative. According to Steinsnes (1956, 72), nineteenth century herring fishers caught tuna regularly with ‘skutel’ when tuna shoals surrounded the herring (Figure 9). On these occasions, a majority of the tuna eagerly caught the herring while swimming in high speed, while some of them drifted calmly around the shoals, presumably to regain strength. Staying oblivious towards the boats, these ‘drifters’ were pierced with toggling harpoons, which were attached to lines. Having been pierced, the tuna usually swam towards the bottom of the sea in order to scour the harpoon off (or so the anglers believed), and catches were often lost in this way. Thus, it is conceivable that the bone layer at Jortveit represent remains from such failed catches. The occurrence of fishing equipment inside the seabed supports this interpretation.

It is also interesting to note that even though the use of toggling harpoons for tuna and basking shark fishing in Norway appear in historical sources from the mid-eighteenth century AD, the earliest historical accounts of toggling harpoons point to whaling as their primary use (Lindquist 1994). As with the tuna fishery, whaling with toggling harpoons was also an opportunistic activity that took place when whales were observed near the coast by occasion. The literary sources describe near-coast whaling in the late nineteenth century as highly social events. Children often spotted the whales, and the catch itself attracted various members of the local communities, i.e. old and young, including dogs, the latter often creating ‘messy’ situations on land (Kalland 2014). There is no reason to suspect a different scenario in prehistoric contexts, such as at Jortveit.

**Conclusion**

The recent investigations at Jortveit show that in the period of roughly 3700–2500 cal BCE, the site as we know it was located at the bottom of a ∼9-11 m deep and sheltered lagoon. The mud layer, in which tuna bones were documented in-situ by excavations in 2018-19, represent a former seabed. It is thus likely that all stray finds discovered in the wetland, starting in 1931, were once encapsulated inside this mud layer. It is also likely that the complete wetland area (35 ha) at Homborsund as of 2019, which includes the Jortveit
farm, represent the true extension of this fossilized, soft-bottom mud layer. So far, all finds and samples from Jortveit date to the Early and Middle Neolithic Periods (3900-2350 cal BCE). The fauna material indicate that mostly Atlantic bluefin tuna, but also cod and orca were caught inside the lagoon. This was a period when the Skagerrak Region of Norway was inhabited by a hunter-fisher-gatherer population, some of which knew of and practiced farming.

Nearly a century after its discovery, we can now interpret the Jortveit wetland site based on new stratigraphic and radiocarbon evidence. On a different note, it is unfortunate to admit that this narrative is not exclusive to Jortveit, as wetland sites in Southern Norway in general remain poorly investigated (however, see Bang-Andersen 1947; Gjessing 1920; Gulliksen, Nydal, and Lovseth 1975; Persson 2014; Saxlund 1908, 1907). It will be a time consuming, yet truly great task for future archaeologists to re-explore the many known, but for various reasons neglected, wetland contexts in Southern Norway.

Figure 9. Historical iron harpoon (‘skutel’) from Austefjord, southwest Norway. These harpoons were used for coast near tuna fishing and whaling in the nineteenth century. (Inventory no. AMU.0063, Austefjord Museum, Photo: Ragnar Albertsen, Austefjord Museum, with permission).
Acknowledgements

Particular thanks is due Norsk Arkeologisk Selskaps Arkeologiske fond for financial support in post-excavation analyses of the 2018–19 field seasons. We would also like to thank Dr. Theis Zetner Trolle Jensen for providing a steady hand during sample extractions from archaeological artefacts in Oslo. The organizers of the student field course at the Institute for archaeology, conservation and history at the University of Oslo, and the students who participated in the 2018–19-excavations, are also thanked. Thanks also to Prof. Hans Arne Nakrem at the Museum of Natural History, University of Oslo, for locating and providing access to the Jortveit zoological material. Finally, a particular thank to the owner of the Jortveit farm for kindly welcoming us, and for his true devotion to local history.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

S. V. Nielsen is a PhD candidate in archaeology at the Department of archaeology, Museum of Cultural History in Oslo, Norway. He has worked with archaeological excavations and surveys in the Nordic countries, but particularly in the Oslo fjord area. His main research interests for the moment is the study of demographic processes in prehistoric Northern Europe, and the application of novel computational methods. Currently he is also conducting excavations at the Skagerrak coast, south Norway.

P. Persson is an associate professor in archaeology at the Department of Archaeology, Museum of Cultural History in Oslo, Norway. He has extensive experience with archaeological excavations in the Nordic countries, and published his doctoral dissertation on the Neolithic transition in northern Europe in 1999. His research interest is in the formation of Mesolithic and Neolithic societies, and particularly the application of aDNA and computational models of prehistoric ecology.

ORCID

S. V. Nielsen ⓒ http://orcid.org/0000-0002-2243-9159

References

Aaris-Sørensen, K., K. L. Rasmussen, C. Kinze, and K. S. Petersen. 2010. “Late Pleistocene and Holocene Whale Remains (Cetacea) From Denmark and Adjacent Countries: Species, Distribution, Chronology, and Trace Elements.” Marine Mammals Science 26: 253–281.

Adersen, S. H. 2018. Vængesø and Holmegaard. Ertebølle Fishers and Hunters on Djursland. Aarhus: Aarhus University Press.

Alin, J. 1955. Förteckning över stenåldersboplatser i norra Bohuslän. Göteborgs och Bohusläns Fornminnesförening, Göteborg.

Almgren, O. 1906. “Upplänska stenåldersboplatser.” Fornvännen 1: 1–19.

Andersen, S. H. 1972. “Ertebøllekulturens harpuner.” KUML. Årb. Jysk Arkaeologisk Selsk 1971: 73–125.

Antonsson, K., and H. Seppä. 2007. “Holocene Temperatures in Bohuslän, Southwest Sweden: A Quantitative Reconstruction From Fossil Pollen Data.” Boreas 36: 400–410. doi:10.1080/03009480701317421.

Bakka, E. 1973. “Gropkeramisk kultur og gropkeramiske kulturelementer i Sør-Norge.” In Bonde-Veidemann. Bofast-Ikke Bofast i Nordisk Forhistorie. Tromsø museum skrifter vol. XIV, Tromsø, P. Simonsen and G. S. Munch, 74–83.

Bakke, G. P. 1933. “Stenalderfund i Eide.” Medl. Eide Sognelag 1933: 32–37.
Bakker, J. A. 1979. *The TRB West Group. Studies in the Chronology and Geography of the Makers of Hunebeds and Tiefstich Pottery.* Amsterdam: Sidestone Press.

Bang-Andersen, A. 1947. “Et forhistorisk pålebyggverk fra Kylles i Høyland.” *Stavanger Museum / Årb. 57:* 77–98.

Becker, C.-J. 1951. “Den grubekeramiske kultur i Danmark.” *Aarbøger Nord. Oldkynd. og Hist 1951:* 153–274.

Bergsvik, K. A. 2002. Arkeologiske undersøkelser ved Skatestraumen Bind I. *Arkeologiske avhandlinger* og rapporter fra Universitetet i Bergen 7, Bergen Museum, Universitetet i Bergen, Bergen.

Bergsvik, K. A. 2012. “The Last Hunter-Fishers of Western Norway.” In *Becoming European. The Transformation of Third Millennium Northern and Western Europe,* edited by C. Prescott and H. Glørstad, 100–114. Oxford: Oxbow Books.

Bergsvik, K. A., and E. David. 2015. “Crafting Bone Tools in Mesolithic Norway: A Regional Eastern-Related Know-how.” *European Journal of Archaeology* 18: 190–221.

Bincewska, A., M. Moros, I. Polovodova Asteman, J. S. and M. Bąk. 2018. “Changes in the Inflow of Saline Water Into the Bornholm Basin (SW Baltic Sea) During the Past 7100 Years – Evidence From Benthic Foraminifera Record.” *Boreas* 47: 297–310.

Bjørn, A. 1932. “Et Eiendommelig Stenåldersfunn fra Sørlandet.” *Univ. Oldsaksaml. Årb.* 1930: 27–35.

Boe, J. 1934. Boplassen i skipshelleren på Straume i Nordhordaland. Bergen Museum/Årbøger Nord. Oldkynd. og Hist 17, Bergen.

Borgmark, A. 2005. “Holocene Climate Variability and Periodicity in South-Central Sweden, as Interpreted From Peat Humification Analysis.” *The Holocene* 15: 387–395.

Bronk Ramsey, C., 2013. OxCal v4.3.2.

Bulbeck, D. 2013. “The Transition From Foraging to Farming in Prehistory and “Ethnography.”” *World Archaeology* 45: 557–573. doi:10.1080/00438243.2013.821668.

Butruille, C., V. R. Krossa, C. Schwab, and M. Weinelt. 2017. “Reconstruction of mid- to Late-Holocene Winter Temperatures in the Skagerrak Region Using Benthic Foraminiferal Mg/Ca and δ18O.” *Holocene* 27: 63–72. doi:10.1177/0959683616652701.

Calvo, E., J. Grimalt, and E. Jansen. 2002. “High Resolution U37Ksea Surface Temperature Reconstruction in the Norwegian Sea During the Holocene.” *Quat. Sci. Rev.* 21: 1385–1394. doi:10.1016/S0277-3791(01)00096-8.

Clark, G. 1947. “Whales as an Economic Factor in Prehistoric Europe.” *Antiquity* 21: 84–104.

Clark, S. T., D. K. Odell, and C. T. Lacinak. 2000. “Aspects of Growth in Captive Killer Whales (Orcinus Orca).” *Mar. Mammal Sci.* 16: 110–123.

Coles, J. M. 1988. “A Wetland Perspective.” In *Wet Site Archaeology,* edited by B. A. Purdy, 1–14. Florida: CRC Press.

Conradsen, K., and S. Heier-Nielsen. 1995. “Holocene Paleoceanography and Paleoenvironsments of the Skagerrak-Kattegat, Scandinavia.” *Paleoceanography* 10: 801–813. doi:10.1029/95PA01142.

Eide, W., H. H. Birks, N. H. Bigelow, S. M. Peglar, and H. J. B. Birks. 2006. “Holocene Forest Development Along the Setesdal Valley, Southern Norway, Reconstructed From Macrofossil and Pollen Evidence.” *Veg. Hist. Archaeobot* 15: 65–85. doi:10.1007/s00334-005-0025-7.

Enghoff, I. B., B. R. MacKenzie, and E. E. Nielsen. 2007. “The Danish Fish Faune During the Warm Atlantic Period (ca. 7000-3900 bc): Forerunner of Future Change?” *Fisheries Research* 87: 167–180.

Ericson, P. G. P. 1989. “Faunahistoriskt Intressanta Stenålderfynd Från Stora Karlsö.” *Flora och Fauna* 84: 192–198.

Eriksson, G., A. Linderotholm, E. Forndamer, M. Kanstrup, P. Schoultz, H. Olofsson, and K. Lidén. 2008. “Same Island, Different Diet: Cultural Evolution of Food Practices on Öland, Sweden, From the Mesolithic to the Roman Period.” *Journal of Anthropological Archaeology* 27: 520–543. doi:10.1016/j.jaa.2008.08.004.

Erlandson, J. M., and T. C. Rick. 2010. “Archaeology Meets Marine Ecology: The Antiquity of Maritime Cultures and Human Impacts on Marine Fisheries and Ecosystems.” *Ann. Rev. Mar. Sci* 2: 231–251. doi:10.1146/annurev.marine.010908.163749.

Erlandson, J. M., T. C. Rick, and T. J. Braje. 2009. “Fishing up the Food Web?: 12,000 Years of Maritime Subsistence and Adaptive Adjustments on California’s Channel Islands.” *Pacific Sci.* 63: 711–724. doi:10.2984/049.063.0411.
Fischer, A. 2002. “Food for Feasting.” In The Neolithisation of Denmark - 150 Years of Debate. Sheffield Archaeological Monographs 12 J.R., edited by A. Fischer, and K. Kristiansen, 343–393. Sheffield: Collis Publications.

Fischer, A. 2007. “Coastal Fishing in Stone Age Denmark – Evidence From Below and Above the Present sea Level and From Human Bones.” In Shell Middens and Coastal Resources Along the Atlantic Facade, edited by N. Milner, G. Bailey, and O. E. Craig, 54–69. Oxford: Oxbow books. doi:10.1016/j.micron.2012.12.008.

Fornander, E., G. Eriksson, and K. Lidén. 2008. “Wild at Heart: Approaching Pitted Ware Identity, Economy and Cosmology Through Stable Isotopes in Skeletal Material From the Neolithic Site Korsnäs in Eastern Central Sweden.” J. Anthropol. Archaeol 27: 281–297.

Gaustad, F. W. 1961. “Til Vega’s forhistorie.” Vega Bygdeb 1: 11–44.

Gjessing, H. 1920. “Fangstfolk.” Oslo: Aschehoug & Co.

Gjessing, G. 1941a. “Arktisk og Sørskandinavisk i Nord-Norges Yngre Steinalder.” Viking 5: 75–116.

Gjessing, G. 1941b. “Yngre Steinalder i Nord-Norge. Instituttet for sammenlignende kulturforskning. Oslo: Aschehoug & co.

Gjessing, G. 1945. Norges Steinalder. Norsk Arkeologisk Selskap, Oslo.

Glørstad, H. 1996. Neolittiske smuler. Små teoretiske og praktiske bidrag til debatten om neolittisk keramikk og kronologi i Sør-Norge. Varia 33. Oslo: Universitetets Oldsaksamling.

Glørstad, H., and L. Sundström. 2014. Hamremoen - an enclosure for the hunter-gatherers?, in: Furholt, M., Hinz, M., Mischka, D., Noble, G., Olausson, D. (Eds.), Landscapes, Histories and Societies in the Northern European Neolithic. Frühe Monumentalität und soziale Differenzierung 4. Institut för Ur- och Frühgeschichte der CAU Kiel, Kiel, pp. 29–48.

Gulliksen, S., R. Nydal, and K. Løvseth. 1975. “Trondheim Natural Radiocarbon Measurements VII.” Radiocarbon 17: 364–395.

Gunn, J. S., N. P. Clear, T. I. Carter, A. J. Rees, C. A. Stanley, J. H. Farley, and J. M. Kalish. 2008. “Age and Growth in Southern Bluefin Tuna, Thunnus Maccocyii (Castelnau): Direct Estimation From Otoliths, Scales and Vertebrae.” Fish. Res 92: 207–220. doi:10.1016/j.fishres.2008.01.018.

Gyllencreutz, R. 2005. “Late Glacial and Holocene Paleoceanography in the Skagerrak From High-Resolution Grain Size Records.” Palaeogeogr. Palaeoclimatol. Palaeoecol 222: 344–369. doi:10.1016/j.palaeo.2005.03.025.

Hagen, A. 1967. Norges Oldtid. J. W. Cappelens Forlag, Oslo.

Hamre, J. 1957. Makrellstørje. Hovedfagsoppgave. Universitetet i Bergen, Bergen.

Haug, A. 2011. “Kontinuitet og erverv belyst ved hellerfunn fra Midt-Norge.” Eksempler fra Nordmøre og Romsdal. Nord. Museum. Årb 2011: 57–70.

Hedges, R. E. M., A. R. Millard, and A. W. G. Pike. 1995. “Measurements and Relationships of Diagenetic Alteration of Bone From Three Archaeological Sites.” J. Archaeol. Sci 22: 201–209. doi:10.1006/jasc.1995.0022.

Helmer, J. W. 1991. “The Palaeo-Eskimo Prehistory of the North Devon Lowlands.” Arctic 44 (4): 301–317.

Henningsmoen, K. E., and H. I. Høeg. 1985. “Pollen Analyses From the Skagerrak Core GIK 15530-4.” Nor. Geol. Tidsskr 65: 41–47.

Henrici, P. 1936. Benfkynd från boplatsen vid Rörvik. Göteborgs och Bohusläns Fornminnesforbunds Tidskr. 82–91.

Heyning, J. E., and M. E. Dahlheim. 1988. Orcinus orca. Mamm. Species 304, 1–9.

Hinsch, E. 1955. Traktbegerkultur - Megalitkultur. En studie av Øst-Norges eldste, neolittiske gruppe. Univ. Oldsaksamlingen Ārb. 1951-1953 10–177.

Hufthammer, A. K. 1997. The unburned bones at the Auve site - the remains of a large bone collection?, in: Østmo, E., Hulthén, B., Isaksson, S., Hufthammer, A.K., Sørensen, R., Bakkevig, S., Thomsen,
M.S. (Eds.), Auve. Bind II. Tekniske Og Naturvitenskapelige Undersøkelser. Norske Oldfunn XVII. Institutt for arkeologi, kunsthistorie og numismatikk. Universitets Oldsaksamling., Oslo, 59–63.

Iversen, R. 2010. “In a World of Worlds. The Pitted Ware Complex in a Large Scale Perspective.” Acta Archaeol 81: 5–43.

Jaksland, L. 2005. Hvorfor så Mange Økser? En Tolkning av Funnene fra den Klassiske Nøstvettplassen i Ås, Akershus. Hovedfagsoppgave i arkeologi, Institutt for Arkeologi, Konservering og Universitetet i Oslo, Oslo.

Jiang, H., S. Björck, and N. Svensson. 1998. “Reconstruction of Holocene sea-Surface Salinity in the Skagerrak–Kattegat: a Climatic and Environmental Record of Scandinavia.” J. Quat. Sci 13: 107–114. doi:10.1002/(SICI)1099-1417(199803/04)13:2<107::AID-JQS336>3.3.CO;2-R.

Johannessen, P. N., and L. H. Nielsen. 2006. “Spit-systems - An Overlooked Target in Hydrocarbon Exploration: The Holocene to Recent Skagen Odde.” Denmark. Geol. Surv. Denmark Greenl. Bull 10: 17–20.

Jonsgård, Å, and P. B. Lyshoel. 1969. A Contribution to the Knowledge on Biology of the Killer Whale (Orcinus Orca). C.M. 1969/N.6., Oslo.

Jonsson, L. 2005. Hvorfor så Mange Økser? En Tolkning av Funnene fra den Klassiske Nøstvettplassen i Ås, Akershus. Hovedfagsoppgave i arkeologi, Institutt for Arkeologi, Konservering og Universitetet i Oslo, Oslo.

Jiang, H., S. Björck, and N. Svensson. 1998. “Reconstruction of Holocene sea-Surface Salinity in the Skagerrak–Kattegat: a Climatic and Environmental Record of Scandinavia.” J. Quat. Sci 13: 107–114. doi:10.1002/(SICI)1099-1417(199803/04)13:2<107::AID-JQS336>3.3.CO;2-R.

Johannessen, P. N., and L. H. Nielsen. 2006. “Spit-systems - An Overlooked Target in Hydrocarbon Exploration: The Holocene to Recent Skagen Odde.” Denmark. Geol. Surv. Denmark Greenl. Bull 10: 17–20.

Jonsgård, Å, and P. B. Lyshoel. 1969. A Contribution to the Knowledge on Biology of the Killer Whale (Orcinus Orca). C.M. 1969/N.6., Oslo.

Jonsson, L. 2002. Animal bones from the Middle Neolithic site Hakeröd in Bohuslän, Sweden. ANL-rapport 2002:1, Institutionen för Arkeologi, Göteborgs universitet, Göteborg.

Jonsson, L. 2007. Djurbenen från Sandhem. Tidigare undersökningar av djurben från kökkenmöddingar i Västsverige, in: Lönn, M., Claesson, P. (Eds.), Vistelser Vid Vatten. Gropkeramiska Platser Och Kokgropar Från Bronsålder Och Järnålder. Riksantikvarieämbetet & Bohusläns museum, Ödeshög, 231–235.

Kaelas, L. 1973. Gropkeramisk kultur vid den svenske västkuste - bofast eller ej, in: Simonsen, P., Munch, G.S. (Eds.), Bonde-Veidemann. Bofast-Ikke Bofast i Nordisk Forhistorie. Tromsø museum skrifter vol. XIV, Tromsø, 62–74.

Kalland, A. 2014. Hval og Hvalfangst på Vestlandet 1600-1910. Novus forlag, Instittet for sammen-lignende kulturforskning, Oslo.

Karlsen, ÅM. 2009. Breaking and Making Bodies and Pots. Material and Ritual Practices in Sweden in the Third Millennium BC. Department of Archaeology and Ancient History. AUN 40, Uppsala.

Krossa, V. R., M. Moros, G. Leduc, M. Hinz, T. Blanz, and R. Schneider. 2017. Regional climate change and the onset of farming in northern Germany and southern Scandinavia. The Holocene 095968361770222.https://doi.org/10.1177/0959683617702223.

Lidén, K. 1996. “A Dietary Perspective on Swedish Hunter-Gatherer and Neolithic Populations. An Analysis of Stable Isotopes and Trace Elements.” Laborativ Arkeologi 9: 5–23.

Lindquist, O. 1994. Whales, Dolphins and Porpoises in the Economy and Culture of Peasant Fishermen of Norway, Orkney, Shetland, Faroe Islands and Iceland, ca. 900-1900 AD, and Norse Greenland, ca. 1000-1500 A.D. (Vol I). PhD Thesis, Faculty of Arts, University of St. Andrew, St. Andrews.

Löugas, L., A. Kriiska, and L. Maldre. 2007. “New Dates for the Late Neolithic Corded Ware Culture Burials and Early Husbandry in the East Baltic Region.” Archaeofauna 16: 21–31.

Magnus, B., and B. Myhre. 1976. Norges Historie. Bind 1. Forhistorien. Fra Jegergrupper til høvdingsamfunn. J. W. Cappelens Forlag, Oslo.
Mangerud, J., S. Bondevik, S. Gulliksen, A. K. Hufthammer, and T. Høisæter. 2006. “Marine 14C Reservoir Ages for 19th Century Whales and Molluscs From the North Atlantic.” *Quat. Sci. Rev* 25: 3228–3245. doi:10.1016/j.quascirev.2006.03.010.

Mayewski, P. A., E. E. Rohling, J. C. Stager, W. Karlén, K. A. Maasch, L. D. Meeker, E. A. Meyerson, et al. 2004. “Holocene Climate Variability.” *Quat. Res* 62: 243–255. doi:10.1016/j.yqres.2004.07.001.

McCartney, A. P. 1984. “History of Native Whaling in the Arctic and Subarctic.” In *Arctic Whaling. Arctic Centre*, edited by H. K. Jacob, K. Snoeijjing, and R. Vaughan, 79–111. Groningen: University of Groningen.

Midtbø, I., L. Prøsch-Danielsen, and S. K. Helle. 2000. Den Holocene (etteristidens) strandlinje i området Mandal-Kristiansand, Vest-Agder, Sør-Norge. Et forprosjekt, in: Selsing, L. (Ed.), Norsk Kvartærbotanikk Ved Årtusenskiftet. AmS-Varia 37, Museum of Archaeology, Stavanger, pp. 37–50.

Mikkelsen, E. 1977. Østnorske Veideristninger - Kronologi og Øko-Kulturelt Miljø. Viking XL, 147–201.

Nesje, A., and M. Kvamme. 1991. “Holocene Glacier and Climate Variations in Western Norway: Evidence for Early Holocene Glacier Demise and Multiple Neoglacial Events.” *Geology* 19: 610–612. doi:10.1130/0091-7613(1991)019<0610:HGCVWE>2.3.CO;2.

Nielsen, S. V., J. Åkerstrøm, J.-S. F. Stokke, and K. F. Eskeland. 2016. Quartz Utilization Along the Coast of Southern Norway: Results from a Stone Age Survey in East Agder, in: Bjerrck, H.B., Breivik, H.M., Fretheim, S., Piana, I.A., Skar, B., Tivoli, A.M., Zangrando, A.F.J. (Eds.), Marine Ventures: Archaeological Perspectives on Human-Sea Relations. Proceedings from the Marine Ventures Int. Symposium in Trondheim 2013. Oxbow books.

Nielsen, S. V., J. Åkerstrøm, and T. Vihovde. 2013. Lithic Experiments in Rescue Archaeology - a Case from Southern Norway. EXARC J. 2013.

Nielsen, S. V., P. Persson, and S. Solheim. 2019. ”De-Neolithisation in Southern Norway Inferred From Statistical Modelling of Radiocarbon Dates.” *J. Anthropol. Archaeol* 53: 82–91. doi:10.1016/j.jaa.2018.11.004.

Nærøy, A. J. 1994. “Chronological and Technological Changes in Western Norway 6000-3800 BP.” *Acta Archaeol* 63: 77–95.

Oldeberg, A. 1952. Studien Über die Schwedische Bootaxtkultur. Wahlström & Widstrand, Stockholm.

Olsen, H. 1976. Skipsbølteren. Osteologisk materiale. Zoologisk Museum. Universitetet i Bergen, Bergen.

Olsen, A. B. 1992. Kotedalen - en boplass gjennom 5000 år. Fangstbosetning og tidlig jordbruk i vestnorsk steinalder: Nye funn of nye perspektiver. Historisk Museum, Universitetet i Bergen, Bergen.

Østmo, E. 2007. “The Northern Periphery of the TRB Graves and Ritual Deposits in Norway.” *Acta Archaeol* 78: 111–142.

Østmo, E. 2008. Auve. En fangstboplass fra yngre steinalder på Vesterøya i Sandefjord. Norske Oldfunn XXVIII. Kulturhistorisk Museum, Oslo.

Persson, P. 2014. Gunnarsrød myr - spår av medeltida aktivitet, in: Reitan, G., Persson, P. (Eds.), Vestfoldbaneprosjektet. Arkeologiske Undersøkelser i Forbindelse Med Ny Jernbane Mellom Larvik Og Porsgrunn. Bind II. Seinmesolittiske, Neolitiske Og Yngre Lokaliteter Vestfold Og Telemark. Portal forlag og Kulturhistorisk Museum, Arkeologisk seksjon, Oslo, pp. 311–319.

Petersen, K. S. 1991. “Holocene Coastal and Faunal Development of the Skagen Odde, Northern Jutland, Denmark.” *Quat. Int* 9: 53–60.

Prescott, C. 1996. “Was There Really a Neolithic in Norway?” *Antiquity* 70: 77–87.

Price, T. D., and J. H. Brown. 1985. “Aspects of Hunter-Gatherer Complexity.” In *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity*, edited by T. D. Price, and J. H. Brown, 3–20. Orlando: Academic Press.
Reimer, P. J., E. Bard, A. Bayliss, J. W. Beck, P. G. Blackwell, C. Bronk Ramsey, P. M. Grootes, et al. 2013. “IntCal 13 and Marine13 Radiocarbon age Calibration Curves 0-50,000 Years cal BP.” Radiocarbon 55: 1869–1887.

Reitan, G., and L. Sundström, eds. 2018. The Stone Age Coastal Settlement in Aust-Agder, Southeast Norway. Archaeological Excavations Along the new E18 Tvedestrand-Arendal. Oslo: Cappelen Akademisk Forlag.

Reitan, G., L. Sundström, and J.-S. F. Stokke. 2018. “Grains of Truth. Neolithic Farming on Mesolithic Sites. New Insights Into Early Agriculture in Southeast Norway.” In The Stone Age Coastal Settlement in Aust-Agder, Southeast Norway. Archaeological Excavations Along the New E18 Tvedestrand-Arendal, edited by G. Reitan and L. Sundström, 521–539. Oslo: Cappelen Damm Akademisk.

Romundset, A. 2018. “Postglacial Shoreline Displacement in the Tvedestrand-Arendal Area.” In The Stone Age Coastal Settlement in Aust-Agder, Southeast Norway. Archaeological Excavations Along the New E18 Tvedestrand-Arendal, edited by G. Reitan and L. Sundström, 463–478. Oslo: Cappelen Akademisk Forlag.

Rosvold, J., R. Andersen, J. D. Linnell, and A. K. Hufthammer. 2013. “Cervids in a Dynamic Northern Landscape: Holocene Changes in the Relative Abundance of Moose and red Deer at the Limits of Their Distributions.” The Holocene 23: 1143–1150. doi:10.1177/0959683613483625.

Särlvik, I. 1976. Fornlämning 72 och 116, stenåldersboplats, Gröninge, Tölö sn, Halland. Vol. 9. Riksantikvarieämbetet Rapport 1976 B, Stockholm.

Saxlund, S. H. 1907. Harøhytten og mypælene. Meddelelser om fund, gjort på Harøen med fl. steder i Akerø prestegjeld. Det Kgl. Norske Videnskabers Selskab i Trondhjem. Aktietrykkeriet i Trondhjem, Trondhjem.

Saxlund, S. H. 1908. Orten-gammen m.m. Meddelelser om fund gjorte i Akerø i yttre Romsdalen. Det Kgl. Norske Videnskabers Selskab i Trondhjem. Aktietrykkeriet i Trondhjem, Trondhjem.

Schulting, R. 2015. “Stable Isotopes and Neolithic Subsistence: Pattern and Variation.” In The Oxford Handbook of Neolithic Europe, edited by C. Fowler, J. Harding, and D. Hofman, 1–31. Oxford: Oxford Handbook Online.

Seppä, H., A. E. Bjune, R. J. Telford, H. J. B. Birks, and S. Veski. 2009. “Last Nine-Thousand Years of Temperature Variability in Northern Europe.” Climate Past 5: 523–535. doi:10.1016/j.neuroscience.2012.12.036.

Siani, G., M. Peterne, M. Arnold, E. Bard, B. Métivier, N. Tisnerat, and F. Bassinot. 2000. “Radiocarbon Reservoir Ages in the Mediterranean sea and Black sea.” Radiocarbon 42: 271–280. doi:10.1026//0933-6885.13.3.129.

Sjögren, K.-G. 2003. “Megaliths, Settlement and Subsistence in Bohuslän, Sweden.” In Stones and Bones: Formal Disposal of the Dead in Atlantic Europe During the Mesolithic-Neolithic Interface 6000-3000 BC, BAR International Series 1201, edited by G. Burenhult and B. Westergaard, 167–176. Oxford: BAR International Series 1201.

Skjølsvold, A. 1977. Slettabyrinthoplassen. Et bidrag til diskusjonen om forholdet mellom fangst- og bondesamfunnet i yngre steinalder og bronzealder. AMS-Skrifter 2, Stavanger.

Solheim, S. 2012. Lokal praksis og fremmed opphav. Arbeidsdeling, sosiale relasjoner og differansiering i østnorsk tidlineolitikum. Avhandling for graden Ph.d. Universitetet i Oslo, Oslo.

Steinsnes, S. 1956. Når kvalen rek til lands. Årb. Karmsun. Haugesun Museum. Årshefte 1951–1955 68–82.

Storå, J. 2002. “Neolithic Seal Exploitation on the Åland Islands in the Baltic Sea on the Basis of Epiphyseal Fusion Data and Metric Studies.” Int. J. Osteoarchaeol 12: 49–64. doi:10.1002/oa.612.

Storå, J., and P. G. P. Ericson. 2004. “A Prehistoric Breeding Population of Harp Seals (Phoca Groenlandica) in the Baltic Sea.” Mar. Mammal Sci 20: 115–133.

Tauber, H. 1986. Analysis of stable isotopes in prehistoric populations, in: Bernd, H. (Ed.), Innovative Trends in Der Prähistorischen Anthropologie. Mitteilungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, Berlin, 31–38.

Terrell, J. E., J. P. Hart, S. Barut, N. Cellinese, A. Curet, T. Denham, C. M. Kusimba, et al. 2003. “Domesticated Landscapes: The Subsistence Ecology of Plant and Animal Domestication.” J. Archaeol. Method Theory 10: 323–368. doi:10.1023/B:JARM.0000005510.54214.57.
Tiews, K. 1963. Synopsis of biological data on bluefin tuna Thunnus thynnus (Linnaeus) 1758 (Atlantic and Mediterranean). Species Synopsis No. 13. FAO Fisheries Biology Synopsis No. 56.Institut fur Kusten- und Binnenfischerei der Bunderforschungsanstalt fur Fischerei, Hamburg.

Torke, W. 1993. “Die Fischerei am Prähistorischen Federeese.” Archäologisches Korrespondenzblatt 23: 49–66.

Tuck, J. A. 1970. “An Archaic Indian Cemetery in Newfoundland.” Sci. Am 222: 112–122.

Velle, G., S. J. Brooks, H. J. B. Birks, and E. Willassen. 2005. “Chironomids as a Tool for Inferring Holocene Climate: an Assessment Based on six Sites in Southern Scandinavia.” Quat. Sci. Rev 24: 1429–1462.

Warden, L., M. Moros, T. Neumann, S. Shennan, A. Timpson, K. Manning, M. Sollai, et al. 2017. “Climate Induced Human Demographic and Cultural Change in Northern Europe During the mid-Holocene.” Nature Scientific Reports 7: 1–11. doi:10.1038/s41598-017-14353-5.

Wieckowska-lüth, M., W. Kirleis, and W. Doerfler. 2017. Holocene history of landscape development in the catchment of Lake Skogstjern, southeastern Norway, based on a high-resolution multi-proxy record. The Holocene. https://doi.org/10.1177/0959683617715691.

Wiens, J. A. 1976. “Population Responses to Patchy Environments.” Annu. Rev. Ecol. Syst 19: 81–120.

Winterhalder, B. 1980. “Environmental Analysis in Human Evolution and Adaptation Research.” Hum. Ecol 8: 135–170. doi:10.1007/BF01531439.

Yesner, D. R. 1980. “Maritime Hunter-Gatherers: Ecology and Prehistory [and Comments and Reply].” Curr. Anthropol 21: 727–750. doi:10.2307/2742514.

Zápotocký, M. 1992. Streitäxte des mitteleuropäischen Äneolithikums. VCH, Acta Humaniora, Weinheim.