Specialists facing climate change
The 8200 cal. BP event and its impact on the coastal settlement in the inner Oslofjord, southeast Norway

Abstract

Around 8200 years ago the gradual rise in Holocene temperatures was interrupted by a marked cooling period, which is referred to as the 8200 cal. BP event. The event is detected as a significant fall in temperatures in multiple palaeoclimatic records in the North Atlantic region and is linked to the drainage of the proglacial Laurentide lakes in North America. The cooling period lasted c. 150–200 years. In northern Europe, this cooling period has been linked to cultural changes in several regions. To investigate human responses to prehistoric climate changes this article provides a case study from Oslofjord area in southeast Norway.

At the onset of the climatic cooling, the Oslofjord was populated by specialised hunter–gatherers who relied on marine resources, especially fish. Groups with specialised subsistence strategies, so-called specialists, are generally assumed to be vulnerable for climate–induced changes in resources. This study uses the temporal and spatial distribution of shore bound sites dated within the timespan 9000–7600 cal. BP to investigate if the specialised hunter–gatherers were affected by the 8200 cal. BP event. The data set shows fluctuations in the frequency of shore bound sites, but no distinct decline in the number of sites is documented corresponding in time to the climatic cooling. From 8000 cal. BP there is a marked growth in the number of sites, which implies increased activity in the coastal area and perhaps an even larger dependency on marine resources in the course of the 8200 cal. BP event. This suggests that although being characterised as potentially vulnerable, the specialised hunter–gatherers in the Oslofjord area appear to be resilient to climate change.

Introduction

Among the best documented climatic events in the early Holocene (c. 11 7000–8000 cal. BP) is the so-called 8200 cal. BP event which is detected as a significant, but short–term fall in temperatures in multiple palaeoclimate records in the North Atlantic region. The cooling period is linked to the drainage of the proglacial Laurentide lakes in North America, which destabilised the thermohaline circulation in the North Atlantic Ocean. Ice core records from Greenland indicate that the 8200 cal. BP event began around 8175 ± 30 cal. BP and lasted for c. 150 years, with a maximum cooling of c. 3°C lasting c. 70 years (Alley & Ágústsdóttir, 2005; Alley et al., 1997; Antonsson & Seppä, 2007; Barber et al., 1999; Clarke et al., 2004; Kobashi et al., 2007; Nesje et al., 2005; Seppä et al., 2007; Seppä et al., 2009; Thomas et al., 2007; Veski et al., 2004; Walker et al., 2012).

In northern Europe, this cooling period has been linked to cultural changes in several regions. Manninen (2014) detected changes in technological organisation, settlement pattern, and land use in northernmost Fennoscandia. Wicks and Mithen (2014) inferred a population collapse from the radiocarbon record in western Scotland, and they argue that the collapse is due to a low-density population that lacked the capacity to adapt their technology and lifestyle to new environmental conditions in the course of the 8200 cal. BP event. A similar pattern is detected by Apel et al. (2017) on the island of Gotland in the Baltic Sea where a gap in the summed calibrated radiocarbon date frequency distribution between 8200 and 8000 cal. BP is interpreted as a drop in population. On the basis of a Bayesian statistical modelling of archaeological sites in northwest Europe, Griffiths and Robinson (2018), on the other hand, cannot identify a decline in human activity and they argue that the population in northwest Europe was resilient to the climatic changes.

Evidently, different regional case studies will provide different results depending on the methodological approaches (e.g. Griffiths & Robinson, 2018). Moreover, as stressed by Nieuwenhuyse and Biehl (2016): “cultural adaptations to the same climate event should not a priori be expected to play out similarly across larger regions” (p. 4). Firstly, the environmental effects of the 8200 cal. BP event varied greatly from region to region. Secondly, as the cultural adaptations of hunter–gatherer groups differed in terms of subsistence strategies, mobility strategies, contact networks, environmental knowledge, and societal organisation; it is reasonable to expect differential responses to environmental change. This article provides a case study from the Oslofjord area in southeast Norway and addresses hunter–gatherers in a coastal environment.

Several scholars argue that coastal environments have played an important role in human prehistory (Bailey, 2004; Bailey & Milner, 2002; Bjerck, 2007; Breivik, 2014; Erlandson, 2001; Yesner, 1980), Coastal zones tend to have a large number of ecological niches within a smaller area, and thus they exhibit a large species diversity (Yesner, 1980, p. 729). Yesner (1980) argues that marine resources are more stable than terrestrial resources, especially if stability is taken to mean the amplitude of resource variations (Yesner, 1980, p. 729). Further, coastal zones can ease transportation and communication as waterways allow people to move more easily, facilitating cultural contact and exchange with other groups (Bailey, 2004, p. 44). Boats allow dispersed resources to be harvested and brought to camp, and the use of boats can expand the foraging range and allow long logistical moves (Ames, 2002). Still, the exploitation of coastal resources, and fishing in particular, have been viewed as a costly, technology–dependent and highly specialised subsistence strategy (Binford, 2001, p. 444; Kelly, 2013, pp. 127-128). The archaeological record from well-preserved coastal sites in southern Norway and western Sweden demonstrates the importance of fishing during early Holocene. Groups with specialised subsistence strategies, so-called specialists, may be vulnerable for climate–induced changes in resources as they will have fewer skills and a narrower experience from which to draw on for adaptation strategies (Marshall et al., 2010, p. 11). Assuming that the coastal hunter–gatherers living in the Oslofjord area were so-called specialist, and therefore vulnerable for the environmental changes, we can expect changes in the archaeological record following the 8200 cal. BP event.

This study will use shore bound sites dated within the timespan 9000–7600 cal. BP to investigate temporal and spatial changes in the site pattern in the course of the 8200 cal. BP event. The location of the sites can be seen in figure 1. The Oslofjord area is well–suited for investigating prehistoric human–climate relations in coastal areas as the constant marine regression after the retreat of the Scandinavian Ice Sheet from ca. 12 500 cal. BP has caused shore bound sites from all prehistoric periods to be located above present-day sea level. Recently, Breivik et al. (2018) used the temporal distribution of shoreline–dated sites to investigate if the 8200 cal. BP event had an impact on the coastal settlement on the western side of the outer Oslofjord. No significant decline in the number of archaeological sites following the 8200 cal. BP event was identified and it was suggested that coastal Mesolithic hunter–gatherers were resilient to climate changes. In this article, this is investigated further by additional data from the inner part of the Oslofjord. A total of 138 shore bound sites (123 surveyed and 15 excavated/partly excavated sites) dated within the timespan 9000–7600 cal. BP are mapped in order to investigate temporal and spatial changes in the site pattern following the 8200 cal. BP event. The results provide a point of departure for discussing the resilience of the hunter–gatherers in the Oslofjord area.

The Oslofjord area, c. 9000–7600 cal. BP: Geographical setting and subsistence strategies

The Oslofjord is situated 58–59°N and lies in the northern part of the Skagerrak Strait that connects the Baltic Sea and North Sea areas. Skagerrak is among the most productive areas in the world, but has been detrimentally influenced by human activity in modern times (Danielssen et al., 1997; Gjøsæter, 1992).

The Skagerrak and the case study region have undergone several palaeooceanic changes during the Holocene. An oceanic circulation pattern in Skagerrak similar to the present was likely established between 8500 and 8000 cal. BP as a result of increased Atlantic inflow, the opening of the Danish Straits, Øresund and the English Channel, and finally, the isolation of the Dogger Bank (Erbs-Hansen et al., 2012; Gyllencreutz, 2005; Gyllencreutz et al., 2006). Few reconstructions on palaeoproductivity in the Skagerrak have been conducted. However, a recent article by Polovodova Asteman et al. (2017), covering the timespan from 4500 cal. BP and up until today, shows how productivity has varied through time and has been affected by climatic shifts. The primary production in the Skagerrak is influenced by several nutrient inputs, including the freshwater supply by the Baltic outflow and river runoff from the Swedish and Norwegian coast and the inflow of the surface water from the North Sea and Atlantic Ocean (Polovodova Asteman et al., 2017).

Between 9000–7800 cal. BP the sea level in the case study region was 55–70 metres above present sea level and the inner Oslofjord was characterised by narrow fjords and straits whereas the outer part formed an archipelago. The water mass exchange between the ocean and the fjord would have been greater than at present situation and the topography would generate strong tidal currents (Jaksland, 2001b). In this coastal landscape Stone Age sites are numerous, and they cluster around narrow straits, inlets, and long, crooked fjord arms (figure 1).

Our knowledge of the resource exploitation and seasonal movements of the costal hunter–gatherer in this area is still limited. Due to poor preservation of organic material it difficult to assess the resource spectrum of hunter–gatherers based on direct sources, and much of our evidence of subsistence economy is based on locational data of the sites. The proximity to prehistoric shorelines indicates the importance of marine resources and waterborne transportation. Despite the marine location of the sites, the available zooarchaeological remains are dominated by terrestrial species. The frequency of identified species, however, is likely heavily biased, as mammal bones are more resistant to taphonomic processes compared to small and fragile fish bones. Moreover, fish bones require special field– recovery techniques in order to be recorded, and thus fish bones are likely underrepresented in the archaeological record (Boethius & Ahlström, 2018). Zooarchaeological remains from well–preserved sites dated to the early Holocene located along the coast of southern Norway and western Sweden demonstrate the importance of fishing. Prestemoen 1 (c. 9700–9600 cal. BP) is the oldest known site in the Oslofjord area with preserved fish bones and these constitute c. 90 % of the faunal remains. Different cod species (*Gadus morhua, Pollachius pollachius, Pollachius virens, Merlangius merlangus, Molva molva*) are the most numerous (Mansrud & Persson, 2018; Persson, 2014b). Fish bones make up 73 % of the zooarchaeological remains at the younger site Skoklefald (c. 8000–7600 cal. BP), which is located in the inner Oslofjord. Herring (*Clupea harengus*) is the dominant species (75 %) followed by different cod species (Jaksland, 2001a, 2001b). Sites along the Swedish west coast display a similar pattern. At Dammen (c. 9000–8600 cal. BP), 93 % of the bones were fish, dominated by herring and different cod species (Schaller Åhrberg, 2007). Fishing appear to be an important subsistence strategy during all Mesolithic occupation phases at Huseby Klev, but especially during the two later occupation phases dated to 9600–8700 cal. BP and 8000–7700 cal. BP. Different cod species are the most common (Boethius, 2018a).

The importance of fishing among early Holocene hunter–gatherers in southern Scandinavia has recently been addressed by Boethius and Ahlström (2018). By combining previously published stable isotope data with new analyses of human and animal bone remains from southern Scandinavia, a

Bayesian mixing model was used to reveal that fish, both marine and freshwater species, played a more significant role than previously anticipated. They also argue that the dependency on fishing increase from the early to the latter part of early Holocene and that fishery becomes more specialised over time. Several sites, such as Dammen, suggest targeted fishery and the use of specialised technology. The occurrence of herring imply the use of seines (Schaller Åhrberg, 2007, pp. 50-52) and other species, such as ling and large cod, indicate deep-sea fishing with long line (Boethius, 2018a, pp. 112-113; Schaller Åhrberg, 2007, p. 51), but the evidence of offshore fishing during the Mesolithic is, however, debated (see Pickard & Bonsall, 2004).

Although, the importance of marine resources, and especially fish, has been highlighted, scholars usually characterise the subsistence strategy of the Mesolithic hunter–gatherers in the Oslofjord area as a broad spectrum economy (Glørstad, 2010, pp. 73-86; Mansrud, 2014, pp. 84-86). The zooarchaeological remains along with the seasonal and varied environment in which these sites are located can support the hypothesis that the Mesolithic groups were generalists as opposed to specialists. However, fishing can be regarded as a specialised subsistence strategy that involves complex and costly technologies and skills.

Within the framework of human behavioural ecology, fishing is considered a complex and costly subsistence strategy. Compared to terrestrial animals, fish are viewed as marginal resources because they provide a lower net energy return. In energy–based foraging models (optimal foraging theory etc.), hunter–gatherers are not expected to harvest low ranked items, unless post–encounter return rates of higher–ranked ones decreased (Bicho & Haws, 2008). In order to increase the return rates, technologies for mass–harvesting can be applied, such as fishing nets and weirs, but these technologies are costly and complex and require large investments of time when first constructed. Once constructed, they require regular maintenance until they wear out. Mass–harvesting of fish further implies technologies for processing and storage, such as drying, smoking, fermenting etc. (Kelly, 2013, pp. 127-128).

Several scholars have questioned the assumption that marine resources have played a marginal role in prehistoric hunter–gatherer societies and further argue that coastal hunter–gatherers have traditionally been viewed as exceptions in hunter–gatherer research. Further, the predictive models within the human behavioural ecological framework are based upon terrestrial, pedestrian hunter–gatherers, and these models may not be appropriate for hunter–gatherers living in coastal areas (Ames, 2002; Arnold et al., 2016; Bailey, 2004; Bailey & Milner, 2002; Bicho & Haws, 2008; Breivik et al., 2016). This discussion will not be further addressed here, but what is important to stress is that fishing, as a subsistence strategy can be considered complex and costly in terms of technology, knowledge, and time investment. In spite its cultural costs, this particular cultural adaptation appears to have been reproduced among the coastal hunter–gatherer in Scandinavia during the early Holocene. In addition, the archaeological evidence suggests it becomes more specialised over time. Prior to the 8200 cal. BP event, the Oslofjord was inhabited by specialised hunter–gatherers, and according to Marshall et al. (2010), this particular specialisation may have made them vulnerable for climate–induced changes in resources.

The 8200 cal. BP event and its impact on the Oslofjord area

The relatively low sampling resolution, chronological uncertainties, possible delays in ocean atmospheric coupling and inconsistent responses of different proxy records make the different climate records difficult to compare and the total impact of the 8200 cal. BP event difficult to address (Ojala et al., 2008; Randsalu-Wendrup et al., 2012; Rohling & Pälike, 2005; Snowball et al., 2010). In addition, the chronological precision of the archaeological frameworks is often poor which makes it difficult to compare the two data sets. This problem has recently been addressed by Griffiths and Robinson (2018) who argue that in order to understand human responses to the 8200 cal. BP event, studies should encompass sites within a broad time envelope and high resolution palaeoclimatic records.

Inferred Holocene temperature reconstructions from Lake Trehörningen on the Swedish western coast and Lake Flarken in central Sweden show a temperature drop corresponding to the 8200 cal. BP event (Antonsson & Seppä, 2007; Seppä et al., 2005). At Lake Flarken the inferred temperature drop is c. 1–1.5°C (Seppä et al., 2005, p. 294). This drop reflects colder and shorter growing seasons, and the pollen records further demonstrate changes in forest vegetation in the course of the 8200 cal. BP event. At Lake Flarken there is a decline in the frost-sensitive *Corylus* and also *Ulmus* and *Alnus* (Seppä et al., 2005, p. 290). The same pattern is detected in the high resolution pollen core from Lake Skogstjern, on the western side of the Oslofjord (Wieckowska-Lüth et al., 2017). Between 8270–8110 cal. BP there is a decline in *Corylus* as well as other deciduous trees such as *Ulmus, Quercus, Fraxinus* and *Tilia*. At the same time, the low temperature adapted *Pinus*, *Betula* and *Juniperus* increase (Wieckowska-Lüth et al., 2017, p. 9).

Hammarlund et al. (2005, p. 477) point out that the pattern of inferred changes in moisture conditions in association with the cold event is more complex than temperature reconstructions. Magny et al. (2003) have suggested that areas north of 50°N experienced drier conditions during the 8200 cal. BP event, and several records from southern Norway and western Sweden do indicate that winter precipitation decreased during the event compared to earlier and later periods (Dahl & Nesje, 1994, 1996; Hammarlund et al., 2005; Nesje & Dahl, 1991; Paus, 2010; Paus & Haugland, 2017; Seppä et al., 2005).

The temperature drop around 8200 cal. BP is evident also in marine proxy records and there is a decrease in the palaeosalinity estimates in Skagerrak (Erbs-Hansen et al., 2012; Erbs-Hansen et al., 2011; Risebrobakken et al., 2003). How these environmental changes affected the marine primary productivity is still not clear. Krossa et al. (2017) argue that a reduction in ocean temperatures caused by an increase in outflow of cold Baltic Sea between 6300 and 5400 cal. BP did have a negative impact on the natural ecosystems, particularly the marine realm. Polovodova Asteman et al. (2017), on the other hand, argue that a climatic cooling could in fact improve the marine primary productivity. Recalling that the marine productivity in the Skagerrak is influenced by several nutrient inputs, such as the Baltic outflow and river runoff from the Swedish and Norwegian coast and the inflow of the surface water from the North Sea and Atlantic Ocean (Polovodova Asteman et al., 2017), the documented decrease in salinity may suggest that the Atlantic inflow is weakened or less saline as a result of the freshwater pulse. Further, the reduction in winter precipitation following the cooling event indicates a decreased river runoff and spring flooding. Thus, the reduction in salinity and a reduced winter precipitation may have had a negative effect on primary productivity in Skagerrak, which may have affected the hunter–gatherers who were heavily dependent on marine resources.

Temporal and spatial distribution of shoreline–dated sites

Shoreline dating: strengths and limitations

Recently, Breivik et al. (2018) and Solheim and Persson (2018) have demonstrated how the temporal distribution of shoreline–dated sites can be used as a population proxy. As the radiocarbon data set from the case study area within the timespan covered here is too small (n=14, see table 1) for conducting summed radiocarbon date frequency distributions, site count of shoreline–dated sites is a more appropriate method for investigating short–lived population fluctuations. Since the introduction of pollen analysis and radiocarbon dating, shoreline displacement curves have been created independently of archaeological data (Persson, 2014a, p. 78). As shown below, there is only a small risk of circular reasoning as the extensive data shows coherent patterns that support the validity of shoreline dating as a method.

The glacio–isostatic rebound in the Oslofjord provides us with a unique chronological sequence of shore bound Stone Age sites. As the land rose, shorelines changed, and shore bound sites lost their coastal location and were abandoned. Thus, based on the premise of a shore bound location, by comparing a site’s position above sea level with a local shore displacement curve we can obtain relative dates of shore bound Stone Age sites. This assumption has been corroborated by extensive archaeological fieldwork and studies combining radiocarbon dates and typological and technological traits of archaeological material from shore bound sites, and local shore displacement curves (Breivik et al., 2018; Glørstad, 2004, pp. 78-80; Solheim, 2013, pp. 255-258; Solheim & Persson, 2018). Further, the marked relief contributes to create a consistent pattern for the shoreline dating of sites in this region. Sites are often located on small terraces in steep terrain which were best accessible when the shoreline was near, and these locations limits long–term occupation or repeated occupation over long time spans (Jaksland, 2014, pp. 37-38). Obviously, there are sites that stretch over large areas and height levels that may have been used over many occasions over a long time span. The radiocarbon record also demonstrates that sites have several occupation phases (table 1). Further, there are of course sites that were not shore bound and demonstrate that activities were carried out in the surrounding hinterland and not at the shore. These sites are, however, not abundant (Solheim & Persson, 2018, p. 336).

The shoreline displacement in the Oslofjord region varies through time and from area to area. During the first part of the Holocene the land rise was initially rapid, then gradually slowing down. The land uplift was stronger in the inner and northern part of the fjord than in the outer, southern part, but the difference was most prominent in the beginning of early Holocene (Sørensen, 1979; Sørensen, Henningsmoen, et al., 2014). The direction and gradient of the shoreline displacement have implications for the dating of the sites. Places with the same land upheaval can be connected by isobases and these are perpendicular to the direction of the land uplift (Påsse, 2003, p. 48). Sites situated along the same isobase can be dated by the same shore displacement curve. Compared to the western side of the fjord, the marine regression in the inner Oslofjord was constant throughout the early and mid-Holocene (Sørensen, 1979; Sørensen, Henningsmoen, et al., 2014; Sørensen, Høeg, et al., 2014) and the relative dating of shore bound sites can therefore be made with greater precision. That being said, shoreline dating is a relative dating method that allows us to work at the century scale at best.

Gathering the data

A total of 138 sites are included in the analysis, and 15 of these are excavated or partly excavated (see table 1) and the remaining 123 are surveyed sites. Information on surveyed sites was gathered from the Directorate for Cultural Heritage’s online database Askeladden (Askeladden, 2017). Sites were primarily mapped to gain spatial information (metres above sea level, location on a micro and macro scale), thus sites with uncertain spatial reference, typically sites surveyed a long time ago, sites stretching over large areas and height levels, and sites defined by the occurrence of stray finds, were excluded from the analysis. As the analysis is based on data generated by development–led archaeological excavations and surveys, there is a risk that some height levels are over– or underrepresented. However, the case study area has been thoroughly surveyed in response to infrastructure projects, and these surveys cover most of the heights included in this analysis.

Tore Påsse’s (2003) shore displacement curve for Lake Vaglarna in Bohuslän, Sweden, was used to shoreline date the sites. Although, Lake Vaglarna is located up to 70 kilometres south of the sites in this study (figure 2), Påsse’s curve is built on an empirical model (Påsse, 2001) that allows the curve to be transformed and moved which makes it convenient for this particular study. Corrections were made according to the distance between the sites and the reference isobase line for Lake Vaglarna.

According to Påsse (2003, p. 48), the isobases are oriented N 30°O (see figure 2). Thus, it is possible to transform and apply the curve for Lake Vaglarna to places further north along the Oslofjord and provide tentative curves for the entire area. In order to test the reliability of the new curves, the two radiocarbon dates from Sørensen's 'Ski curve' (1979) dating the transition levels between marine and lacustrine sediments (isolation basins) were compared to the new curves and they correspond well. Further, the radiocarbon dates from the excavated sites were also used to test the reliability of the curves, and as can be seen from figure 3 they correspond quite well to the adjusted curves. In this fashion, sites were given a shoreline date based on their height above sea level and spatial coordinates in relation to the new curves. To determine the shoreline date of a site, the contemporary shoreline was set to 2 meter below the lowest height of the site area.

To avoid claiming a false level of precision the sites were distributed into 200-year time slices. Griffiths and Robinson (2018) have recently argued that a 200–year precision is too coarse to identify human responses to short–lived climatic changes at the level of individual sites as it is "significantly beyond the duration of individuals' lives and generations". This is of course true, and the resolution provided by the method applied here might not be sufficient to discover human responses to climate change at individual site levels, but rather allows us to detect trends in the coastal site pattern within a broad time envelope. Yet, even if the 8200 cal. BP event is portrayed as a short-term climate change, it is perhaps best described as a long-term change on a human scale.

What do the sites represent?

The sites in the analysis clearly represent different activities, meanings, and temporalities. Some sites may be the lithic traces of a single episode while others may be the result of many, different activities conducted by different people over several occasions within the same week, season, year, decade, or perhaps even centuries. The majority of sites in the analysis are surveyed sites, and we have partly limited knowledge of the representativeness and character of these sites, in terms of size, features, the amount of lithic waste, and the composition of lithic remains. As can be seen from table 1, the excavated sites vary in size, location, duration of occupation, features, the number, and character of the lithic remains, and zooarchaeological remains, and thus reflect a complex site and mobility pattern during the period covered here. However, the character of the sites will not be further addressed here, as the purpose of the analysis is use shoreline–dated sites as a proxy for human activity through time.

Results and discussion

Temporal and spatial changes in the site pattern, c. 9000–7600 cal. BP

By dividing the sites into 200 yearlong time slices it is possible to obtain a general impression of the site pattern from 9000–7600 cal. BP. As can be seen from figure 4, there is an increase in the number of sites from 9000 cal. BP towards c. 8500 cal. BP. From c. 8500 cal. BP the number of sites appears to stabilise and slowly decrease towards 8000 cal. BP. From c. 8000 cal. BP there is a marked increase in the site frequency followed by a decrease after 7800 cal. BP (figure 4).

According to Binford (2001, p. 444) changes in subsistence will produce dramatically different settlement patterns. This is clearly not the case here, as the spatial distribution of sites indicates no substantial changes in site location between 9000–7600 cal. BP. Sites show a preference for the mainland (81 %) rather than islands (17%) throughout the entire period (figure 5). Further, sites are preferably located in the sheltered, inner part of the fjord. The only noticeable change concerns the site location on a micro level, especially sites' proximity to narrow straits (figure 6). Between 9000 to 8200 cal. BP, one fifth (18–23%) of all sites are located by narrow straits compared to nearly half of all sites (41–52 %) within the timespan 8200–7600 cal. BP.

The temporal distribution of shoreline–dated sites from the inner Oslofjord shows fluctuations in the frequency of sites during the timespan 9000–7600 cal. BP. As earlier mentioned, the chronological uncertainties with timing the 8200 cal. BP event and the relatively coarse resolution of the archaeological record make it difficult to compare these two data sets. A recent study by Kelly et al. (2013) complicates the matter even further. Their study suggests up to 300 year lags in human responses to Holocene climate change events caused by either that the population or the ecological carrying capacity responds slowly to changes in climate. Thus, it is likely that the slight decrease in the frequency of shoreline–dated sites beginning around 8500 cal. BP cannot be attributed to the 8200 cal. BP event. However, the increase in number of sites from c. 8000 cal. BP can perhaps be caused by a delayed human response to the 8200 cal. BP event indicating increased activity in the coastal area following the climate change.

Resilient or plain luck?

Although being characterised as potentially vulnerable for climate–induced changes in resources, the results provided by the spatial and temporal distribution of shore bound sites suggest that the hunter–gatherers in the Oslofjord region were not affected by the climatic cooling 8200 years ago. The results are further supported by zooarchaeological material from sites such as Skoklefald and Huseby Klev, which demonstrates that the specialised subsistence strategy of the hunter–gatherers in the Oslofjord area persisted after the cooling period. The fact that the knowledge, technology, and skills associated with this particular subsistence strategy were reproduced and transmitted to future generations, implies that the dependency on marine resources, and fishing in particular, was a successful adaptation and that the hunter gatherer population were resilient to the environmental changes that were brought upon by the 8200 cal. BP event. Moreover, the increase in frequency of shore bound sites from c. 8000 cal. BP indicates an even larger dependency on marine resources after the climatic cooling. Further, the percentage of shore bound sites situated near straits increases during the latter part of the period covered by this study. Straits are associated with strong tidal currents with rich and predictable marine resources. Along the Norwegian coast, especially along the western coast, an abundance of Stone Age sites are found in connection to these straits, signifying the importance of marine resources, especially fish (Bakka, 1993; Bergsvik, 2001). Thus, there appears to be an increasing preference for this particular location from 8200 cal. BP and onwards and may support the earlier mentioned assumption that fishing becomes gradually more important and specialised in the latter part of early Holocene.

But, how was the adaptation successful and what made the hunter–gatherers resilient in spite of being characterised as potentially vulnerable? Clearly, its success can of course result from the fact that the ecological niche of the hunter–gatherers was not negatively affected by the environmental changes. Nevertheless, part of the success of the hunter–gatherers can perhaps also be linked to different strategies for coping with changes and variability in resources.

Although, fishing may be considered a costly, technology-dependent and specialised subsistence strategy, there is a difference between groups who target a particular type of fish and those who target a range of different species using different techniques – the latter group being less vulnerable for climate–induced changes in resources (Marshall et al., 2010, p. 11). The zooarchaeological material indicates that the hunter–gatherers in the Oslofjord area practised different types of fishing techniques and targeted different types of fish species – likely due to seasonal variations in resources. Unfortunately, the available zooarchaeological material from the case study region is too fragmented and limited to reveal potential short-term adjustments in their behavioural strategies, such as intensification or diversification of marine resources, during the climatic cooling. Another risk–reducing strategy is food storage. Food caching is an important strategy to store food for future use, and ethnographic data shows that this is particularly common among hunter-gather groups living in cold environments with resource variability (Kelly, 2013, p. 103), such as the case study region. Apart from a possible fermentation pit from the site Sunnansund in southern Sweden, there is little direct evidence of food storage in Scandinavia during the early Holocene. The assumption that the hunter–gatherers stored food is largely based on indirect evidence, such as traps and weirs as well as the zooarchaeological material (Boethius, 2018b, pp. 327-328). Mobility is another important strategy for dealing with resource variability, and hunter–gatherers can adjust their mobility if the environmental conditions change (Halstead & O'Shea, 1989; Kelly, 2013, ch. 4).

The results of the present analysis demonstrate that the specialised subsistence strategy of the coastal hunter–gatherers in the case study region was successful and persisted over time. The results do, however, raise several issues that need to be explored further, initially by additional palaeoenvironmental reconstructions of past climate changes' effect on different ecosystems, and by more detailed studies of the lithic material from the prehistoric sites. The scale of the present analysis provides a certain pattern that may have several explanations and additional investigations into the character of the sites are therefore needed. For example, why did the site frequency between 8500–8000 cal. BP stabilise and then slightly decrease? Is it linked to changes in the mobility pattern where the hunter–gatherers decrease their mobility and occupy fewer sites? Likewise, is the marked increase in sites after c. 8000 cal. BP a result of an increased mobility or an actual population growth? If the latter is the case, can the growth be attributed to an actual growth in the coastal population due to more favourable conditions or movement of groups from areas where the environmental impact of the climatic cooling was more severe? More detailed studies of the character of the sites will hopefully provide us with more insight into what made the specialised hunter–gatherers resilient to climate change.

Conclusion

Initially, it was suggested that these hunter–gatherers in the Oslofjord in southeast Norway area had a specialised subsistence strategy and potentially vulnerable for climate changes. Yet, the results from the present study suggest that the coastal hunter–gatherers in the Oslofjord area were not affected by the environmental changes following the 8200 cal. BP event. The results may further indicate an even larger dependency on marine resources. However, the results from this study need further and more detailed investigations in order to explore the resilience of the hunter–gatherers. Also, palaeoenvironmental reconstructions of past climate changes' effect on different ecosystems are crucial for further studies.

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Figures

Table 9.1: Key information of the 15 excavated sites in this study. * First presented in this publication.

Figure 9.2. The distance from the reference isobase line (0) and the study area varied between 30 to 70 km. The isobases are positioned N 30 °O. Illustration: P. Persson, Museum of Cultural History, University of Oslo.

Figure 9.3. Figure showing the correlation between the shoreline dates and the radiocarbon dates from the study area. Radiocarbon dates are listed in Table 9.1. Illustration: P. Persson, Museum of Cultural History, University of Oslo.

Figure 9.4. The graph shows the temporal distribution of shoreline dates from 9000–7600 cal BP.

Figure 9.5. The location of the sites at a macro level.

Figure 9.6. The location of the sites at a micro level.

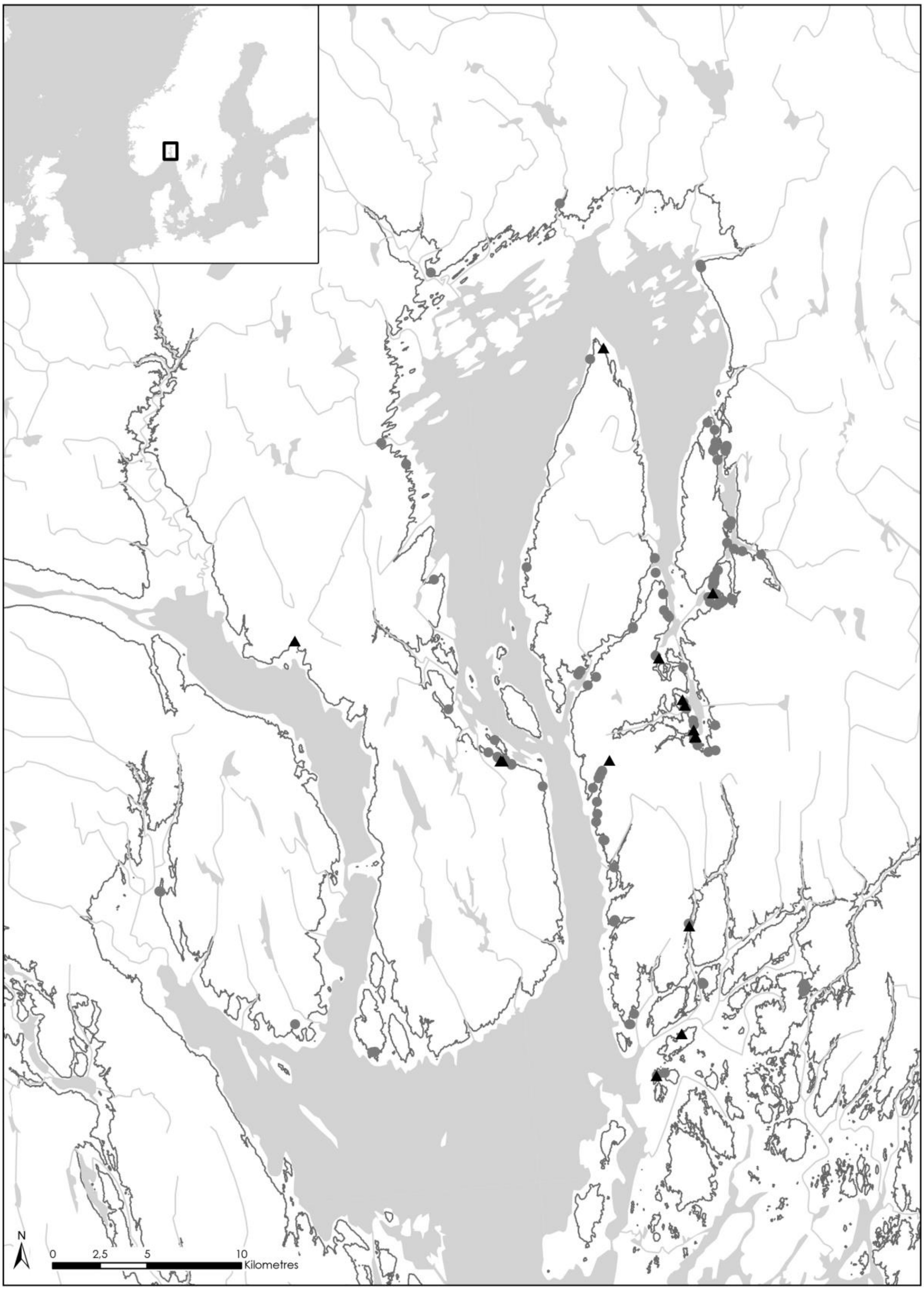

Figure 9.1. The Oslofjord area. The black line marks the shoreline at 60 m above present sea level. The 123 surveyed sites in the study are marked with orange dots and the 15 excavated sites are marked with black triangles. Illustration: G. Fossum and J. Håland.

Sites	**Masl**	**Number of finds**	**Excavation method**	**Excavated area (m^2)**	**Features**	**Fauna (number of fragments and species)**	**Shoreline date (cal. BP)**	**Date (BP)**	**Lab number**	**Sample**	**Reference**
Trolldalen	74-75	1448	¼ m^2 units, 10 cm spits, sieving	55	1 hearth, 1 layer	N/A	9200-8900	7977±44 7876±53	Ua-49212 Ua-49212	Betula Corylus (nutshell)	Solberg (2014)
Kongsdelene 61	70	1020	¼ m^2 units, 10 cm spits, sieving	40	N/A	N/A	8800-8700	N/A	N/A	N/A	Ballin (1998)
Bleivik Nordre	64	2181	¼ m^2 units, 10 cm spits, sieving	27	1 hearth/ cooking pit	N/A	8400-8300	N/A	N/A	N/A	Åstveit (2008)
Kongsdelene R71/72	67	3117	¼ m^2 units, 10 cm spits, sieving	53	N/A	N/A	8500-8400	N/A	N/A	N/A	Ballin (1998)
Trosterud 1	69-70	5380	¼ m^2 units, 10 cm spits, sieving	141	3 hearths	N/A	8600-8400	7745±75 7435±75	TUa-1549 TUa-1548	Betula/Corylus/Salix Betula/Corylus/Salix	Berg (1997)
Rød Nedre 72	63	1593	¼ m^2 units, 5 cm spits, sieving	48	N/A	N/A	8200-8100	N/A	N/A	N/A	Berg (1995)
Kongsdelene R62	64	11107	¼ m^2 units, 10 cm spits, sieving	63	N/A	N/A	8300-8100	N/A	N/A	N/A	Ballin (1998)
Kvestad lok. 3	66-67	8782	¼ m^2 units, 10 cm spits, sieving	117	N/A	65 (mammalia indet.)	8400-8200	7435±70 7040±45 *	TUa-1547 LuS-13500	Corylus (nutshell) Calcined bone (mammalia indet.)	Berg (1997)
Hyggen vest 2	65-70	8	Mechanical removal of topsoil	c. 2500	2 cooking pits, 1 pit	N/A	8600-8200	7540±45 7670±45 7825±50	TUa-5896 TUa-5897 TUa-5900	Betula Betula/Pinus Betula/Pinus	Kjos (2006)
Bråtan 4	65	772	¼ m^2 units, 10/5 cm spits, sieving	65	N/A	N/A	8200-8100	N/A	N/A	N/A	Ballin (1998)
Horgen 4	59-61	357	¼ m^2 units, 10 cm spits, sieving	29	N/A	N/A	7800-7600	N/A	N/A	N/A	Berg (1997)
Kvestad lok. 2	60-61	1112	¼ m^2 units, 10 cm spits,	70	N/A	3 (mammalia indet.)	7900-7700	7055±45 *	LuS-13499	Calcined bone (mammalia indet.)	Berg (1997)

			sieving								
Skoklefald	62	257	1 m units, 5-10 cm spits, sieving	8	1 hearth, layer	473 (clupea harengus, gadus morhua, ostrea edulis + +)	7800-7600	7050±110 7090±80 6860±70 6820±80	T-15058 TUa-2894 TUa-2895 TUa-3094	Pinus Salix caprea/ Salix/ Populus Corylus (nutshell) Corylus (nutshell)	Jaksland (2001)
Nøstvet	56-60	5882	1 m units, 10 cm spits, sieving	60	N/A	48 (mammalia, aves, pisces)	8200-6800	6565±45	TUa-4602	Calcined bone (mammalia indet.)	Jaksland (2005)
Knapstad R113	56	2937	¼ m^2 units, 5 cm spits, sieving	60	N/A	N/A	8700-8600	N/A	N/A	N/A	Berg (1995)

Table 9.1: Key information of the 15 excavated sites in this study. * First presented in this publication.

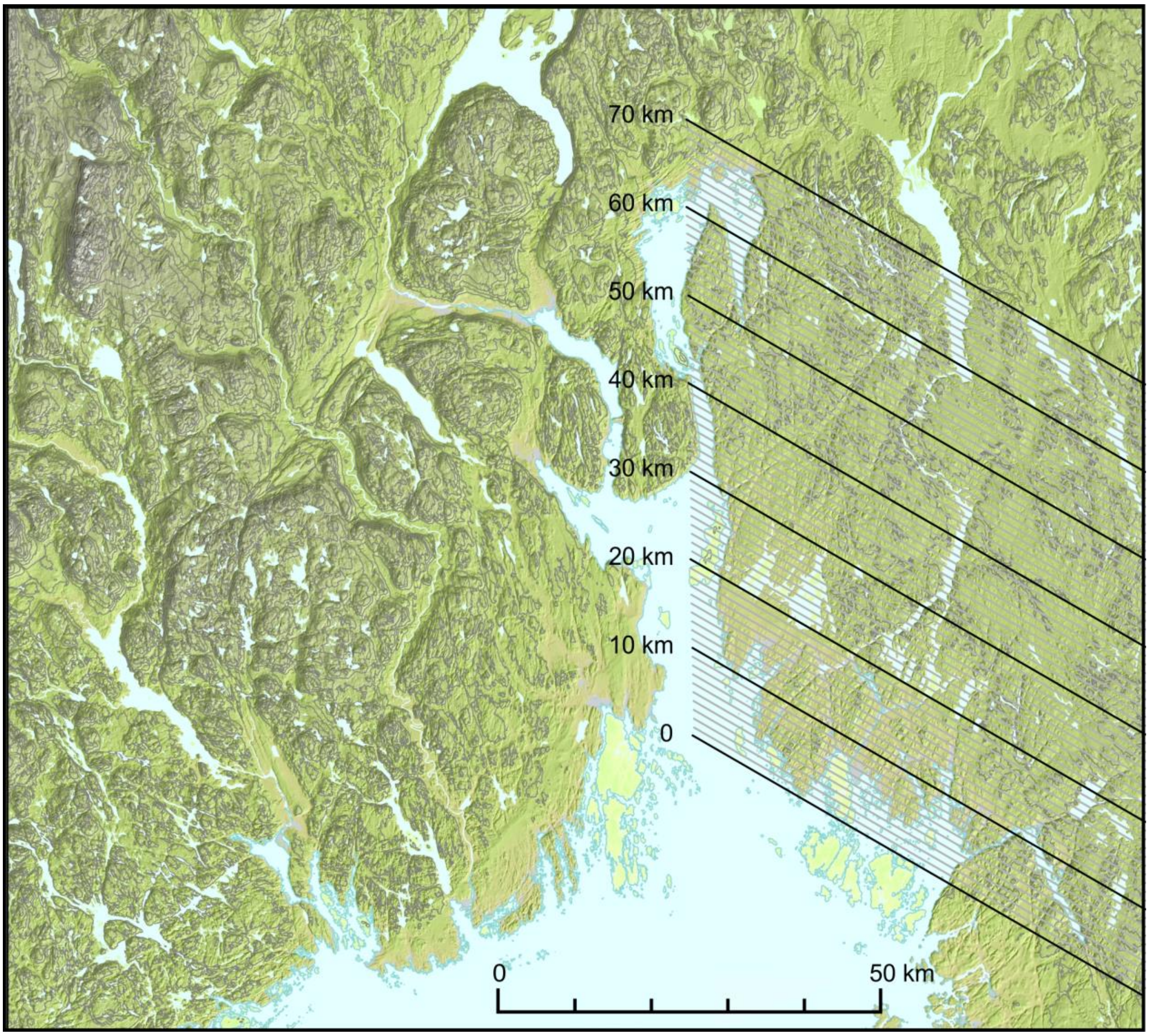

Figure 9.2. The distance from the reference isobase line (0) and the study area varied between 30 to 70 km. The isobases are positioned N 30 °O. Illustration: P. Persson, Museum of Cultural History, University of Oslo.

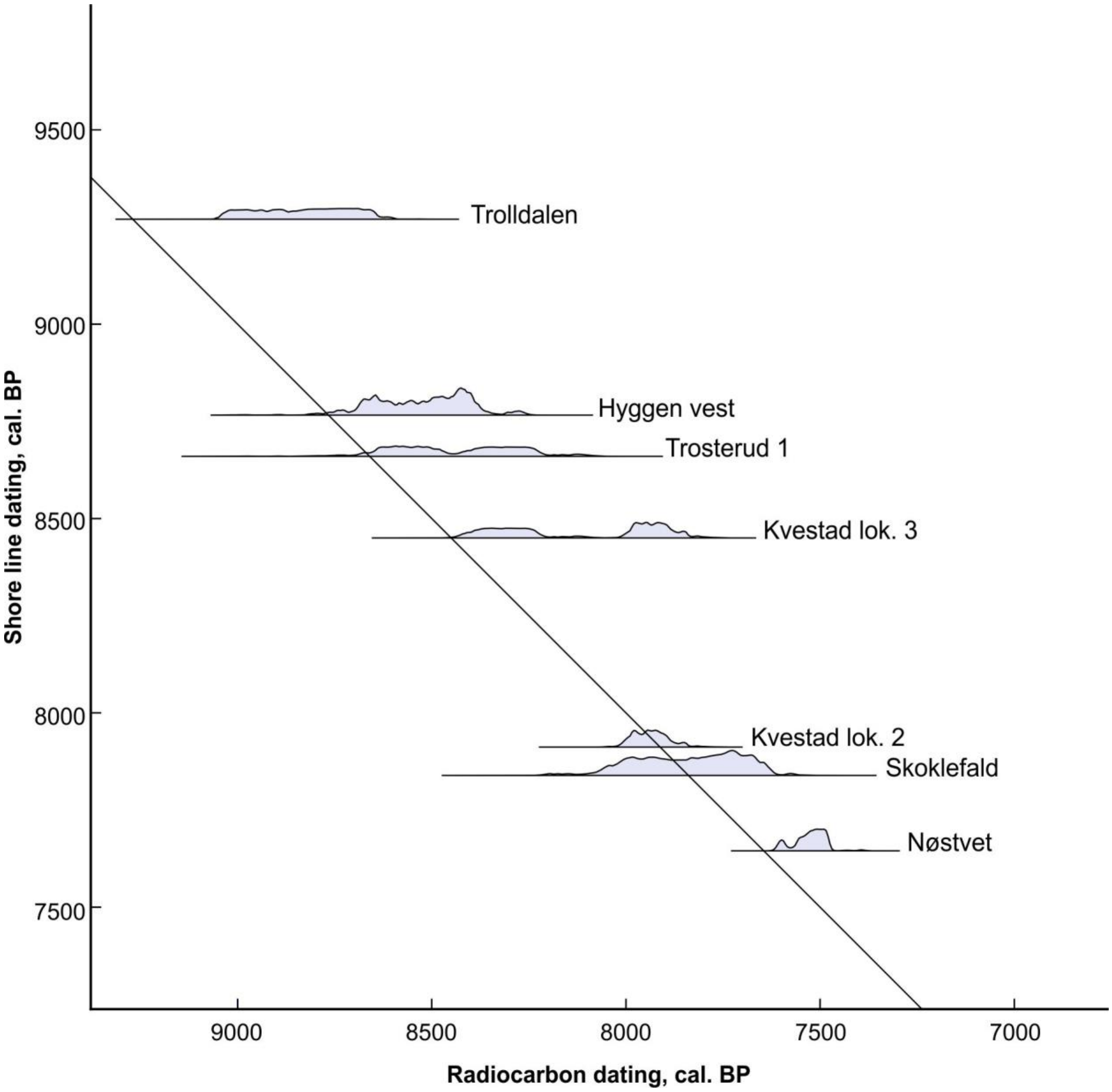

Figure 9.3. Figure showing the correlation between the shoreline dates and the radiocarbon dates from the study area. Radiocarbon dates are listed in Table 9.1. Illustration: P. Persson, Museum of Cultural History, University of Oslo.

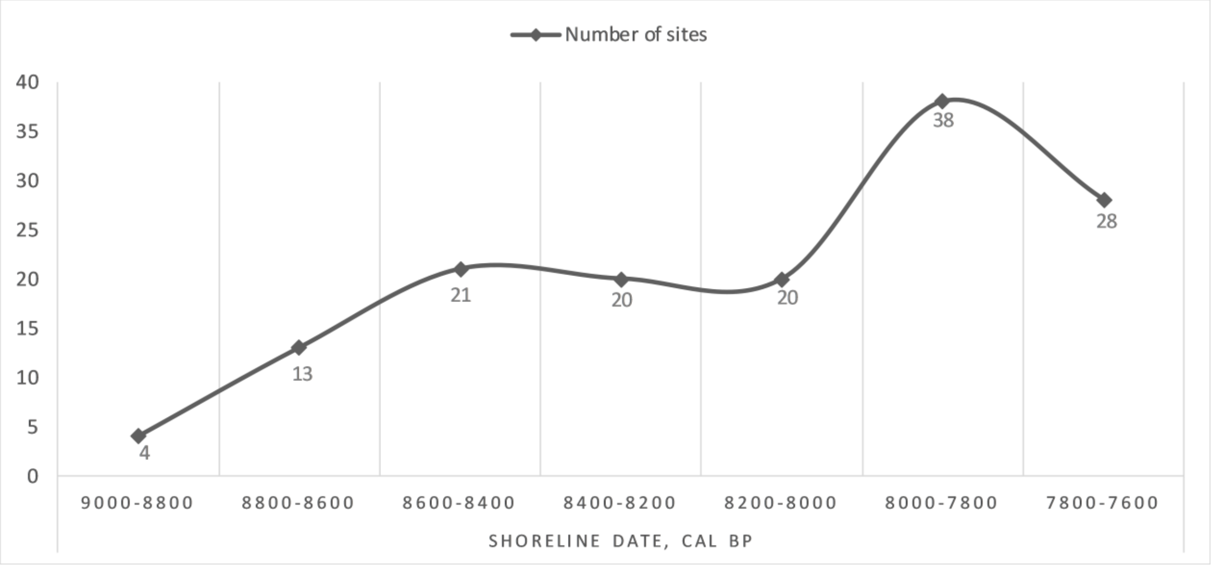

Figure 9.4. The graph shows the temporal distribution of shoreline dates from 9000–7600 cal BP.

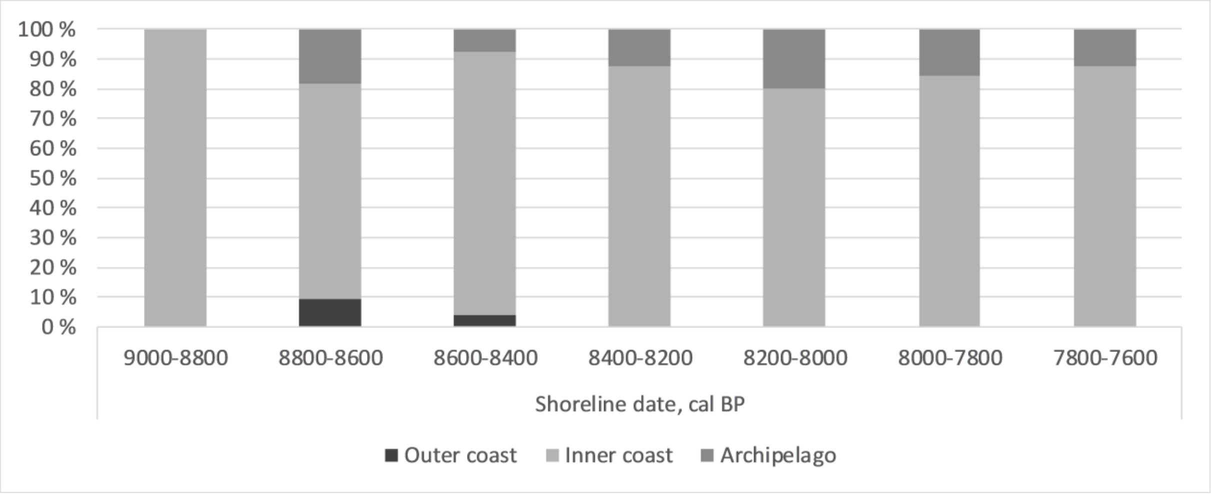

Figure 9.5. The location of the sites at a macro level.

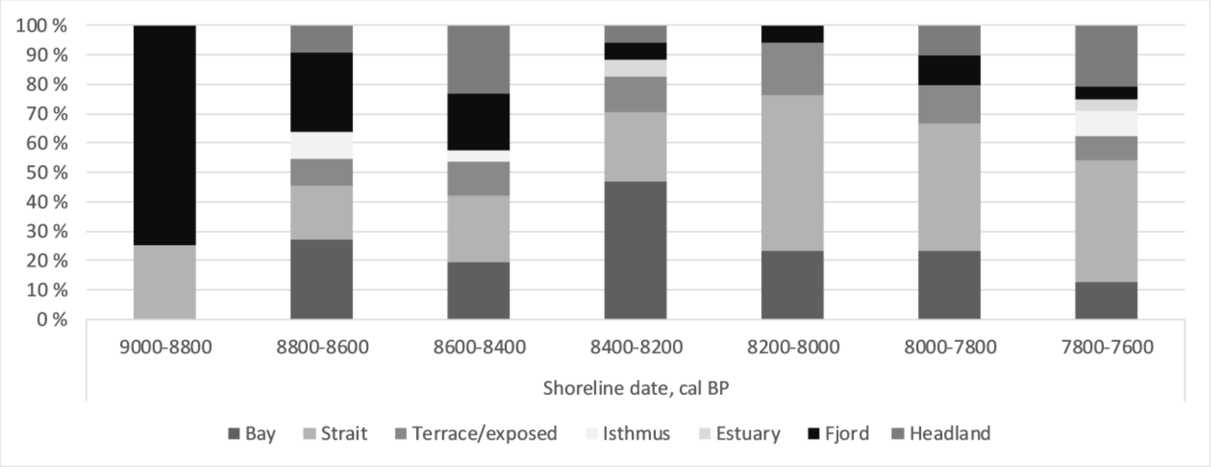

Figure 9.6. The location of the sites at a micro level.

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