

# **The success and failure of resilience in the European Mesolithic**

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## **Introduction**

Resilience theory is situated at the interface of society and the environment (Adger 2000). It offers one way to explore the effects of environmental change on human communities, or indeed other forms of social, economic or political change such as those experienced by many communities today through processes of globalization. Its extension to the archaeological record offers a framework within which to investigate human responses to changing circumstances in the past. As has often been noted, archaeology—and prehistoric archaeology in particular—offers a long-term perspective that is lacking in other human-centered disciplines (Bailey 1983). What this means in the context of resilience theory is that we can see the long-term outcomes of the choices made by individuals and communities, including unintended consequences (Redman 2005). This is not to say that the application to the archaeological record is straightforward. Key issues are what we mean by ‘resilience’ in an archaeological context (part of a wider debate concerning the utility of the concept in the social sciences – Olsson et al. 2015) and how its investigation can be operationalized. In this paper, resilience among the fisher-hunter-gatherers of Mesolithic Europe is explored through stable carbon and nitrogen isotope analysis of human remains, and the insights that they provide concerning rapid changes in foodways. Foodways, in turn, are seen as intimately linked with sociocultural identity—a core aspect of resilience in human communities (Cumming et al. 2005; Cumming and Collier 2005)—and so provide a means of applying the concept that permits an assessment of the success and failure of resilience under different circumstances and challenges. The focus is on two periods: the 8.2kya cal BP climatic event, and the transition to farming that marks the end of the Mesolithic (11,500 to 8800/6000 cal BP).

## **Resilience to what?**

We do we mean by resilience, and at what levels does it operate? While the term itself has a much older currency in both the natural and social sciences (Rival 2009), ‘resilience theory’

as currently understood has its genesis in a seminal paper by C.S. Holling, which outlined a new approach to ecological systems in which multiple stable states were possible, as a challenge to the then-prevailing model of ideal static 'climax' states towards which systems strived (Holling 1973). Resilience refers to the amount of disturbance an ecosystem can withstand before shifting to a new stable state, a process termed transformation (Holling 1973; 1987; Gunderson 2000). Adapting the term from its use in ecology, Adger (2000: 361) defines social resilience as 'the ability of communities to withstand external shocks to their social infrastructure' (that internally-generated stressors are not a central feature of the theory as usually presented could be seen as problematic, though a consideration of the issue is beyond the scope of this paper). Social and ecological resilience are explicitly and inextricably, though not unproblematically, linked in the notion of a socioecological system (SES) (Adger 2000; Carpenter et al. 2001; Cumming et al. 2005; Gallopín 2006; Redman 2005; Widlok et al. 2012), providing a framework within which to consider the kinds, levels and frequencies of stresses to which individuals and communities might be expected to respond. If the ecosystem is resilient, then human communities are more likely to be buffered against external stressors. Ecosystem resilience may be exceeded when major social changes are implicated, whether generated internally or externally (e.g., through significant population immigration), leading to a change in the system state followed by a new adaptive cycle. While there are parallels in the use of the concept of resilience in the ecological and social sciences literature, the relationship is by no means a straightforward one (cf. Cote and Nightingale 2012; Davidson 2010; Olsson et al. 2015), a point to which we return later in the paper.

For the purposes of this paper it is useful to make a broad distinction between the aquatic (mainly marine, but including certain productive inland waterways) and inland habitats exploited by hunter-gatherers. In the absence of modern damming, pollution and overfishing, many marine ecosystems can be said to be extremely resilient compared to their terrestrial counterparts (Costanza et al. 1995; Mann 1982). The extent to which this translates directly into the resilience of human communities depends in part on the technology being employed. A complicating factor is that access to the best marine resources can be highly spatially (and temporally) heterogeneous, leading to a greater degree of sedentism, which in turn creates a greater investment in specialised capture technology (e.g., boats, large nets, stationary fishing facilities, etc.), and an even greater

reliance on the sea for subsistence, i.e., a positive feedback loop (Yesner 1987). Combined with the generally relatively high population densities seen in productive coastal zones, this can lead to greater vulnerability to perturbations either affecting marine resources directly, or the ability of people to access them. An example of this situation is considered below.

Minor environmental shifts are unlikely to result in game-changing challenges to the SES, though of course this depends on the resilience of the system in question. Changing weather patterns and ocean currents can impact on the abundance of various marine species, but people can usually adjust their fishing and harvesting strategies to target other species without affecting the overall system to the degree that requires its major re-organization. A more serious event such as a tsunami might deplete resources for a substantial period (e.g., by covering shellfish beds with sand), which could result in populations temporarily relocating, and/or calling upon support networks in adjacent inland territories that would be less affected. Such relatively short-term events would not generally be discernable archaeologically, and again would probably not lead to a loss of resilience and hence a transformation of the system (buffered by individual and social memory, with an ecological analogue in terms of deeply rooted plants, seed banks, repopulation from neighbouring regions, etc.). A potential exception to this is the final catastrophic flooding of Doggerland (Weninger et al. 2008).

Terrestrial environments can be more vulnerable. Optimal foraging theory predicts that game will be preferentially targeted according to criteria of body size and encounter rate, the latter a function of density. Thus, aurochs (*Bos primigenius*) and moose (*Alces alces*), being the largest terrestrial herbivores across northern Eurasia, should be pursued whenever encountered by hunters. But because large terrestrial mammals are K-selected, they are more vulnerable to over-exploitation (MacArthur and Wilson 1967). Indeed, it is likely that it was human hunting pressure combined with habitat loss as a result of isostatic sea-level rise that led to the local extinction of aurochs (*Bos primigenius*) on the large Danish island of Zealand by the Late Mesolithic (Aaris-Sørensen 1999). The much smaller roe deer, by contrast, should only be pursued when the encounter rates for larger game fall below a certain threshold (or in situations in which returning to a camp with any game is preferable to returning empty-handed) (Mithen 1990). While they may encourage different

hunting practices, and the social formations underlying these, a shift from large to medium-size terrestrial mammals would probably not bring about a change in the SES, though this is a matter that would benefit from further research.

Importantly, the simple persistence of a population need not imply resilience as defined here (cf. Cumming et al. 2005 – see below), since it may have undergone a significant ‘step change’ or transformation to a new adaptive strategy, and hence have a different set of relationships with the ‘natural’ and ‘social’ environment (accepting that the distinction can be seen as largely artificial). Conversely, and perhaps counter-intuitively, the abandonment of a region also need not imply a lack of resilience, since mobility may be a highly successful strategy, particularly for those hunter-gatherers at low population densities and with minimal investment in fixed facilities (Testart 1982). There is a crucial distinction—especially for those involved—between local extinction and group migration. Population migration or displacement is ambiguous in terms of resilience. It could refer to the failure of the socioeconomic/sociocultural system to adapt to changing conditions, or, considered at another spatial scale, it could be seen as an integral part of those adaptations, and hence a prime example of resilience. The deciding factor is whether or not the community is reconstructed elsewhere in a form that, while not necessarily unmodified, is still recognizable in terms of its fundamental institutions and practices (Adger 2000: 348). Unfortunately, these distinctions may not be detectable in the prehistoric archaeological record. The appropriate spatiotemporal scale of the units of analysis is another problematic area (Cumming and Collier 2005).

Resilience is a function of cycles operating at different scales. At one end of the scale it can be seen as simply referring to the ability of an individual organism to survive adverse environmental and/or social conditions (e.g., psychological resilience; Maclean et al. 2017). While archaeology does deal with individuals—by definition when considering human skeletal data—here we are more concerned with the survival of sociocultural systems, or of particular institutions within those systems (even though of course this ultimately comes down to the behavior of individuals – nested scales of analysis being a feature of panarchy theory, which draws heavily on notions of resilience at different levels of complex systems; Allen et al. 2014). A relevant example in the present context would be the persistence of a strong sharing ethic, often taken to be a defining social institution in ‘simple’ hunter-

gatherers or 'foragers' (Bird-David 1990; Cashdan 1980; Peterson 1993; Woodburn 1998). Sharing for these groups forms part of what can be termed 'livelihood strategies' (Lancelotti et al. 2016), involving day-to-day subsistence and other economic activities. 'Subsistence' itself is perhaps too restricted a term here, given the complex and multi-faceted elements of technology, social organization, resource acquisition, preparation and consumption that constitute foodways in a wider sense (Schulting 2008). These in turn can be argued to form a large part of identity at various levels from the individual to the community and society. Thus, at the scale of analysis of particular interest here, resilience refers to the persistence of a recognizable cultural identity (Adger 2000; Cumming et al. 2005; Forbes et al. 2009), in which foodways, especially for small-scale societies, can be argued to be an integral component (Fernández-Armesto 2002; Schulting 2008; Twiss 2007).

### **Operationalizing resilience in the prehistoric archaeological record**

Applying resilience theory in any empirical study, let alone in the prehistoric archaeological record, is not straightforward (Carpenter et al. 2001; 2005; Cumming et al. 2005; Cumming and Collier 2005). Following on from the above discussion, social resilience is defined here as a society's ability to maintain a recognizable core of identity in the face of environmental and/or social perturbations. In its focus on identity, this approach departs from the usual definition of resilience in ecology (Cumming et al. 2005:976; cf. Cumming and Collier 2005). Identity is maintained through repositories of knowledge held by individuals in the form of personal memory, stories, myths, etc., operating over increasing timescales, but with concomitant loss of specificity. Proficiency in many tasks, for example, is only gained through long repetition, to the extent that the required bodily motions become habitualised—this is not the kind of knowledge that can be easily transmitted through disembodied oral transmission, and is inherently different from 'memory' in ecological contexts, where it refers to seed banks, soil nutrients, repopulation from neighbouring regions, etc. The central importance of memory and the scale over which it operates in both social and ecological systems is a topic that would benefit from more detailed consideration in future. Of course identity is complex and multifaceted; some aspects of it might change while others remain more or less intact (Díaz-Andreu et al. 2006). Language, for example, is a core element, but even when this is lost individuals and communities can maintain a distinct identity, as is seen with many

indigenous communities around the world today. Rather than attempting to consider identity as a single thing and to recognize its retention or loss, the investigator can select some aspect of the socioecological system that is likely to have important ramifications for identity, termed 'identity thresholds' by Cumming et al. (2005). The example of a ranching system has been used in the social resilience literature, in which a shift from keeping sheep to keeping goats would likely entail only limited restructuring of the SES and therefore no loss of the fundamental 'rancher' identity, while any breakdown of the dynamic between ranchers, stock and the presence of a harvesting relationship between them would constitute a loss of identity, and hence the failure of the resilience of the ranching system and its transformation into something else (Carpenter et al. 2001; Cumming et al. 2005). This example is particularly *apropos* here, since it also makes an intimate connection between the subsistence economy, lifeways and identity (cf. Strang 1997).

For the purposes of this paper, the focus is on the use of marine versus terrestrial resources, as identified through stable carbon and nitrogen isotope analysis of human bone collagen. A foundational tenet is that foodways in small-scale societies are central to identity. This is particularly so for hunter-gatherers, since there is often a strong food-sharing ethic, and there are generally far fewer opportunities for full-time specialists than in agricultural societies that could form the basis for alternative identities. Thus, most individuals will be involved at some level in the acquisition of food and/or its preparation on a frequent, if not daily, basis (Fernández-Armesto 2002; Schulting 2008; Twiss 2007). This allows us to consider foodways as integral to the socioecological system, and to emic understandings of identity.

Stable carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) isotope measurements on human bone collagen are well suited to an investigation of the consumption of marine/aquatic protein. The proportion of the heavier  $^{13}\text{C}$  isotope is higher in marine ecosystems, resulting in bone collagen values in human consumers of ca.  $-12 \pm 1\text{‰}$ , compared to values of ca.  $-21 \pm 1\text{‰}$  for the consumption of terrestrial plants and animals in a  $\text{C}_3$  ecosystem (Richards and Hedges 1999). Stable nitrogen isotope values increase with trophic level, and so tend to be significantly higher in both marine and freshwater aquatic systems, since foodchains tend to be far longer than in the terrestrial systems on which humans tend to focus (primary producers and first order consumers, i.e., plants and herbivores) (Minagawa and Wada

1984). Measurements on human bone collagen reflect the foods consumed over last decade or so of life, depending on the skeletal element analyzed and on the age of the individual. Thus, we are seeing the averaged, long-term isotopic signature of an individual's diet, the cumulative outcome of many thousands of meals, and hence reflecting underlying daily subsistence practices and cuisines. This is particularly appropriate in the context of this discussion, since it imparts a timeframe that is not only relevant to human experience, but also resonates with the notion of (literally) embodied knowledge touched upon above.

While a number of other factors do come into play (e.g., aridity effects), in a European context  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  measurements primarily reflect diet. This in turn serves as a powerful proxy for livelihood strategies. While the details will of course vary, communities focused on marine resources to any great extent will share certain ways of doing things that will form an integral part of their identity. The rhythms of the sea, the affordances it offers (Ingold 2000) and the demands it makes differ from those of the land. Thus, a significant shift in  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values at the community level (defined here as multiple individuals from a reasonably constrained spatiotemporal context) is taken to represent a change in lifeways, and hence the loss of resilience resulting in a change to a new system state, or regime. (Changes in the SES mainly seem to be viewed negatively in social resilience theory, as the failure to adapt, to cope. This view derives from the conservation ethics and sociopolitical action/management contexts in which the theory arose, in both the ecological and social sciences (Garmestani and Benson 2013).) This is not to say that some aspects of identity may not persist, but the overall outlook is taken to have experienced a fundamental transformation. For the purposes of the present discussion, we can define three  $\delta^{13}\text{C}$  bands reflecting different levels of reliance on marine protein, with shifts of more than 3‰ indicating the crossing of a threshold and thus a significant change in livelihood strategy and in identity.

- 1) -21 to -18‰: predominantly terrestrial diets, albeit with the possibility of some minor use of marine resources;
- 2) -17.9 to -15‰: a balanced use of terrestrial and marine resources, potentially involving a greater degree of movement between coast and interior;

- 3) -14.9 to -12‰: strong focus on marine resources, implying a settlement pattern oriented almost exclusively on the coast, and the presence of distinct coastal and (where present) inland identities (see Schulting 2010a).

Ethnographic parallels could be found for groups with all of the above adaptations, with the distinctions clearly recognized by the groups themselves (e.g., Yesner et al. 2003). The movement of individuals between groups (e.g., as marriage partners) does not obviate this distinctiveness. While the specifics can be debated, this scheme has the advantage of clearly setting out criteria by which a transformation in the SES can be identified. It allows a degree of adaptive flexibility within each system, such that there can be considerable movement within its 'basin of attraction' (Walker et al. 2004). Equally, it provides conditions for a system state change, so that the retention of a minor component of marine resource exploitation, while perhaps constituting a degree of 'continuity', does not imply that a major transformation has not occurred. An example of this is discussed below in relation to the Mesolithic-Neolithic transition in northwest Europe. An important corollary of the approach is the need to demonstrate a relatively rapid change in stable isotope values, on the 'meso-scale' of no more than a few human generations. Any gradual trends observed over a longer period of time than this would probably not be discernable to the communities involved, and so cannot constitute a loss of resilience/identity (cf. Cumming and Collier 2005). Ideally this approach would be linked with classic osteological indicators of stress, such as linear enamel hypoplasia, Harris' lines, non-specific infections, adult stature, etc. (Goodman and Martin 2002). But the reality for the present study is that, at least across much of northwest Europe, sample sizes are very small and skeletal remains are often incomplete and highly fragmentary. Isotopic approaches provide a means of using data even from the smallest human skeletal fragments, as long as they represent distinct individuals and either derive from secure stratigraphic contexts, or have been directly AMS radiocarbon dated (Schulting and Richards 2002a; Schulting et al. 2013). The recent development and application of ZooMS (Zooarchaeology by Mass Spectrometry) offers even more potential through the ability to speciate previously unidentifiable bone fragments (e.g., Charlton et al. 2016).

## **Resilience in Mesolithic Europe**



In a European context, the Mesolithic refers to the time between the onset of the Holocene and the adoption of agro-pastoralism as the dominant subsistence economy. While the start is thus fixed, the latter is a moveable feast, with a general diachronic trend from southeastern to northern Europe (Pinhasi et al. 2005). No domestic species other than the dog was present, though the management of some wild species, most notably wild boar, has been proposed (Zvelebil 1995). The degree to which socioeconomic inequality existed is an area of active debate: a limited degree of institutionalized inequality can be proposed for certain places at certain times, based mainly on the burial record, while for other regions and periods such evidence is largely lacking. This is relevant in the present discussion, since greater organizational ‘complexity’, which includes specialization and socioeconomic inequality, can be argued to make a society more vulnerable to perturbations. In chiefdom and state-level societies, for example, the loss of resilience may be, and often is, differentially distributed throughout society, affecting the élite but leaving the general population continuing on in much the same way in terms of their daily lives (e.g., the ‘collapse’ of the Classic Maya – Dunning et al. 2012). The implications of power and inequality relations have yet to be fully integrated into social resilience theory (Abel et al. 2006; Cote and Nightingale 2012; Cretney 2014; Davidson 2010; Hatt 2013).

Another consideration is that, while the archaeological record has the benefit of a long time-scale, it still suffers from imprecision in both absolute and relative chronology, often making even the ordering of events problematic. To some extent these problems are being addressed by the increased precision of radiocarbon dating combined with Bayesian modeling, as well as the use of other dating techniques such as tephrochronology, which are particularly well suited to linking spatially discrete locations together into a single time horizon (Lowe 2011). Even so, our chronologies for the most part remain very general. Moreover, since we are interested in comparing the archaeological record with environmental proxies, the chronological imprecision of the latter introduces an additional source of uncertainty. Thus, the problem of linking changes in the archaeological and environmental records is far from trivial (Robinson et al. 2013; Schulting 2010b). This makes it difficult to know when and whether human communities are responding to environmental perturbations. Given that external stressors are often placed at the core of resilience theory, making these links is crucial in terms of identifying particular sequences of events, or adaptive cycles, and so presents a real challenge in archaeological

applications. Nevertheless, we can make use of the concept of resilience to explore and ‘think through’ our data in novel ways, and this can itself be a very useful exercise (cf. Cote and Nightingale 2012).

Two approaches are considered in the following section, illustrated by case studies drawn from Mesolithic Europe. In the first, we start with a known climatic or other environmental event and seek evidence for its impact on contemporaneous societies in the archaeological record. Depending on the extent of any observed changes, we are then in a position to consider whether the pre- and post-event societies are sufficiently similar to constitute adaptive flexibility in what is still recognizably the same society, and in what specific ways it has changed, or whether the society’s capacity for resilience was exceeded and underwent a more significant transformation leading to a new SES. Of course knowing where to draw the line between these and other possibilities is not straightforward, and will to some extent be subjective. But it does provide grounds for discussion, and potentially for hypothesis building and testing.

#### *The 8.2kya cal BP event*

The best-known and most widespread environmentally-driven change impacting on the early and mid-Holocene in the northern hemisphere is the 8.2kya cal BP climatic downturn, caused by the last major meltwater pulse from the Laurentide ice sheet and its resulting impact on North Atlantic thermohaline circulation (Alley et al. 1997). Despite the indication that this event would have been experienced mostly strongly in the North Atlantic region (Thomas et al. 2007), discussions within archaeology have primarily focused on its potential effects on early farmers, who were at this time restricted to southwest Asia and southeast Europe (Biehl and Nieuwenhuyse 2016; Budja 2007; Flohr et al. 2016; Pross et al. 2009; Weninger et al. 2006). However, as discussed below, some attempts have been made to identify its impact on Mesolithic hunter-gatherers, with conflicting or at least ambiguous results.

A considerable amount of work has focused on the Iberian Peninsula, where the 8.2kya cal BP event manifests through slightly colder and, more importantly, more arid conditions. This seems to have resulted in Mesolithic hunter-gatherers abandoning certain areas and re-structuring settlement organization on a regional level (García-Martínez de Lagrán et al.

2016; González-Sampériz et al. 2009; López de Pablo and Jochim 2010). There is no evidence, however, that this was accompanied by a significant change in the SES, and so this arguably serves as a good example of high resilience. A caveat to note here is that this is based on the limited view provided mainly by lithics and settlement patterns. It might be that this shift entailed the emergence of significantly different lifeways, gender relations, ideas of land tenure, etc., that are simply not visible with the available evidence.

Another approach is to begin with observed changes in some aspect of the archaeological record, and then attempt to situate this within an environmental and social context. Much research on the Mesolithic has focused on stone tool traditions, with a number of recognized shifts over time, such that much of western Europe can be fit into a broad tripartite scheme of Early, Middle and Late Mesolithic. Robinson et al. (2013) observe that the Middle Mesolithic in the Rhine–Meuse–Scheldt area of the Netherlands is bracketed by two climate events at 9.3kya and 8.2kya cal BP. This certainly suggests that human populations might be reacting to environmental changes, but it is difficult to determine the extent to which relatively minor changes – even if very clear in typochronological terms – in the form and size of microliths can be seen as reflecting a substantial shift in the SES. Furthermore, continuity in landscape use at least in the broad sense and continuity in population suggests adaptation rather than transformation.

The interpretive challenge comes into sharper focus when we look at the dating of comparable changes in stone tool typologies elsewhere in northwest Europe. For example, the shift from Early to Late Mesolithic (the latter broadly equivalent to the Middle Mesolithic on the Continent) microlith traditions in Britain occurs at ca. 9700 cal BP (Tolan-Smith 2008), well before either of the abovementioned climate events. What is arguably a more dramatic shift is seen in the change from an Early Mesolithic microlithic tradition in Ireland to a macrolithic tradition in the Late Mesolithic, yet this occurred at ca. 9000 cal BP (Costa et al. 2005) and so again appears unrelated to any known climate change event *per se*. It is likely that it instead relates to Ireland's insular position and impoverished terrestrial fauna. While this may indeed represent a shift in the SES (though a case would need to be made), it does not appear to have been climate-driven.

One recent study that considers the effect of the 8.2kya cal BP event on north-temperate hunter-gatherers is that by Wicks and Mithen (2014). Using radiocarbon dates as a proxy for population, they note a marked fall-off in the summed probability distribution for dates from the west coast of Scotland seemingly coinciding with this climatic downturn (Wicks and Mithen 2014: fig. 5). It is not clear why coastally-adapted hunter-gatherers would be so strongly affected by a temperature drop of a few degrees, since the marine environment itself would presumably be highly resilient to a shift of this order, and indeed might even be expected to see greater fish productivity, as colder water holds more oxygen (Keeling et al. 2010). To address this, Wicks and Mithen refer to palaeoenvironmental studies supporting a concomitant increase in storminess at this time (Clarke and Rendell 2009), which may have physically impeded the exploitation of marine resources, as well as adversely affecting near-shore shell beds, etc. But what is even more striking is that no 'recovery' is seen in the summed probability distribution of radiocarbon dates until after ca. 7kya cal BP. It is hard to understand how a relatively short-lived climatic downturn lasting no more than a century or so should lead to the apparent near-abandonment of the region for a millennium. It may be more a matter of archaeological visibility that is driving this pattern, though this remains a matter for future research. Taken at face value, this is a good candidate for the loss of resilience. The timeframe seems too long for this to be simply a matter of temporarily readjusting the nature of activities across the landscape, while retaining sufficient knowledge through cultural memory to return to the same coastally-focussed SES many centuries later.

Unfortunately, human remains on the Scottish west coast are currently only available for the last few centuries of the Mesolithic, ca. 6200–5800 cal BP, and are also restricted to the small island of Oronsay, so that the available stable isotope data lack both temporal depth and spatial extent. Nevertheless, it can be noted that diets here fall into the category of extremely high reliance on marine resources (Charlton et al. 2016; Richards and Mellars 1998; Richards and Sheridan 2000; Schulting and Richards 2002b). Thus, if we accept that increased storminess from ca. 8.2kya cal BP adversely affected the ability to pursue the kind of strongly marine-oriented economy seen towards the end of the Mesolithic, and assuming that something similar was in place millennia earlier, then this could provide an example of an environmental perturbation that exceeded the ability of hunter-gatherers to cope, presumably leading to a new SES focussed elsewhere on the regional landscape.

Unfortunately the character and even existence of this new adaptation is purely hypothetical, since the region is largely bereft of evidence of human presence during the period in question. The implication is that the population here, if present at all, was highly mobile and left minimal archaeological traces of their activities. Given the existence of the sizeable Late Mesolithic shell middens on Oronsay, the high marine diets seen in human stable isotope values, and the concomitant implication of some degree of sedentism and attachment to 'place', we can also propose a second major shift in lifeways. But, unlike the previous shift, we might debate whether this should be termed a loss of resilience, since it implies a more 'successful' (i.e., larger) population on the west coast of Scotland. (This highlights an ambiguous aspect of the theory, in that a positive value is often placed on the resilience of human communities, when in the long term persisting in maintaining a lifeway adversely impacted by—or failing to take advantage of—changing conditions may not be the most appropriate response.) Nevertheless, assuming that coastal resources were in fact largely abandoned, and following the methodology outlined above, this shift should also be understood as a transformation of the SES, and hence as a loss of resilience of the previous system in favour of a 'new' (or renewed) basin of attraction. The success of the new SES is irrelevant to the loss of the old. A sudden influx of new resources can be as disruptive to a system, whether social or ecological, as a sudden decline. In this particular case it is the millennium-long gap between the two systems that makes it difficult to accept any meaningful persistence of identity given the terms of reference being employed in this paper (cf. Cumming and Collier 2005). This is not to deny that an alternative account, employing a difference frame of reference, could legitimately see this as an example of successful adaptation, moving between basins of attraction, rather than one of transformation. The difference comes down to the selected identity criteria and the spatiotemporal scale of analysis.

South Wales is currently the only region in Britain or Ireland with a series of directly radiocarbon dated human remains spanning the 8.2kya cal BP event. Moreover, most of the sites from which they derive can be described as 'near coastal' (i.e., within ca. 5-10km), and thus provide an opportunity to investigate whether any isotopic changes can be seen at this time that might imply a shift in the SES to the degree required for crossing an identity threshold. While the sample size is limited, it is apparent that there is no difference pre- and post-8.2kya cal BP, with  $\delta^{13}\text{C}$  values remaining relatively high throughout, averaging -

16.1 ± 1.2‰ (n = 12), indicating a balanced use of marine and terrestrial resources (Figure 1). This provides a sharp contrast to the study on the west coast of Scotland, despite the fact that the increased storminess proposed there as a possible explanation should have also affected southern Britain, and indeed the entire Atlantic façade (Clarke and Rendell 2009). One means, albeit a speculative one, of reconciling these two contrasting outcomes is that the more balanced use of marine and terrestrial resources seen in south Wales may have provided communities with the flexibility to shift their adaptive strategies from one to the other as required. If communities on the Scottish west coast were more committed to a fully marine specialization at the time of the 8.2kya event, as they clearly were in the Late Mesolithic, then this option may not have been viable, though this still does not explain the long gap in  $^{14}\text{C}$  dates there. A marked drop in  $\delta^{13}\text{C}$  values, however, can be observed with the onset of the Neolithic in both south Wales and Scotland. We turn to this in the next section.

#### *The Mesolithic-Neolithic transition*

There continues to be considerable debate over whether or not there was any meaningful ‘continuity’ across the Mesolithic-Neolithic transition in parts of northwest Europe, particularly Britain, Ireland and southern Scandinavia (Cummings and Harris 2011; Milner et al. 2004; Sheridan 2010; Richards, Schulting and Hedges 2003; Richards and Schulting 2006; Thomas 2013). One line of evidence that has featured in this debate is that for the continued use of coastal resources in the Neolithic. This is inferred from the presence of coastal site locations, as well as the persistence of shell middens and evidence for fishing (Milner et al. 2004). More recently, direct evidence for marine products has been identified in residues in Early Neolithic pottery in Denmark (Craig et al. 2011). Conversely, no such evidence has been found in Britain or Ireland, despite a large-scale study aimed at just this (Cramp et al. 2014a; b).

But in both regions, the human bone collagen stable isotope evidence unequivocally supports a reversal in the relative importance of marine and terrestrial resources (Fischer et al. 2007; Price et al. 2007; Richards et al. 2003; Schulting 2013; Tauber 1986). Following the three bands proposed above, the majority of coastal Mesolithic individuals from Denmark exhibit  $\delta^{13}\text{C}$  values indicating diets strongly focused on marine resources, constituting more than half of the signal. By contrast, and with only very few exceptions

(concerning which see discussion in Schulting 2011; 2015; in press), coastal Neolithic individuals exhibit  $\delta^{13}\text{C}$  values consistent with the dominance of terrestrial resources, accompanied by the appearance of domestic animals and plants in the region. A comparable shift is seen in  $\delta^{15}\text{N}$  values, which become significantly lower in the Neolithic (Figure 2). This need not be seen as conflicting with the abovementioned evidence for the continued use of marine resources, since their inclusion as a minor component of the diet (constituting no more than ca. 10-15% of dietary protein) is not precluded by the stable isotope data. The lines of evidence refer to different temporal scales: measurements on adult bone collagen reflect averaged diet over a decade or more of life, reflecting literally thousands of meals (10,950 if one assumes three meals a day over 10 years), while marine contents in a pot could potentially refer to just a single meal. The step change in emphasis from marine to terrestrial resources, and all that that implies concerning lifeways and identity, is argued here to constitute a clear transformation in the SES.

The picture is even clearer in Britain, though finds of Mesolithic human remains from coastal sites are limited to south Wales and to the west coast of Scotland. There is still a gap of over a millennium between the latest known Mesolithic and earliest Neolithic individuals in south Wales (Figure 1). While it would be very useful to fill this gap (and this has been the focus of ongoing research by the author), the Neolithic side of the equation is very clear: the isotopic results are completely dominated by a terrestrial signal (Schulting and Borić 2017). While some minor contribution of marine foods is likely for some individuals, this is on a different order entirely from that seen in the Mesolithic. This is particularly striking in that in a number of cases, directly dated Mesolithic and Neolithic human remains derive from nearby locations (e.g., Caldey Island) or even from the same site (e.g., Foxhole Cave) (Schulting and Richards 2002a; Schulting et al. 2013). Furthermore, due to rising sea levels, the coast would actually have been somewhat more distant from these locations in the Mesolithic than in the Neolithic. As discussed in more detail below, this is strongly suggestive of a loss of resilience by Late Mesolithic communities, leading to a very different adaptive cycle marked by the beginning of the Neolithic in the region.

The west coast of Scotland provides perhaps the clearest case for a rapid shift from the dominance of marine to that of terrestrial resources (Schulting and Richards 2002b). More

recent research has only strengthened this view (Armit et al. 2016; Charlton et al. 2015) (Figure 3). The available radiocarbon dates overlap, raising the intriguing possibility of the co-existence of two very distinct lifeways (Charlton et al. 2015; Richards and Sheridan 2000; Schulting and Richards 2002b). If so, the marine adaptation appears to have disappeared very quickly. It should be noted that the earliest 'Neolithic' individual on Figure 3, at ca. 5800 cal BP, is from Macarthur Cave, Oban, and is not in association with diagnostic Neolithic material culture. Thus, pending the outcome of ongoing DNA analysis, its provisional assignment to the period relies on the  $\delta^{13}\text{C}$  ratio. While this could be seen as a circular argument, previous research has shown the utility of using  $\delta^{13}\text{C}$  as an independent means of identifying Mesolithic and post-Mesolithic humans from coastal contexts in Britain (Schulting and Richards 2002a; Schulting et al. 2013). The later individuals in Figure 3 derive both from caves and from a series of Neolithic mortuary monuments on the Scottish west coast (Armit et al. 2016; Schulting and Richards 2002b; Schulting in Ashmore 2004). As mentioned above, there is also an absence of marine biomarkers in Early Neolithic pottery in the region (Cramp et al. 2014a; b). It is hard to imagine a sharper shift in diet, and hence in associated lifeways, occurring within the span of a few generations, i.e, the period encompassed by social memory. It is, furthermore, accompanied by concomitant changes in material culture, technology, living and funerary architecture and in the scale of ceremonial activity. In this sense, the rehabilitation of the long-discarded term 'revolution' seems warranted, entailing 'among other things, rapid redefinitions between past and future, between shared memories and shared expectations' (Tilly 1994: 247).

The question remains open as to whether this was the result of the rapid adoption of introduced domesticated plants and animals, largely by indigenous hunter-gatherers, or whether there was actually a substantial incursion by a new incoming population with an established farming economy. The results of a number of large-scale projects on ancient DNA including British and Irish Mesolithic and Neolithic human remains are now starting to appear (Armit et al. 2016; Brace et al. 2018; Cassidy et al. 2016; Olalde et al. 2018), and their results make an important contribution to the debate. The aDNA data for Neolithic Britain and Ireland show surprisingly strong genetic affiliation with contemporary farmers in continental Europe, who in turn show affinity with the Near East (Brace et al. 2018; Cassidy et al. 2015; Olalde et al. 2018), a finding consistent with the picture emerging



across Europe (Mathieson et al. 2015). Thus, there appears to have been a large element of population replacement associated with the initial spread of farming, significantly changing the nature of the debate.

Regardless of the outcome of the ongoing genetic studies, the isotopic and archaeological evidence indicates a step change in lifeways across the Mesolithic-Neolithic transition in Denmark, and even more so in south Wales and on the west coast of Scotland. The focus of the subsistence economy clearly underwent a major realignment, along with concomitant changes in technology, settlement and mortuary practices, all of which points towards a transformation of the SES and the loss of the previous fisher-hunter-gatherer way of life, i.e., the resilience of that system was exceeded and failed. Drawing upon the previous discussion, it is important to emphasize that this does not imply that individuals or even entire communities failed to adapt to their new circumstances, but rather that, in doing so, they significantly altered their way of life and entered a new 'adaptive cycle' in which new identities and relationships were created. Some of these consequences may have been unintended. The ownership of cleared horticultural plots and of animals, for example, may have transformed the nature of social relations, while the new plants and animals themselves would have modified local environments in 'partnership' with humans as part of a process of niche construction (Rowley-Conwy and Layton 2011).

An environmental trigger for the transition to farming in northwest Europe has been proposed (Bonsall et al. 2002; Macklin et al. 2000; Rowley-Conwy 1984), but there are problems both with the chronological imprecision of the archaeological and environmental evidence, and with the scale at which this explanation is intended to apply (see discussion in Schulting 2010b). Alternatively, the transition here could be viewed as the result of purely or largely social factors (Schulting 2010b; see also Lemmen and Wirtz 2012). This explanation becomes more compelling if the accumulating genetic data continue to support a major population influx at this juncture, although of course ultimately this in turn may have had an underlying climate driver (Warner 2011). This presents an interesting example, since it highlights two ways in which resilience may be exceeded, one emphasizing mainly indigenous change in the face of environmental factors and, and the other emphasizing a clash of two different cultures and ways of life. The exciting thing is

that we are in a position to discuss this in increasingly more nuanced detail than was thought possible before the turn of the millennium.

## **Conclusions**

Identifying resilience in the past is a very challenging prospect. I have offered one potentially fruitful approach here, based on the use of stable carbon and nitrogen isotope data to argue for the persistence of ‘livelihood strategies’ and sociocultural identities in south Wales across the 8.2kya cal BP event, the largest climatic downturn known in the Holocene record of the northern hemisphere. That the west coast of Scotland appears, on present evidence, to have been largely depopulated at this time presents an interesting contrast, one that requires explanation. But we are working with so few pieces of a complex puzzle that this is unlikely to be resolved in the near future. The second example draws upon the marked changes observed in stable isotope results across the Mesolithic-Neolithic transition in northwest Europe, focusing on Denmark and Britain. The previously proposed ‘sharp shift’ is re-affirmed, and it is argued that this is a potential candidate for the loss of hunter-gatherer resilience and the instigation of a new ‘adaptive cycle’ focused on mixed farming. The interesting question—possibly one on the verge of being at least partly answered through ancient DNA—is whether this occurred largely within an indigenous context, or whether it was primarily due to a ‘substantial’ (however this is to be defined) incoming population of farmers, as increasingly seems to be the case. The intention is not to present this in simple, overly dichotomized terms, but rather to set up the goal posts between which the ‘real’ scenario must lie.

I have tried throughout the paper to pose some questions regarding what we mean by resilience, and how it can be operationalised archaeologically. This perhaps provides an overly narrow perspective from which to view change, albeit one that is arguably well suited to the modern context within which it arose and is primarily intended to apply, as a response to the increasing pace of habitat destruction and globalization, and the resulting loss of both biological and cultural diversity. Whether this provides a very useful lens through which to view changes in livelihood strategies in the past is a topic ripe for debate.

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## Figure captions

Figure 1. Stable carbon isotope results and radiocarbon dates on human remains from coastal south Wales. The vertical line indicates the 8.2kya cal BP event. Dates calibrated in OxCal 4.2 using the IntCal 13 and Marine 13 calibration curves (Bronk Ramsey 2013; Reimer et al. 2013). Mesolithic dates are corrected for the marine reservoir effect, proportional to the estimated contribution of marine dietary protein (cf. Schulting et al. 2013).

Figure 2. Stable carbon and nitrogen isotope results on Mesolithic and Neolithic human remains from coastal Denmark. The individual from Rødhals dates to the transition period, but clearly shows a strongly marine diet entirely typical of the Mesolithic, and atypical of the Neolithic (Data from Fischer et al. 2007; Price et al. 2007). The lines at -18‰ and 12‰ demarcate predominantly terrestrial (lower left quadrant) and balanced/predominantly marine (upper right quadrant) diets (see Schulting 2015; in press).

Figure 3. Stable carbon isotope results and radiocarbon dates on human remains from the west coast of Scotland (data from Charlton et al. 2015; Richards and Sheridan 2000; Schulting and Richards 2002b). Dates calibrated in OxCal 4.2 using the IntCal 13 and Marine 13 calibration curves (Bronk Ramsey 2013; Reimer et al. 2013). Mesolithic dates are corrected for the marine reservoir effect, proportional to the estimated contribution of marine dietary protein.