22 Marine resource exploitation and the seasonal factor of Neanderthal occupation: evidence from Gibraltar

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Introduction
A scheduled round of activities allows hunter-gatherers to take advantage efficiently of the seasonal appearance of certain resources in often diverse geographical regions. At certain periods, human groups plan their mobility to coincide with anticipated seasonal abundance and the presence of resources that are optimally available. In this way, the group is able to maximize its subsistence strategy. Seasonality has been proposed as one of the most important aspects of site settlement patterning and its assessment is vital in elucidating site-function and developing an integrated view of prehistoric social and behavioural structure.

For several decades, the seasonal factor in archaeology, whilst being seen as a key variable in understanding hunter-gatherer behavioural complexity, was largely ignored. That was mainly due to the lack of expertise in decoding the seasonal information archived in archaeological remains. Several methods for the reconstruction of site seasonality are applicable in the wake of some significant developments in the field of archaeological science. The most comprehensive overview on these methods still remains that published by Monks (1981). He defined seasonality as the temporal concurrence of human activity with naturally occurring phenomena. His suggestion was that the most effective approach for delineating seasonality was to apply a range of methods: confidence in diagnosing the season or seasons of occupation increases if the results of more than one method are in agreement.

In this chapter, we report the results of an investigation into the seasonality of a shell midden feature associated with Neanderthal occupation at the site of Vanguard Cave, Gibraltar and recently redated to c. 108,000 years ago using OSL techniques (Chapter 14). The archaeological assemblage consisted of a feature dominated by common mussels (Mytilus galloprovincialis Lamarck, 1819). Some of the shells were analysed in order to (i) assess the seasonal nature of the midden deposit and to test the hypothesis that the assemblage represented a short-term episode; (ii) investigate Neanderthal coastal adaptation to understand the ways in which they exploited different resources; and (iii) use and compare the results of two independent but complementary analytical techniques (growth-ring analysis of shell rings coupled with limited oxygen isotope analysis) to add confidence to the results obtained. The study is one of the very few (also Emiliani et al. 1964; Stiner 1994) that deals with the seasonal factor of a Middle Palaeolithic site through the analysis of archaeomalacological material, and the only one (to our knowledge) to do so using growth-ring analysis.

Archaeological considerations
A number of scholars have posited differences between the subsistence adaptation of Neanderthals (Homo neanderthalensis) and anatomically modern humans (Homo sapiens sapiens). They suggest that moderns were seemingly able to exploit a wider spectrum of resources, a fact that apparently offered them a competitive advantage (O’Connell 2006, 50; but see Stewart 2004). By comparison, Neanderthals have often been considered to be top-level carnivores (Bocherens et al. 1991, 490; Richards et al. 2000, 7663), with an emphasis on animal hunting (Burke 2000; Marean and Kim 1998 inter alia) and scavenging (Binford 1985, 319; 1991, 113; Stiner 1994, 21, 257, 367; Brugal et al. 2006, 8), but unable to adapt and exploit diverse resources even when these are located in direct proximity. At the same time, theoretical models and archaeological data support the notion of a highly mobile strategy for Neanderthals (Gardeisen 1999, 1152; Patou-Mathis 2000, 393; Boyle 2000, 353; MüNZel and Conrad 2004, 225; Hockett and Haws 2005, 27; Gaudzinski 2006, 138). Unfortunately, however, seasonal evaluations of Neanderthal sites are extremely rare and mainly made through the study of faunal remains (e.g. Stiner 1994; Patou-Mathis 2000; Valensi and Psathi 2004), which often lacks precision. Nevertheless, some significant results have been obtained from various Mousterian sites. Work on the Levantine Mousterian, for instance, has focused on variations in size and density of lithic assemblages, site size and distribution, and other more direct techniques, particularly teeth cementum increment analyses, seasonality according to sex ratios and seasonal growth or reproductive conditions (Lieberman 1991; Speth and Tcher 2006, 156). Some faunal research undertaken on the French (Brugal and David 1993; Valensi 2000) and Spanish (late) Middle Palaeolithic (Pike-Tay et al. 1999) showed that animals were hunted during the cooler periods of the year and especially during autumn and winter. At Mezmaiskaya Cave in the North Caucasus, the alpine location probably implies a summer occupation (Baryshnikov et al. 1999) while in northern Germany, at the Salzgitter Lebenstedt site, reindeer were hunted during autumn by Middle Palaeolithic hominids (Gaudzinski and Roebroeks 2000).

Given the few direct examples from this period demonstrating seasonal procurement strategies, any opportunity to sharpen the picture of Neanderthal resource exploitation and seasonal adaptation must be very attractive for the prehistorian.
Material

Vanguard Cave was excavated under the auspices of the Gibraltar Caves Project (Stringer et al. 2000). In the Upper area, covering the grid squares A4–A6 and Z3–Z5A, a shallow shell 'midden' deposited during the Neanderthal occupation of the cave was revealed (Barton 2000, 212). The midden contained a limited number of refittable Mousterian lithic remains and their horizontal distribution was associated with the spread of white ash from an in situ hearth (Fig. 22.1).

The molluscan assemblage consisted mainly of marine molluscan shells, dominated by *Mytilus galloprovincialis*, *Callista chione*, *Acanthocardia tuberculata*, *Patella vulgata*, *Patella caerulea* and a few barnacles (*Balanus* sp.) (Barton 2000, 213). The mussel shells (*Mytilus* sp.) were well preserved and showed very little surficial damage caused by heat (on the occurrence of fire in the proximity of molluscan shells assemblages see Stiner 1994, 187).

Forty-two *Mytilus galloprovincialis* valves with surviving margins were selected for analysis from the Gibraltar Museum, where most of the material is kept, while two modern samples of the same species were obtained alive from beaches close to Vanguard Cave by Julie Ferguson (Department of Earth Sciences, University of Oxford) for oxygen isotope analysis. The archaeological material, when complete, was of a comparatively large size (8–12 cm), whereas the two modern shells were much smaller, 3 and 4.5 cm respectively.

The uniformly large size of the archaeological mussel samples was consistent throughout the accumulation, perhaps suggesting an estuarine/lagoonal provenance along with a degree of selectivity in their collection.

Methods

We used a growth-ring method for estimating the season of death of a number of the archaeological shells. We also performed selected oxygen isotope analysis on certain specimens. This work is still in progress; the first results are encouraging but some technical limitations in the analysis of the mussels have to be resolved and therefore no results are reported here.

One of the main aims was to investigate whether shells from this archaeological assemblage were collected at the same time. This would shed light on Neanderthal behaviour and seasonal adaptation, and enable us to diagnose a season or seasons of occupation.

Marine mollusc shells can be described as 'biological chart recorders' (Goodwin et al. 2003, 110) that produce discernible concentric lines marking various ontological, environmental, biological and metabolic events. We analysed the mussels on the basis of a clear correlation of growth macro-rings with temporal (annual) periodicity, which is well attested by studies of modern populations. Since the early 1960s various researchers have investigated the growth patterns on external surfaces of molluscan shells assemblages see Stiner 1994, 187).

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Methods

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Several scholars have shown that the most effective method for observing growth lines in mussels is to examine them in polished thin or thick sections (Lutz 1976, 726; Sheppard 1984, 117; Claassen 1998, 155), or to use acetate peels (Pannella and MacClintock 1968, 66; Rhoads and Pannella 1970, 146; Kennish et al. 1980, 597). In our study, sections were found to be of limited use and acetate peels failed to produce effective results. A review of the literature revealed that some researchers had faced similar problems and attributed them variously to (i) the recrystallization of the material (Berry and Barker 1975, 15); (ii) the process of fossilization; (iii) the limited Mediterranean intertidal zone that results in low line visibility (Deith 1985, 121); (iv) the non-reflected shell margin (Pannella and MacClintock 1968, 66); and (v) the unfavourable angular relationship of growth lines to the growing margin and the crystalline elements of the shell structure in this species (Pannella and MacClintock 1968, 75; Richardson 1989, 477).

Another challenge was successfully to resolve annuli and disturbance rings along the surface of the mussel. Usually, bivalve annual growth rings are preceded by several ridges that cluster very closely together. These have been proposed to be a reliable way of distinguishing between annual and spawning or disturbance rings. Disturbance rings, on the other hand, are unrelated to the annual growth of the organism and are produced by various environmental influences, such as storms, reproductive processes (spawning rings), predation threats (shock rings) or even anthropogenic disturbances. These changes are abruptly registered on the outer surface and subsequent growth begins in an equally abrupt manner (Deith 1983a, 433). Disturbance rings do not usually encircle the shell along its margins and the striae preceding and following the rings are equally spaced (Richardson 2001, 105). During our analysis, attention was paid to exclude rings that did not seem to correspond to annuli. In addition, biometric analysis was employed to investigate the conditions within which the mussels lived. In shell-secreting organisms the shell shape is defined by a set of metric relationships, related both to genetic and environmental factors. Comparison of the relative measurements exhibited by a group of samples can support inferences on the environment the shells lived in and were collected from.

Preservation is of crucial importance, since the season-at-death can be inferred only if the final stage of growth, that immediately prior to the death of the animal, is still present and readable. For shell analyses, this means that the posterior and ventral margins should be preserved, particularly at the area where the axis of maximum growth (AMG) meets the lip or edge of the specimen (see Fig. 22.2). Fortunately, the majority of shells from the assemblage were well preserved. Shells that were less well preserved, or ambiguous in terms of their edge characteristics, were excluded.

Seasonal estimates obtained through growth-ring analysis should ideally be undertaken with reference to a modern control population (Deith 1983a, 428; Claassen 1998, 154). Unfortunately, this could not be undertaken on a large scale in this research programme owing to time constraints, and only two modern individuals were examined. A review of the literature to identify suitable work for comparison was undertaken, however without success.

Each specimen was initially cleaned in an ultrasonic bath, in Milli Q (ultrapurified) water, for 30 min and left to dry for 48 hours. In general, no hard accretions were observed. The analysis (measuring and counting) was undertaken on the surficial bands, using an optical microscope (Prior MP302K), at 20× and 40× magnifications with external illumination. Measurements of the increment distances were made using a stage, to the nearest 0.1 mm, along the AMG from umbo to margin (Fig. 22.2). Under this magnification the external surface of Mytilus had a pattern of continuous, concentric brown bands separated by whiter striae. Special attention was given to the areas where the outer surface of the shell changed its orientation, with the faster, new spring growth, producing a step-like section and marking an annual growth ring (annulus).

Results

Some of the mussels exhibited up to eight annuli, and up to 260 observable bands between them. Measurements were compiled on an Excel spreadsheet and plots of the data were constructed. These included the number and width of bands against the number of annuli or the total size of the shell, allometric charts to infer observed growth rates and percentages of new growth compared to that recorded on the penultimate annual increment.

Of the 42 specimens analysed under microscope, 34 were acceptably well preserved (with a minimum of two to three surviving annuli prior to death) while the remainder had broken edges and were not considered further. Twelve were identified as complete with intact shell margins and
for these we compiled a growth rate chart. Reduced growth rates with increasing age are apparent, especially after sexual maturity (Fig. 22.3). The initial phases of the estimated growth curves are quite steep and indicate higher actual growth during juvenility whereas growth during senility and the years before death is considerably decreased. When the absolute widths between annual increments are plotted against the annuli one can clearly observe the expected incremental width reduction with subsequent growth years (Fig. 22.4).

The decrease or even cessation in absolute growth rates with age is well attested in most biological growth studies. Likewise, it has been suggested that after reaching sexual maturity in year 2–3 of life, mussel growth is reduced because energy is channeled towards the production of eggs and sperm (Richardson 2001, 111). Taken together, these observations imply that the growth expectancy for the year during which the animal died will probably be lower than anticipated, particularly if the animal is older than three years of age.

The relationships commonly in use to evaluate the intrinsic parameters and growth conditions of shellfish are those concerning the ratios of total length to maximum height and width of the valve. In our case, allometry was used for the 12 complete valves and the compiled charts were in good agreement with examples published by earlier researchers in which the relationships tended to be linear for all shells. A relatively strong correlation is apparent between height and width to length, with an increase in one corresponding to a relative increase in the other (Fig. 22.5). There is small relative allometric variation amongst the specimens analysed which allows us to comment on the environmental or biological influences experienced by the mussels during their lifetime. Mussels high in the intertidal zone or in the absence of major predators live to a considerable age and morphological differences may be attributed to genetic or environmental influences (Kemp and Bertness 1984, 811). This may suggest stable environmental conditions, with minimal mechanical influences (wave action or predators) and large food availability.

In estimating a season-at-death one is aiming to measure the final shell carbonate deposited and calculate a season based on a comparison with previous annual growth cycles. This is difficult, and previous research has focused on applying two different methods. One method is based on absolute growth rate measurements for living mussels (e.g. Seed 1973; Amano et al. 2000) and estimations of the percentage of new growth expected to occur at each
season of the year (Quitmyer et al. 1985). This is calculated by taking a ratio of the values measured for the penultimate year and the final increment of growth. A second is to use the width of the last annual increment or the average width of the last one to three annual increments in order to infer percentages of the growth at the time of death. These methods have been criticized (Claassen 1998, 152–173) because they have a tendency to overlook the fact that growth is not uniform within the same species, same calendar years or even same population. Moreover it has been suggested that these incremental growth techniques overestimate the actual season-at-death and give generally an earlier calendar approximation. Experiments using marked modern controls, for instance, have proved that some species will never give reliable results (Claassen 1998, 155). Clearly, careful selection of reliable specimens and recognition of the limitations of the technique in terms of precision, allied where possible with the use of modern control samples, is the most effective approach one can take.

Micro- and macroscopic observations of the surfaces of the 34 specimens revealed that in the majority of examples (60 per cent), only a very low percentage of new growth had begun prior to death (Fig. 22.6). In the remainder there was variation in the size of the final growth increment (Fig. 22.8a). This could be taken as evidence for a range of seasons-at-death within the population. However, further, closer analysis of these individuals (N = 13) revealed that small new layers of carbonate had been deposited on the interior of the shell below the previous annual growth increment (Fig. 22.7). These accounted for all of the examples identified as initially having large final increments. The small size of the new growth increment on these individuals supports the interpretation that this has not been incorporated into the main carbonate skeleton, strongly suggesting that the death of the organism occurred during the early stages of the yearly growth cycle. With this in mind, the complete final growth increments uniformly and consistently give low values (Fig. 22.8b).

For the 21 specimens that passed our selection criteria (up to two to three annuli, intact shell margins, last increment attached to the exoskeleton), the average width measured was 1.92 mm which comprised ~12 per cent of the penultimate year of growth. We assume that little or no carbonate deposition occurs between November and March at the latitude at which Gibraltar is located, and over 90 per cent of the total annual growth occurs between April and October (a period of seven months). In addition, if we also consider that the Gibraltar mussels exhibited a highly seasonal preference for growth, then the low percentage of final growth, allied with a rapid deposition of material after the formation of the winter annuli, would suggest that the most likely period of harvesting was spring – probably mid-spring.
Modern samples were collected at the end of the growth season (November 2005) for oxygen isotope analysis and two were incrementally analysed. Measurement of the final year of growth showed that this was ~70 per cent of the width of the penultimate increment, the size of which is consistent with the completion of a final annual growth cycle for older mussels, such as the ones studied. The lack of an acceptable number of modern control samples and the unsuccessful attempt to observe growth lines in sections hampered more precise analysis of the seasonal signals.

Growth-ring analysis, and the preliminary oxygen isotope analysis not reported here, yielded similar results for all analysed shells, providing strong support for a mid-spring collection.

**Discussion**

As mentioned previously, there has been a strong historical tendency to consider Neanderthals less capable of responding to environmentally induced challenges compared with anatomically modern humans, a fact which ultimately may have been linked with their extinction. Stringer and Gamble (1993, 168), for instance, state that ‘... the intricate matching of personnel to resources in the highly seasonal habitats of Europe seems to have been beyond their (i.e. the
Neanderthals) organizational abilities; their modern successors could take advantage of less important foods as they briefly become available … we can find no evidence that the Neanderthals were capable of such complex behaviour. More recent archaeological research, as well as the reassessment of previously excavated material, has modified this view and suggested that in their subsistence activities Neanderthals were close to, or at least as competent as, modern populations (e.g. Sorensen and Leonard 2001, 492). Stringer (2002, 58) has suggested that ‘… recent research on Neanderthal occupation sites certainly requires us to upgrade our views of their capabilities; … there is apparent evidence of “advanced” behavior by some Neanderthal groups, such as the exploitation of marine resources’. Erlandson (2001) has favoured a re-evaluation of the role of aquatic resources in human evolution. In the case of shellfishing at Gibraltar he noted that without further evidence that associates the aquatic fauna to human predation with confidence, it is difficult to be sure how significant these resources were for Neanderthal subsistence strategies (Erlandson 2001, 321). The data we have obtained further strengthen the conclusion that the shell remains from Vanguard Cave evidence deliberate Neanderthal collection, for the reasons outlined earlier. This implies a selective and well planned harvesting action, elucidating one aspect of the adaptation and resource management strategy of the Neanderthals of Gibraltar.

Coastal adaptation

The question of the antiquity of coastal adaptation by prehistoric communities is particularly challenging, often hindered by taphonomic and preservation issues and, generally speaking, impeded by methodological, interpretive and theoretical biases. For many scholars, water has been seen as a physical and psychological barrier, under-utilized in terms of its resource opportunity until the late Upper Palaeolithic (Washburn and Lancaster 1968, 294; Osborn 1977, 157–158; but see Sauer 1962). Yesner (1987, 733) has considered the presence of marine food remains at early sites dating to the Middle Stone Age in Africa (e.g. Sea Harvest, Hoedjies Punt, Klasies River Mouth and Haau Fteah) and Europe (e.g. Terra Amata and Devil’s Tower) as evidencing only isolated instances of the use of marine resources. Strauss (1990, 291) argued that Middle Palaeolithic people ignored aquatic foods. When Gamble (1994, 10, 182–202) listed four important ecological settings as significant to human evolution in the Old World (major habitats: plains, deserts, mountains and forests, and ten sub-settings), no aquatic habitat was listed.

Once again, recent work (Walter et al. 2000; Erlandson 2001) has significantly altered our perception of this issue. On the one hand, a range of archaeological evidence for hunter-gatherer adaptation to coastal marine environments has been identified, some of which is contemporary with the Gibraltar sites (in Figure 22.9 are shown archaeological sites from around Europe and North Africa associated with archaic Homo/Neanderthal industries and reported to contain shellfish remains). On the other, ecologic and ethnographic observations have clearly illustrated the high levels of productivity and species diversity associated with ecotones (Odum 1983, 430–435), the transitional zones between different ecosystems. People living in such areas maintain greater capacity for diversification and are able to maximize their subsistence strategies by drawing on multiple ecosystems and the resources they contain. Turner et al. (2003, 444) have argued that such optimal zones might embrace marine or estuarine environments, well known for their consistent biomass productivity, with woodlands close by. We may find parallels with the situation in Gibraltar as adaptation to an ecological edge-zone and exploitation of the nearby aquatic resources are evident amongst the human occupants of the caves in Gibraltar during the last interglacial.

Wider consideration of this type of coastal adaptation is hampered significantly, of course, by changes in sea-level during the Pleistocene, which have resulted in the inundation of large tracts of land, and with it archaeological sites. Climate oscillations and sea-level variations have accelerated the erosion of coastal sites and seriously blurred, if not obliterated them, and along with these any evidence for earlier coastal settlement and marine resource exploitation. Fortunately, this is not the case with Vanguard Cave during the last interglacial, when sea-levels were much higher (Shackleton et al. 1984, 313) and the local shoreline would have close to where it is today (see Chapter 3).

Despite the inherent difficulties in addressing issues such as these, there is a growing consensus that perceptions that ‘peripheralize the significance of aquatic habitats in human subsistence patterns, relegating them to an essentially incidental role’ (Erlandson 2001, 289) can no longer be valid at a universal scale.

Shellfish exploitation

Generally speaking, shellfish collection is not particularly labour-intensive and requires minimal specialization for the prehistoric forager (Mannino and Thomas 2002, 469). Ecological sampling implies that the common mussel is able to return high outputs of calories. Kopp et al. (2005) recently found, for instance, after cage experiments with Mytilus galloprovincialis, that the content in lipids and proteins reaches a maximum in early spring and late winter, respectively. Traditionally, shellfishing has been associated with a summer collecting season, in the main because it was thought that winter conditions in many locations were too severe for marine shellfish gathering (Lightfoot and Cerrato 1988, 142). However, actual case studies from archaeological accumulations or shell middens support a different conclusion. Several examples from the literature, such as the Sungic midden site in New York (Lightfoot and Cerrato 1988), Nelson Bay Cave in South Africa (Shackleton 1973), research from various Cantabrian sites (Deith 1983b; 1986), Moscerini Cave in Italy (Stiner 1994) and Shag Mouth in New Zealand (Higham 1996) inter alia, have consistently produced a picture of early/late spring shellfishing, as well as a possible year-round occupation or visitation of the sites. This pattern supports a model of shellfish consumption in many contexts during the late winter to mid-spring months, when there is general dearth of other resources. Shellfish comprise a secure and dependable food source, often exploited when other resources are
scarce. Whilst these examples are interesting in the light of our results, it is important to remember that they mainly relate to much more recent periods.

**Further work**

As far as the Gibraltar case is regarded, we cannot of course assess seasonality in detail by examining a unique, one-off event from a single site. The major problem when attempting to determine the function of Vanguard in terms of seasonal occupation and place it within the context of an overall settlement system is that whereas the evidence of Middle Palaeolithic occupation in the area is abundant no major, wide-scale seasonal studies have been attempted.

Mussel shells are relatively common in Palaeolithic archaeological sites around the Mediterranean compared with other species. There is, therefore, considerable potential for these methods to be applied to other archaeological assemblages to evaluate further issues such as behavioural and cultural similarities and differences attributed to human species in terms of environmental adaptations, subsistence strategies and resource scheduling, site-use patterns and more.

**Conclusions**

A seasonal date has been obtained for the Neanderthal shell assemblage excavated at Vanguard Cave, Gibraltar. Shells that were well preserved yielded consistent results, showing mid-spring collection from a nearby marine or estuarine environment. This is the first time, to our knowledge, that Middle Palaeolithic shellfish remains have been analysed incrementally in order to determine a seasonal date. Its success raises exciting prospects for future work in the area.

Some mollusc species appear to be problematic for use in growth-ring analysis, not only because it is difficult to identify the annual rings and distinguish them from random surficial disturbance rings, but also because even in section the growth lines can be obliterated. Thus, the species under investigation should be already tested for suitability and the preservation issues regarding the fossil shells should be considered before bivalve growth increments are used as seasonal indicators from archaeological sites. Any future research requires a modern control collection, preferably with the same species from the same location (if known) to that of the archaeological material, which would enable the proper interpretation of the archaeological data. Within the framework of this brief investigation, only a small study was able to be made of a modern control, but the results were very encouraging.

The presence of other later Neanderthal contexts containing shell midden remains along the Iberian coast suggests that this methodology could be extended far more widely. Molluscan shells are also relatively common in Palaeolithic archaeological sites around the Mediterranean Rim. Hence, there is considerable potential for these methods to be applied to other archaeological assemblages to construct a more complete pattern of seasonal site use,
mobility and coastal adaptation among both Neanderthals and modern humans, in Europe and the Levant.

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