

Sorry, Wrong Phylum: A Neophyte Archaeomalacologist's Experiences in Analyzing a European Atlantic Sea Urchin Assemblage

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ABSTRACT: This paper discusses a recent approach to analyzing the sea urchin remains recovered from a pit of the Gallic Empire era of the Roman period above the Baie de Lannion, northern Brittany, France. Possible solutions for northeast Atlantic urchin assemblages to some problems which all archaeo-zoologists face (identification, the generation of MNI data, diagnosis of butchery methods, and reconstructing the nature of the population exploited) are outlined. The implications for the state of the discipline of archaeomalacology of the diversity of sources consulted, and a number of instances of parallel work by others, are discussed.

KEY WORDS: ARCHAEOLOGY, URCHINS, IDENTIFICATION, QUANTIFICATION, METHODS

RESUMEN: Este trabajo expone un modo de actuación aplicado al análisis de los restos de erizos de mar recuperados en un hoyo de la era del imperio galo correspondiente al periodo romano sobre la bahía de Lannion (Bretaña Septentrional, Francia). Se señalan una serie de soluciones para problemas comunes con los que se encuentran los arqueozoólogos al estudiar las muestras de erizos de mar del Atlántico nordoriental, entre los que se incluyen la identificación, la estimación del NMI, la diagnosis de los métodos de fracturación y la inferencia de la naturaleza de la población explotada. Asimismo se valoran las implicaciones de todo ello para el desarrollo de la arqueomalacología en relación con la diversidad de fuentes consultadas y los casos de trabajos en paralelo desarrollados por otros investigadores.

PALABRAS CLAVE: ARQUEOLOGÍA, ERIZOS, IDENTIFICACIÓN, CUANTIFICACIÓN, MÉTODOS

INTRODUCTION

The site

Le Yaudet (48°43' N, 3°31' W) is a small steep-sided isthmus commanding the estuary of the River Léguer in the southeast corner of the Baie de Lannion, on the Côtes d'Armor of northern Brittany, on the Atlantic coast of France (Figure 1a-c). A joint excavation over several years by the Institute of Archaeology at Oxford University and Le Centre du Recherche Brettone et Celtique at the University of Brest (Cunliffe & Galliou, 2005) has shown that the isthmus has been occupied at least intermittently since the Neolithic. Le Yaudet was fortified as an *oppidum*, and the defences supplemented (Figure 1d) during the La Tène Iron Age (c. 150BC- c. 10BC). Occupation continued into the early part of the Roman period (c. 10BC- AD 260), with the defences and layout re-modelled in the late Roman period (AD 260-300). The site was occupied from about the 6th Century AD into the medieval period, probably by an ecclesiastical community, and was a rural agricultural settlement in the later medieval period (c.11th - 15th Century AD).

Shell preservation was poor, since the deposits were the coarse free-draining acidic types typical of a granite outcrop. Nevertheless, some samples produced sizable numbers of marine shells. In the end the excavations produced some 28,000 shells from 22 deposits. The proportions of edible species from different habitats showed the bay was dominated by rocky shores and lacked an extensive estuary until the medieval period (Campbell, 2007).

Sea urchin remains were visible in the base of a large shallow pit (Feature 1081) dug during the Gallic Empire (AD 260-300) in the yard behind one of a row of small wooden structures (Figure 1e). Therefore the base fill (deposit 700) of this pit was sampled specifically for urchin remains, but samples taken for shells and charred plant remains from later fills in the same pit also contained urchin remains. In fact, urchin remains ranged in age from the late Iron Age to the late medieval. The application of some previously applied techniques and some novel approaches to the urchin-rich Gallic Empire pit fill 700 are discussed here. The full analysis of the urchin remains is included in the interpretation of the marine invertebrate remains from the site (Campbell, 2007).

Sea Urchin Biology

Sea urchins are marine invertebrates in the Phylum Echinodermata, the starfishes and related animals. Urchins, or 'regular echinoids' [the Order Cidaroida and the Superorder Camarodonta (Smith, 2005)], are typically a flattened spherical shape (Figure 2) with the anus in centre of top, the mouth in centre of the base, and the surface bearing numbers of prominent maneuverable spines and less obvious tube-feet. The tests are elliptical in a few urchins [in the camarodont subfamily Echinometrinae (Smith, 1988: 348, 2005)]. Ranging from low tide to hundreds of fathoms down, urchins are intensive surface grazers, and herbivores of seaweeds and sea-grasses, on stable shores from the sub-littoral fringe to the lower limit of good illumination. Here, their grazing determines the structure of the habitat, by controlling the type and extent of the seaweed cover (Smith, 2005). They are critical in maintaining two of the ocean's largest and biologically richest habitats: temperate kelp forests (Steneck *et al.*, 2002: 440) and tropical coral reefs (Morrison, 1988).

Sea Urchins in Archaeology

Sea urchins are useful for understanding the human past, principally because their use for food is long and widespread. Urchins have been used as food since at least 15,500-16,000 years ago, in Atlantic Spain (Menéndez *et al.*, 1986: 286). Urchin remains from prehistoric Pacific cultures include New Zealand (Best, 1929), East Timor (Szabó, 2002), Hawaii (Jones, 2001), South America (Jerardino *et al.*, 1992; Lavallee *et al.*, 1999) and especially Pacific North America (Desautels *et al.*, 1971; Green, 1999; Erlandson *et al.*, 2005: 16; Sumpter, 2005: 136-172). North Atlantic examples include prehistoric North America (Black, 1993: 59), and Europe in the Mesolithic (Gutiérrez Zugasti, 2006) and Neolithic (Gruet, 2003). Mediterranean urchins were eaten from at least 10,000 years ago, the end of the Epipalaeolithic (Reese, 1999: 188). Urchins were eaten by the Minoans (Reese, 1995) and the Phoenicians (García & Moreno, 1994: 183-4; Reese, 2003: 414). Roman urchin recipes survive (Apicius IX, 8), and the few reported Roman urchin remains include Pompeii (Ciaraldi, 1997) and the Red Sea port of Berenike (Van Neer & Ervynk, 1999).

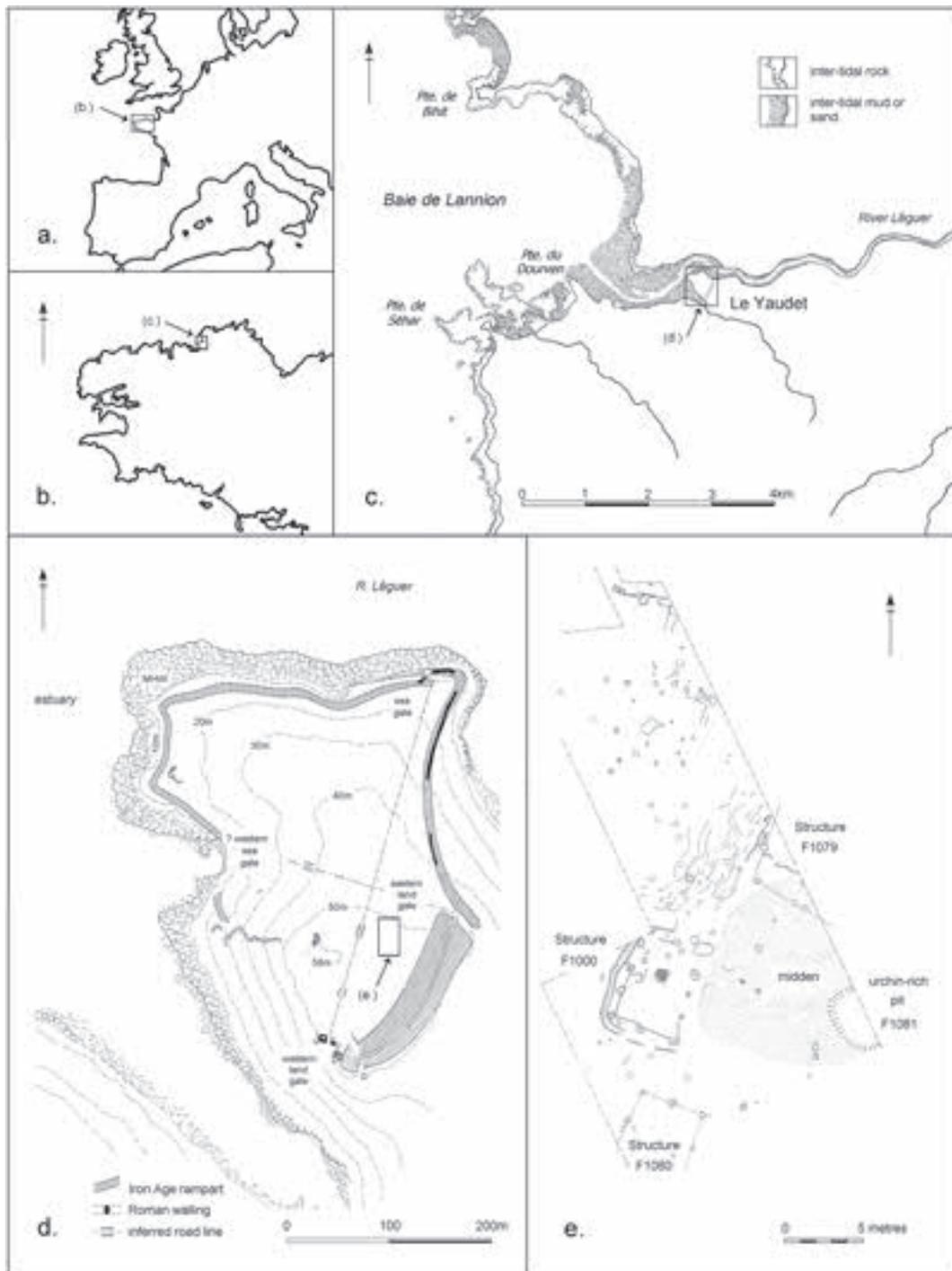


FIGURE 1

Location of Le Yaudet, and archaeological features associated with urchin remains. (a): W Europe (& some of NW Africa) showing the coast of Brittany. (b): N & W coast of Brittany, showing the Baie de Lannion. (c): The Baie de Lannion and Le Yaudet. (d): Topography and principal archaeological features of Le Yaudet. (e): Plan of Gallic Empire period urchin-rich pit 1081, associated structure F1000, and adjacent contemporary structures and features. From Cunliffe & Galliou (2005).

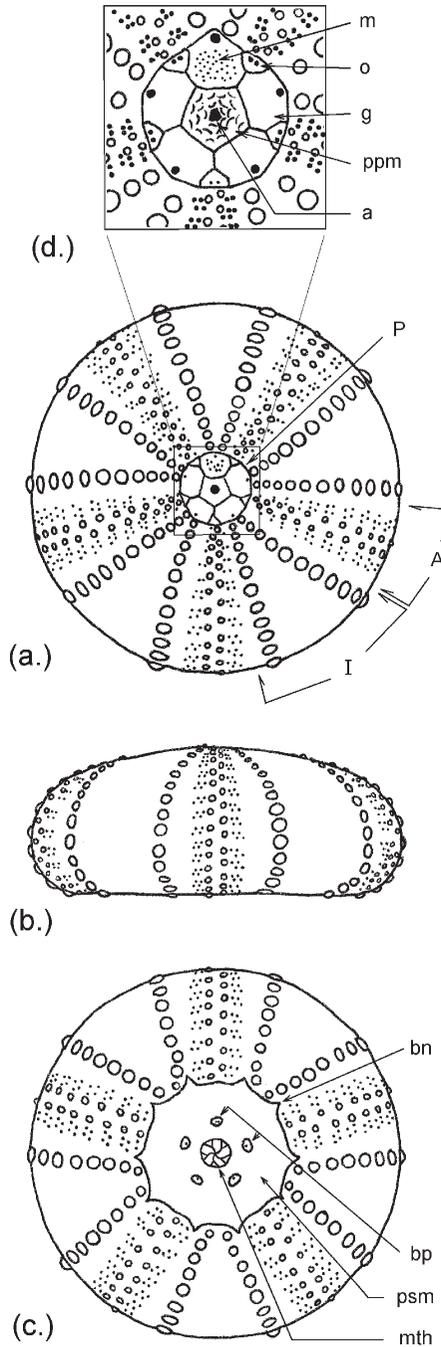


FIGURE 2

Diagram of sea urchin (regular echinoid) test, with pattern of tubercles (circles) and pairs of pores (dots) much simplified for clarity. (a): top view, with anus central. (P), periproct with apical disk; (A), one of the five ambulacral zones; (I), one of the five interambulacral zones. (b): side view, directly facing an ambulacral zone. (c): base view, with peristome central. (mth), mouth; (psm), peristomal membrane; (bp), buccal plate; (bn), buccal notch, formerly called gill-slit. (d): magnified view of periproct, showing apical disk of specialised plates. a, anus; ppm, periproctal membrane with closely-packed plates; g, one of the four genital plates; o, one of the five ocular plates; m, madreporite.

Harvesting sea urchins is simple. They can be collected by hand, from the sub-littoral fringe at low tide or from deeper water by wading or diving. Deeper-water urchins can also be harvested by spearing from the shore or boats. Breton fishermen collected sub-tidal urchins in a mop-like trap called a 'faubert' (Allain, 1975: 198). Human coastal exploitation can indirectly affect urchins and their habitats. Near-extinction of kelp-forest apex predators caused population explosions of urchins which then devoured most of the kelp forest, on the North American Pacific coast through sea otter kill-off for furs, and on the North American Atlantic coast through cod over-fishing (Steneck *et al.*, 2002: 446-7). Prehistoric over-exploitation of the same species probably produced smaller-scale 'urchin barrens' in the same regions (Steneck *et al.*, 2002: 447). Reduction in predatory fish on coral reefs through over-fishing also inflates urchin populations and the effects of grazing (McClanahan & Shafir, 1990).

Urchins are useful indicators of seasonality. The edible portion is the roe, and the roe bodies are large enough to eat for only a few consecutive weeks in a year (at least in middle and high latitudes). They aid with reconstructing former climate, because each species has a different sea temperature tolerance range (although ranges can overlap). They also aid in understanding the shore type being exploited, since each species also has a different tolerance range for salinity and for exposure to wave action, and since the size and age distribution of a given species differs for different habitats. This archaeological potential has been under-exploited because an understanding of molluscs or vertebrates confers little advantage when faced with urchin remains.

Sea urchin solid anatomy

Urchins do not have shells like molluscs; they have tests made up of *test plates*. Each plate is a single calcite crystal, which is porous, and most of living tissue of the animal lies within these pores. The plates for the bulk of the test are held together at their margins by strong sutures (somewhat like the sutures between vertebrate cranial bones). The test is composed of five ambulacral zones (Figure 2a) in which the plates have rows of pores arranged in pairs (for the 'hydraulic fluid' which maneuvers the tube-feet) and tubercles (knobs for the bases of the spines). These ambulacral zones

alternate with five interambulacral zones in which the plates have tubercles only (Figure 2a).

Sea urchins are the spiniest of the echinoderms, and the *spines* are frequently coloured. This colour can be retained almost indefinitely. In the centre of the barrel-like base is an acetabulum (a shallow concave hollow which articulates with a tubercle on the test). Camarodont urchins (which are more common in temperate and cold oceans) each bear thin needle-like spines with fine sharp longitudinal ridges, in large numbers with a wide range of lengths on an animal. Cidaroid urchins (which are more common in tropical and sub-tropical seas) each bear relatively few thick blunt spines with shallow ribs, hooks or knobs on the shaft.

In the centre of the top of the test lies the periproct ('P' in Figure 2a; Figure 2d), in which the plates are weakly sutured. The five *ocular plates* ('o' in Figure 2d), one at the upper end of each ambulacral zone, are small heart-shaped plates with holes opposite the point ('o' in Figure 3). The five *genital plates* ('g' in Figure 2d), one at the upper end of each interambulacral zone, are irregularly pentagonal plates each with a hole near one apex ('g' in Figure 3). One of these, the *madreporite* ('m' in Figure 2d) is enlarged into a roughly equilateral pentagon, and visibly porous ('m' in Figure 3). Within the ring defined by these elements is the periproctal membrane ('ppm' in Figure 2d) with numerous near-microscopic plates, surrounding the centrally placed anus ('a' in Figure 2d).

The mouth ('mth' in Figure 2c) with its protruding teeth lies centrally in the base of the animal. The space between the mouth and the test is covered by the tough peristomal membrane ('psm' in Figure 2c) which is densely packed with small plates in the cidaroids. In the camarodonts the membrane is sparsely packed with near-microscopic plates; the only sizable ones are the five pairs of *buccal plates* ('bp' in Figure 2c), small and D-shaped with a perforation near the distension ('b' in Figure 3). The margin of the test to which the peristomal membrane attaches is incised by five pairs of buccal notches ('bn' in Figure 2c), called 'gill-slits' in the older literature; these are shallow in some urchin species and deep in others. Inside the margin is a ridge, the perignathic girdle, which bears pairs of inward extensions for the muscles which align the jaws. Cidaroid urchins have apophyses (simple sub-rectangular pads from the base of the interambulacral zone) while camar-

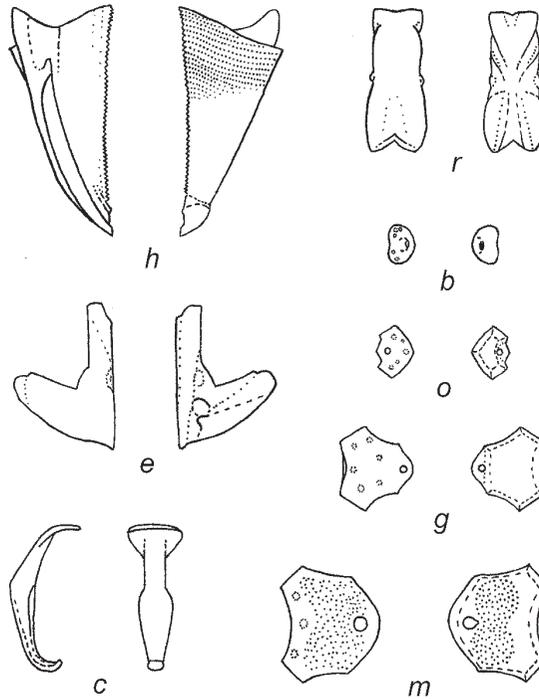


FIGURE 3

Sea urchin non-test elements recovered from Le Yaudet. Elements from the jaw or Aristotle's lantern include the hemipyramid (h), the epiphysis (e), the compass (c), and the rotula (r); buccal plates (b) from the membrane around the mouth; ocular plates (o), genital plates (g) and madreporites (m) from the periproct at the top of the test. Scale approx 1:5.

odonts have *auricles* (extensions of the ambulacral base plates of varying complexity, often arched towards each other and fused together at the tips: Figure 4).

Within the animal, just above the peristomal membrane, lies the urchin's jaw, a complex structure also called Aristotle's lantern. The jaw is made up of

- Five *teeth*. An urchin tooth (a gentle spiral or open comma in shape) grows continuously throughout life, to compensate for continuous wear through grazing. Each tooth sits flat in the same plane as the centre of an ambulacral zone, with the outer end of the spiral (the 'tail' of the 'comma') downwards (so the tooth emerges through the mouth in the centre of the base of the animal). Teeth are hard, brittle and easily broken. Cidaroid urchins have a tooth with a U-shaped cross-section, resembling roof-guttering. Camarodont urchins have a tooth with a T-shaped cross-section, resembling railway track.

- Ten *hemipyramids* ('h' in Figure 3), thin flat plates in the shape of a right triangle with a short leg about half the length of the longer; one face of the plate is covered with parallel fine weakly sinuous grooves. The other face of the plate bears a thin ridge parallel with and set slightly back from the hypotenusal side; this ridge thickens and expands away from the plate towards the point where the hypotenuse meets the long leg, projecting beyond the plane of the outer face as a blunt hoof-like tip. This thicker curved part of the ridge bears a flat crescentic face in both places, with the concave edge (facing towards the long leg of the triangle) bearing a slight step to make a small groove (the dental slide). Hemipyramids are paired in the jaw. Mirror images articulate along the long leg of the plate and the flat crescentic face on the ridge, with a tooth held in the dental slide, so one hemipyramid sits clockwise of the tooth (when viewed from above), and the other in

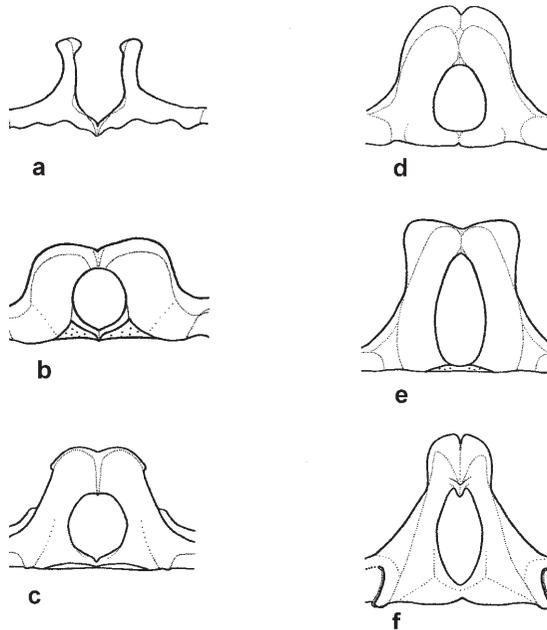


FIGURE 4

Auricles of the various genera of the near-shore regular echinoids of Atlantic Europe. Side shown is that facing the jaws. a: *Arbacia*; b: *Psammechinus*; c: *Echinus*; d: *Paracentrotus*; e: *Strongylocentrotus*; f: *Sphaerechinus*.

the pair sits counterclockwise. A hemipyramid resembles an odd jawbone from a small rodent, or a tiny shoulder blade.

- Five pairs of *epiphyses* ('e' in Figure 3), short shafts roughly sub-rectangular in cross-section which are met at an angle by a longer shaft roughly square in cross-section. An epiphysis resembles a tiny axe, or a Roman letter V with the thicker arm shortened.
- Five *rotuli* ('r' in Figure 3), shafts with a rounded D-shape in cross section, bearing a transverse cylindrical process with a slight central v-notch at one end, and a distinct central v-notch at the opposite end. The cartoon 'dog-bone' of Green (1999: 145), a rotula resembles a miniature pig's metatarsal.
- Five *compasses* ('c' in Figure 3), shafts with a rectangular cross-section, with one end (bearing small wing-like flanges to give a T-shaped cross-section) tapered and curled round the flanged face to form a hook. The other end of the shaft tapers and the end bears a wide transverse plate which is bent in the

same direction as the hook. An intact compass resembles a capital letter 'T'.

The solid parts of the urchin are described in many good biology textbooks, and online at a site dedicated to echinoids maintained by the Natural History Museum, London (Smith, 2005), on which much of this description is based. Sea urchins are seldom found whole after death. The spines, periproct, and jaw come free of the test and the jaw disarticulates because the soft tissues holding them together rot, and the urchin test usually collapses along plate sutures (Smith, 1984: 15-16).

LE YAUDET URCHIN REMAINS: RECOVERY

A sample of was taken from context 700, the base fill of Gallic Empire pit 1081 (Figure 1e) for urchin remains. A sub-sample of 3.0 ± 0.1 kg weight without air-drying (2.0 ± 0.2 litres) was taken for comparison of the deposit's composition

with a series of samples of similar weight from other shell-rich deposits at the site. The sub-sample was then gently disaggregated in water, and washed through a stack of 10 mm, 6 mm, 2 mm and 1 mm sieves. The resulting fractions (>10 mm, 10-6 mm, 6-2 mm and 2-1 mm) were rinsed, air-dried, and sorted for urchin remains.

The remainder of the bulk sample (11 litres in volume) was wet-sieved through a 10 mm mesh and processed by mechanically aided washover flotation for charred plant remains, retaining the sample on a 0.5 mm mesh. The residue was wet-sieved through 4 mm and 1 mm mesh. The resulting coarse (>10 mm), medium (10-4 mm) and fine (4-1 mm) fractions were air-dried. When fully dry the coarse and medium fractions were sorted to extract remains. The fine fraction was dry-sieved through 2 mm mesh and the 4-2 mm fraction sorted to extract urchin elements other than spines.

All the elements italicised in the section on anatomy above (including those illustrated in Figure 3) were recovered. However, in this manifestly urchin-rich deposit (11.6% of the 3.0 kg sub-sample's weight was urchin remains), only 9.8% of the weight of remains was greater than 10 mm, and only 23.5% was greater than 6 mm (1/4"). Urchin fragments bigger than 10 mm indicate exceptionally well-preserved urchins. Finding no urchin fragments in sievings over 6 mm does not show there are no useful urchin remains in a deposit.

The 2-1 mm fraction of the 3.0 kg sub-sample contained 16% of the urchin remains by weight (57.4 g of the total 347.9 g recovered), over half the weight of the spines, and significant numbers of the smaller elements. Therefore the 2-1 mm fraction of the sample of the urchin rich Gallic Empire fill 700 was also sorted for the elements illustrated in Figure 3. Sorting the 2-1 mm fraction recovered all the ocular and buccal plates, nearly all the compass fragments, over three-quarters of the tooth fragments, and a fifth of the genital plates. Elements critical for MNI, animal size, growth rate, and demographics were only retrieved by sorting down to 1 mm. Sorting to 1 mm would be even more important for naturally small species, or for populations of small animals in a larger species.

Spines were usually coloured (usually pale purple, sometimes pale green) and usually broken, with the base and lower part of the shaft recovered. Most of the tests were recovered as loose single

plates, or squarish fragments of two to five plates. No test fragment bore an ambulacral or interambulacral zone complete from peristome to periproct. Other elements were found to be broken in substantial numbers, so only elements with the consistently well-preserved portion were counted. Madreporites were usually complete, occasionally found with a corner or two missing. Genital, ocular and buccal plates were only found whole, since once broken they were too small to be recognisable or recoverable. Auricles were quite well-preserved, but seldom whole (paired, with the central hole) and often with the edges damaged. Auricles were counted as either whole, or as a fragment originally clockwise or counterclockwise from the central hole (as viewed from above, within the animal). Teeth were always found broken; any tooth fragment was counted as one (thus overestimating the number of teeth recovered). Clockwise and counterclockwise hemipyramids were counted separately. The narrow part of the ridge, the hoof-like tip, and in some cases the flat plate could all be lost. A hemipyramid was counted if the expanded portion of the ridge bearing the crescentic face was present. The V-shaped portion of each epiphysis was counted, whether one or both arms were still attached; it was common for the thinner arm to be missing. Most rotuli were found whole; all rotuli or fragments with the broad V-notch were counted. Compasses were usually broken, lacking the hook and the edges of the transverse plate; a compass fragment was counted if the junction of the transverse plate with the shaft survived.

Since the relative proportions of the various elements in an urchin are known, the relative preservation of the different elements can be assessed by comparing the proportions recovered to the proportions expected. The best-preserved elements of the jaw were the hemipyramids, with 419 clockwise and 427 counterclockwise recovered. The number of rotuli in an urchin is the same as the counterclockwise hemipyramids, so the 379 rotuli recovered represents 89% of those expected in the sample; the rotuli were therefore slightly less well-preserved than the hemipyramids. Other jaw elements were more poorly preserved than the rotuli (compasses 69% of the expected, epiphyses 67%, teeth 56%). Auricles were well-preserved (clockwise 94%, counterclockwise 83%). Periproctal elements were under-represented in this sample (genital plates 47%, madreporites 41%, ocular plates 3%), although madreporites and genital plates were the best-preserved ele-

ments in other Le Yaudet samples. The 3.0 kg subsample had identifiable elements in about the same relative proportions as in the bulk sample, so processing by mechanical flotation does not seem to bias recovery.

LE YAUDET URCHIN REMAINS: RESULTS

Identification

The seven species of Atlantic European urchin which are found from the inter-tidal to easy diving depth (Mortensen, 1927; Hayward *et al.*, 1996: 292-4) are all camarodont. The northern sea urchin *Strongylocentrotus droebachiensis* (Müller, 1776), an Arctic animal now rare south of Shetland, may have ranged further south in colder climates. The common sea urchin *Echinus esculentus* L., 1758 and the green sea urchin *Psammechinus miliaris* (Gmelin, 1778), of temperate seas, range from north Norway to Portugal. The violet sea urchin *Paracentrotus lividus* Lamarck, 1816 and the purple sea urchin *Sphaerechinus granularis* (Lamarck, 1816) are principally Mediterranean species with Brittany as their present northern limit; the latter is the only European Atlantic species with deep buccal notches. The black sea urchin *Arbacia lixula* (L., 1758) and the Mediterranean green urchin *Psammechinus microtuberculatus* (Blainville 1825) are Mediterranean species now restricted to south Portugal that may have ranged further north in warmer climates.

Spines are not a good means of identification, especially when broken, because any urchin can have a wide range of sizes and colours, and spine structure is very similar amongst camarodonts. Generally the various species are identified by their test surface patterns, especially the typical number of pore-pairs on their ambulacral plates (Mortensen, 1927; Smith, 2005). *Arbacia* has three pore-pairs on small pentagonal ambulacral plates usually with only one tubercle. *Echinus* and *Psammechinus* have pore-pairs arranged in rows of three on a distinctly rectangular ambulacral plate, the latter commonly with tubercles interspersed with the pore-pairs. *Sphaerechinus* has an arc of four pore-pairs. *Paracentrotus* has 5-7 pore-pairs, in arcs curving round one or more tubercles, while *Strongylocentrotus* also has 5-7, in rows separated by rows of small tubercles.

Unfortunately for archaeology, fragmentary urchin test plates are difficult to identify since the different genera can have the same number of pore-pairs on a plate. *Sphaerechinus* can have up to six pore-pairs per plate, overlapping with *Paracentrotus* and *Strongylocentrotus*. Ambulacral plates on the base frequently are reduced in pore-pair number, often down to three regardless of species (Mortensen, 1927: 314). Ambulacral plates near the periproct often have an enlarged number, up to seven or eight for *Paracentrotus* and *Strongylocentrotus*. Younger *Echinus* tests (and therefore the bases of older tests) occasionally have tubercles within the rows of pore-pairs, making them difficult to distinguish from *Psammechinus* ambulacra (Mortensen, 1927: 314; Smith, 2005). One ambulacral test fragment from Gallic Empire pit fill 700 had three pore-pairs per plate and tubercle pattern of immature *Echinus*. The great majority of ambulacral test fragments bore 5-7 pore pairs per plate, with a few with as many as eight or with as few as four. All the fragments with perignathic girdle had shallow buccal notches, making *Sphaerechinus* unlikely. However, pore-pair counts were consistent with either *Paracentrotus* or *Strongylocentrotus*.

Mortensen (1943: 167) noted that *Paracentrotus* and *Strongylocentrotus* tests are almost identical, but can be separated by the shape of their auricles. The author therefore compared the auricle shape of the European Atlantic species in the collections at the Oxford University Museum of Natural History and the Natural History Museum, London, and the author's own small collection. The auricles on mature animals are quite distinct for each genus (Figure 4), ranging in complexity from simple upright pegs with expanded tips (Figure 4a) to elaborate flanged forms (Figure 4f). Urchin-rich Gallic Empire base pit fill 700 contained 751 auricle halves (81 still paired), of which 93.6% were of *Paracentrotus* type, with the remainder too damaged to identify.

Minimum Numbers of Individuals (MNI)

Since each urchin contains a known number of each of the elements illustrated in Figure 3, MNI can be calculated as the maximum value of the counts of the various elements divided by the number of that element per animal. The best-preserved elements in the bulk sample of pit fill 700 were the hemipyramids. Since there are five coun-

terclockwise hemipyramids in an urchin, the 427 recovered gave an MNI of 85, giving a density of 7.7 urchins per litre of sample. In some of the other Le Yaudet samples the madreporites and genital plates were the best-preserved elements, and these were used to calculate MNI. Previously, researchers have based MNI on madreporites and rotuli (Green, 1999) and on hemipyramid count (Szabó, 2002; Gruet, 2003).

Butchery methods

For this urchin-rich base fill 700, the numbers of the well-preserved elements from the top of the animal (genital plates, madreporites) were similar to each other, but much smaller than those expected for the well-preserved elements from the base (auricles, hemipyramids, rotuli). A series of χ^2 tests showed that the well-preserved elements of the top were all present in similar numbers, and the well-preserved elements of the base were also similar, but the number of top elements was statistically very significantly smaller than the number of base elements ($\chi^2 = 70.2$, $P = 5.3 \times 10^{-17}$). Therefore, far more bases than tops were discarded in fill 700.

Since the roe-masses within the test are the edible parts of the urchin, it is common practice to invert the animal, break out the base and jaws, fill up the resulting hole with roe from another urchin, and use the filled tests as natural bowls. This leaves a mass of preparation waste rich in base and jaw elements. It seems this was the type of material discarded to form deposit 700. Significant differences would not be found if the urchins were opened by cleaving the test in half.

The significant differences found between peristomal and basal elements, used to determine butchery practices, have implications for MNI; since tops and bases can be treated differently during consumption, MNI must be based on calculations of elements from both the top and the base of the test.

Size Distributions, and type of shore harvested

Since archaeological urchin remains are typically fragmentary, direct measurement of test diameter is not possible. Even estimates from large fragments are unreliable, because they are so few and because they are biased towards the larger

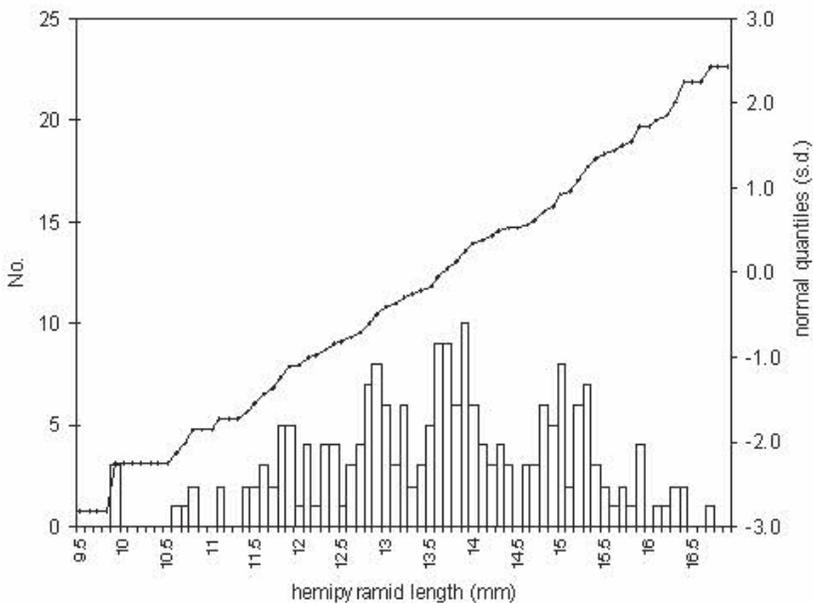


FIGURE 5

Urchin-rich Gallic Empire pit fill 700 intact counterclockwise hemipyramid lengths: 0.1 mm interval count histogram (scale on left) & normal quantile plot (scale on right).

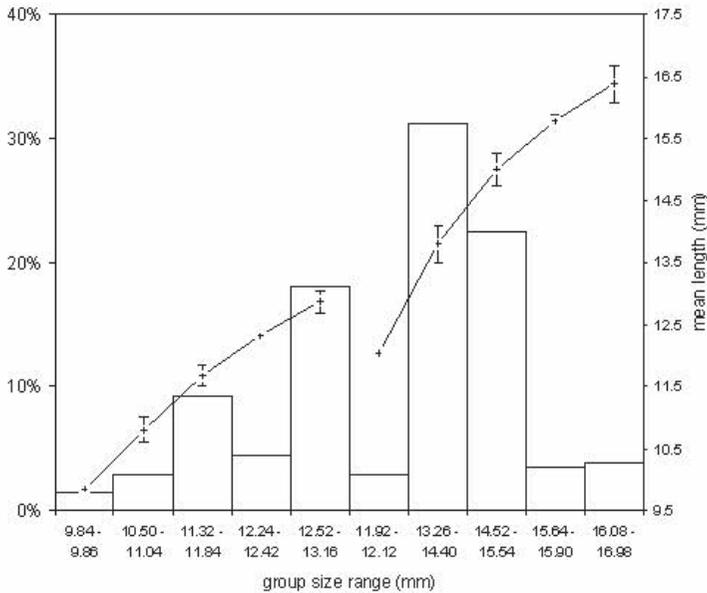


FIGURE 6

Urchin-rich Gallic Empire pit fill 700 intact hemipyramid year groups: group's percentage of the 205 intact (scale on left) & group mean length (scale on right: error bars ± 1 s.d.).

tests. Fortunately an urchin's jaw size (the length of the hemipyramid) is very nearly linearly proportional to the test diameter in a number of species, although the relationship varies between species, and between habitats for the same species (Ebert, 2001).

So the 205 counterclockwise hemipyramids from Gallic Empire pit fill 700 found to be intact under low-power magnification had their lengths (from tip of the ridge to the margin of the hoof-like tip) measured to the nearest 0.1 mm with vernier calipers. The bar-chart in Figure 5 shows the distribution of these lengths as a count histogram. The line in Figure 5 is the same data re-scaled as a normal quantile plot. This re-scaling makes a single normal distribution plot as a straight line while groups of normal distributions appear as a series of flattened S-shaped steps (Sokal & Rolph, 1995: 117). By analogy with the conclusions of Cerrato (1980: 427) on bivalves, each step is probably a year-class. The hemipyramid length data was divided into these putative year-classes, and an average length for the year-class calculated. The results of this transformation (Figure 6) showed the year-class averages traced out two von Bertalanffy curves, a growth pattern common in marine Archaeofauna 17 (2008): 77-90

organisms where organisms approach a maximum average size over time, the growth rate and maximum size being different for different growth conditions (Sparre & Venema, 1998: 47).

The relationship between urchin diameter and hemipyramid (jaw) length for comparable modern populations is sometimes known, or can be established from collections on the modern shore by the researcher. This allows the transformation of hemipyramid data into urchin diameter estimations, and the transformation of the hemipyramid von Bertalanffy curve into a curve estimating urchin size. For Le Yaudet, animal sizes were estimated from the relationship established for modern Breton *P. lividus* by Gruet (2003).

By re-working the formula for the von Bertalanffy curve it is possible to calculate the age of the various groups, and the growth rate and maximum potential size of the population. Working with length data to derive a von Bertalanffy curve, and to derive growth rate and maximum potential size, is also discussed by Sparre & Venema (1998: 63-94).

At Le Yaudet, two populations of urchins were exploited to form fill 700, one small, slow-grow-

ing and dominated by aged urchins (probably from low intertidal shores or rock-pools), and another of urchins that were larger and faster-growing. This population of larger urchins was neither fast-growing nor large compared to modern sub-tidal *P. lividus* in the same bay (Allain, 1975), so it was likely to have lived at or just below the low-tide line.

Hemipyramid lengths have previously been used to estimate archaeological urchin sizes (Gruet, 2003). However, within the author's knowledge, this is the first time hemipyramid length distributions have been used to re-create urchin population demography in archaeology or in palaeontology. The author would be pleased to hear of any such studies.

CONCLUSION

When the directors of Le Yaudet's excavation first presented me with the urchin-rich sample discussed here, it was with the tacit assumption (or perhaps hope) that I had the capacity to interpret the solid remains of any animals without bones. I suspect other shell specialists have been similarly disconcerted by the realisation that what they expected of themselves was considerably less than what was expected of them; for the marine shell researcher this realisation often involves crab fragments or barnacle plates. Having done our best with the arthropods, it is no surprise that some of us have found, when faced with archaeological sea urchins in their typically tiny numbers of typically tiny remains, that one phylum more is simply one phylum too many.

Nevertheless, the interest in archaeological sea urchins is long (e.g. Dall, 1877) and widespread, and has many notable successes. Minimum numbers of individuals can be based on the counts of jaw, peristomal and periproctal elements recovered. Meat yield can be reconstructed accurately from size estimations based on hemipyramid length. And now, urchin assemblages can be identified (or at least assigned to one of a limited number of potential genera) using pore-pair count and auricle shape in tandem. Butchery methods can be studied by comparing anatomical elements of the top of the test, the base and the jaws. Also, demographics can now be reconstructed from hemipyramid length distributions, and the shore being exploited can be inferred by comparison with urchin populations from known habitats. Archaeo-

logical urchins can be put to good use despite their typically small and fragmentary remains. These remains can be very small and fragmentary indeed. The lack of urchins in 1/4" sievings cannot be taken to show urchins are effectively absent from a deposit. Good retrieval relies on methods similar to those required for retrieving fish.

My experiences in searching out previous work on archaeological sea urchins has shown there is much that is encouraging about the present state of archaeomalacology. While researching archaeological methods for interpreting urchins, I found curiosity in the discipline about the remains is global, and that most of the basic methods for interpretation had already been developed. If such an obscure side branch of the discipline is this advanced, it is very likely that most of the interpretive problems we face are solvable, and that many already have been solved. However, we are so few and so widely spread that we can easily become isolated, and laboriously re-create methods that others have already developed. For example, using hemipyramids for urchin MNI has been independently developed at least three times previously (Desautels *et al.*, 1971; Szabó, 2002; Gruet, 2003). To prevent ourselves from 're-inventing the wheel', we must get advances in method out of their hiding places in unpublished theses and site report appendices, and make them widely available. The mutual cooperation and wider dissemination fostered by this new Working Group will be a key part in our discipline's development.

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