

Direct Evidence for Bottom-fishing in Archaeological Whelks (*Buccinum undatum*)

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Summary



Bottom-fishing is a major step in the increase of exploitation of marine resources, requiring specialised craft, technology, and practitioners. However, the onset and development of bottom-fishing is almost impossible to observe directly in the archaeological record, and is usually reconstructed by implication. The shells of common whelk (*Buccinum undatum*) from a kitchen midden at Carisbrooke Castle, Isle of Wight, southern England, showed a pattern of damage characteristic of harvesting by bottom-fishing, rather than the usual baited pots. Some whelks had survived being dredged several times. The very consistent size-shape relationship made it likely the whelks were all from a single habitat, probably in the fast tidal flows typical of the oyster-beds just north of the island. The whelks were harvested along with oysters: the whelks' shells were encrusted in a similar way to the oysters in the same midden, and the whelks even bore sub-adult oysters (spat), despite these being potential prey for whelks. This may be the first time whelks have been shown to have been harvested along with oysters and also seems the first direct evidence for a bottom-fishery for whelks.

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1. Introduction

Putting to sea to fish has been a way of life and an important economic activity for millennia (e.g. Robinson [2013](#)). However, archaeological evidence for specific types of offshore marine fishing is uncommon: the objects and vessels used were usually lost at sea or salvaged and re-used, and most of their components were organic and therefore have not survived (Beltrame [2010](#)). Once-common kinds of fishing vessel have completely disappeared, leaving no historical description or archaeological trace (e.g. Hutchinson [1994](#), 142). Also, the technology employed in the past to fish for a particular catch almost never left direct physical marks on that catch, but has to be inferred from the size and habitat of the catch (Morales Muniz [2010](#); e.g. Barrett *et al.* [2004](#)). The methods for drawing these inferences are quite developed for archaeological remains of consumed shellfish (Campbell [2008](#); e.g. Cabral and da Silva [2003](#); Kent [1992](#)).

The common whelk, edible whelk or buckie (*Buccinum undatum* L., 1758) is one of the consumed shellfish found archaeologically. It is a marine gastropod of the cold North Atlantic (Hayward and Ryland [1995](#), 685–86); its shell is large (up to 165mm: Jeffreys [1867](#), 287), spiral, and sharply conical, with a prominent, open siphonal canal at its base and a distinctive undulating surface with fine spiral ribs (Figure 1). Whelks are highly mobile carnivore-scavengers found across all types of sea-bed, from the low inter-tidal to deeper coastal waters (Fretter and Graham [1962](#), 517–

19) down to 1200m (Hayward and Ryland [1995](#), 686), but usually in waters between 15m and 30m deep (Valentinsson *et al.* [1999](#)).

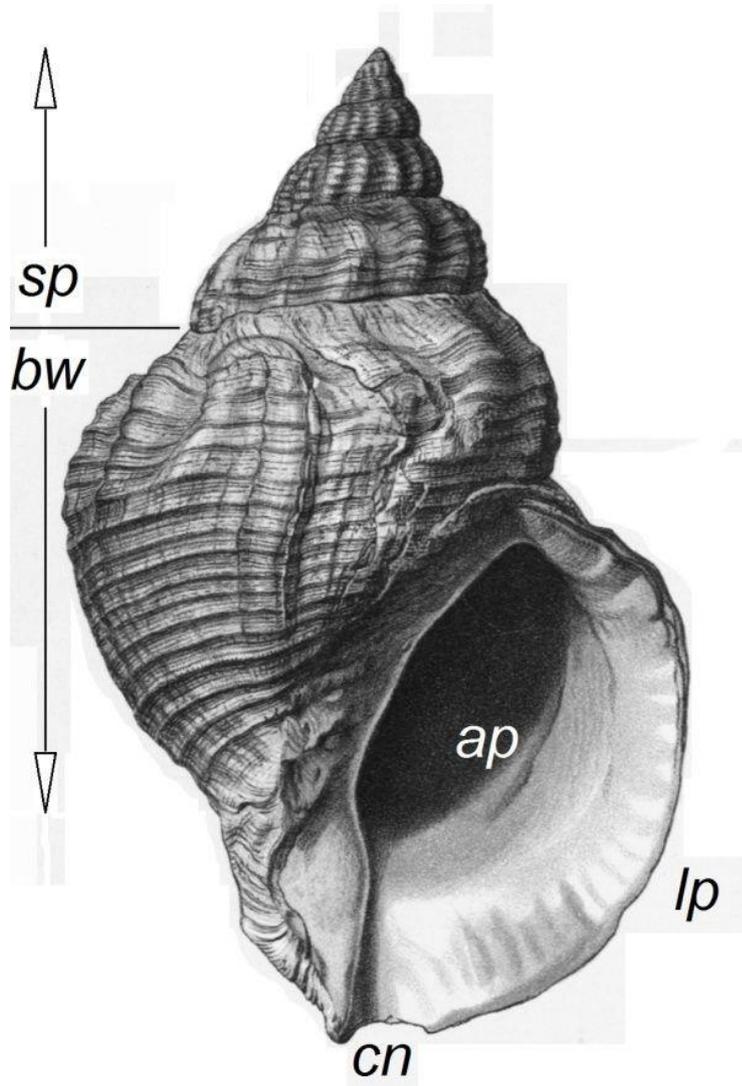


Figure 1: Shell of common whelk, *Buccinum undatum* L. *ap*: aperture; *bw*: body-whorl; *cn*: siphonal canal; *lp*: lip of aperture; *sp*: spire. (Image credit: amended from Dautzenberg and Fischer [1912](#), pl. 4)

Whelks can be fished by both methods of bottom-fishing, bottom-trawling (Mensink *et al.* [2000](#)) and dredging (Hancock [1967](#), 4). In bottom-trawling, a roughly conical net, with its open end weighted and held open by some structure such as a wooden or metal beam (Figure 2a), is dragged ('trawled') behind a vessel along the surface of the sea-bed (Nédélec and Prado [1990](#), 25). In dredging, the structure holding the net open includes a bar at its base (Figure 2b) that scrapes the sea-bed (Nédélec and Prado [1990](#), 31). Dredging seems to be the older method, employed principally for oysters. Oyster-shells with shapes characteristic

of uncrowded dredged beds, not natural reefs, are usual in Saxon (Winder and Gerber-Parfitt [2003](#)), Roman (Winder [1985](#), 93) and prehistoric deposits (Milner [2002](#)). Oyster-dredging has been regulated and taxed in England since the 12th century AD (Eyton [1858](#), 4). Bottom-trawls seem to have developed later; a Royal Commission was set up to investigate their introduction to England in AD 1376 (Engelhard [2008](#), 2). Bottom-fishing requires boats designed specifically for power, stability and sailing a steady course, and equipped with specialised gear for raising, lowering and surviving the dragging of heavy nets, and with a crew who know how to work that gear (McKee [1983](#), 40-41; Rawson and Tupper [2001](#), 689); its onset marks the emergence of a specialised marine fishing technology from general-purpose fishing.

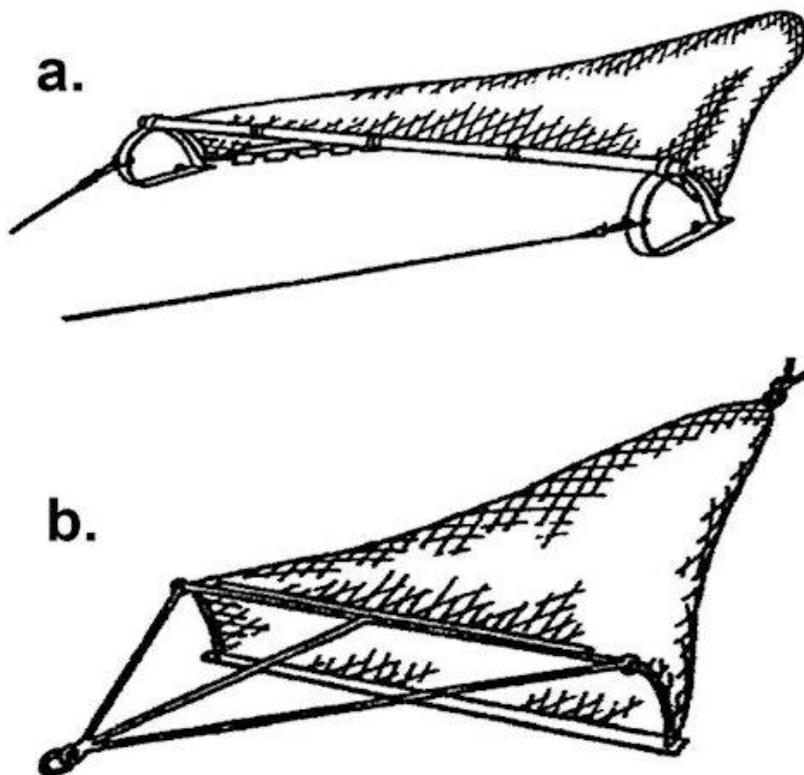


Figure 2: Types of bottom-fishing gear. (a): bottom-trawl of beam-type (b): dredge. (Image credit: after Nédélec and Prado [1990](#))

Bottom-fishing damages the sea-bed (Kaiser *et al.* [1996](#)) and its occupants (Jenkins *et al.* [2001](#)), including the whelks themselves (Mensink *et al.* [2000](#)), contributing to their local extermination (Cadée *et al.* [1995](#)). Therefore, the usual method uses 'pots' of woven wicker or wire, baited with dead fish or carrion (Hancock [1967](#), 4-6), much like

fishing for crab or lobster. This method has been used for whelks for generations (e.g. Jeffreys [1867](#), 289-90).

Whelks are relatively uncommon in archaeological sites in North Atlantic Europe. They are infrequent in the region's Palaeolithic, Mesolithic and Neolithic shell-middens (Gutiérrez-Zugasti *et al* [2011](#); e.g. Dupont [2006](#); Thomas and Mannino [1999](#), 96) including the classic examples in Denmark (Andersen [2008](#); e.g. Nielsen [2008](#)). Whelks were brought to sites far inland in the British Neolithic: a large perforated shell was found at Windmill Hill (Smith [1965](#), 135). They are found occasionally in later prehistoric deposits (Bell [1977](#), 287), in Roman towns (O'Connor [1986](#), 8) and rural settlements (e.g. Cartwright [1982](#), 25), in Viking-era settlements in northern Britain (e.g. Milner *et al.* [2007](#), 1466; O'Connor [1984](#)), in later Saxon English towns (e.g. Winder [1980](#), 125) and coastal sites (e.g. Murray [2001](#)), and in medieval towns (Campbell [2011](#), 5; O'Connor [1984](#)). The recent recovery of a sizeable number of whelks from a single well-stratified deposit at a well-understood site (Carisbrooke Castle) meant those whelks merited detailed analysis.

2. The Site

2.1 Introduction

[Carisbrooke Castle](#) (50°41'13.7"N, 1°18'49.6"W), on the Isle of Wight (Figure 3), is one of England's best-preserved castles (English Heritage [1995](#)), with a well-understood history (Stone [1891](#)) and archaeology (Young [2000](#)). Begun soon after the Norman Conquest of England in AD 1066 as a motte-and-bailey castle on a steep-sided chalk hill previously used as a Saxon *burh*, the castle commands the central part of the Isle, which also has access to the sea by the long, narrow estuary of the River Medina. The motte-and-bailey had been converted into a stone shell-keep before a siege in AD 1136; the medieval domestic arrangements seen today were largely constructed in the mid-13th century (under Countess Isabella de Fortibus, who late in life reluctantly sold the castle to the English Crown). In the face of the threat of Spanish invasion of Tudor England at the end of the 16th century, the interior was

altered to accommodate the residence of the Island's Captain (later Governor), and the whole of the medieval castle was surrounded by an essentially rectangular bastioned trace artillery fort.

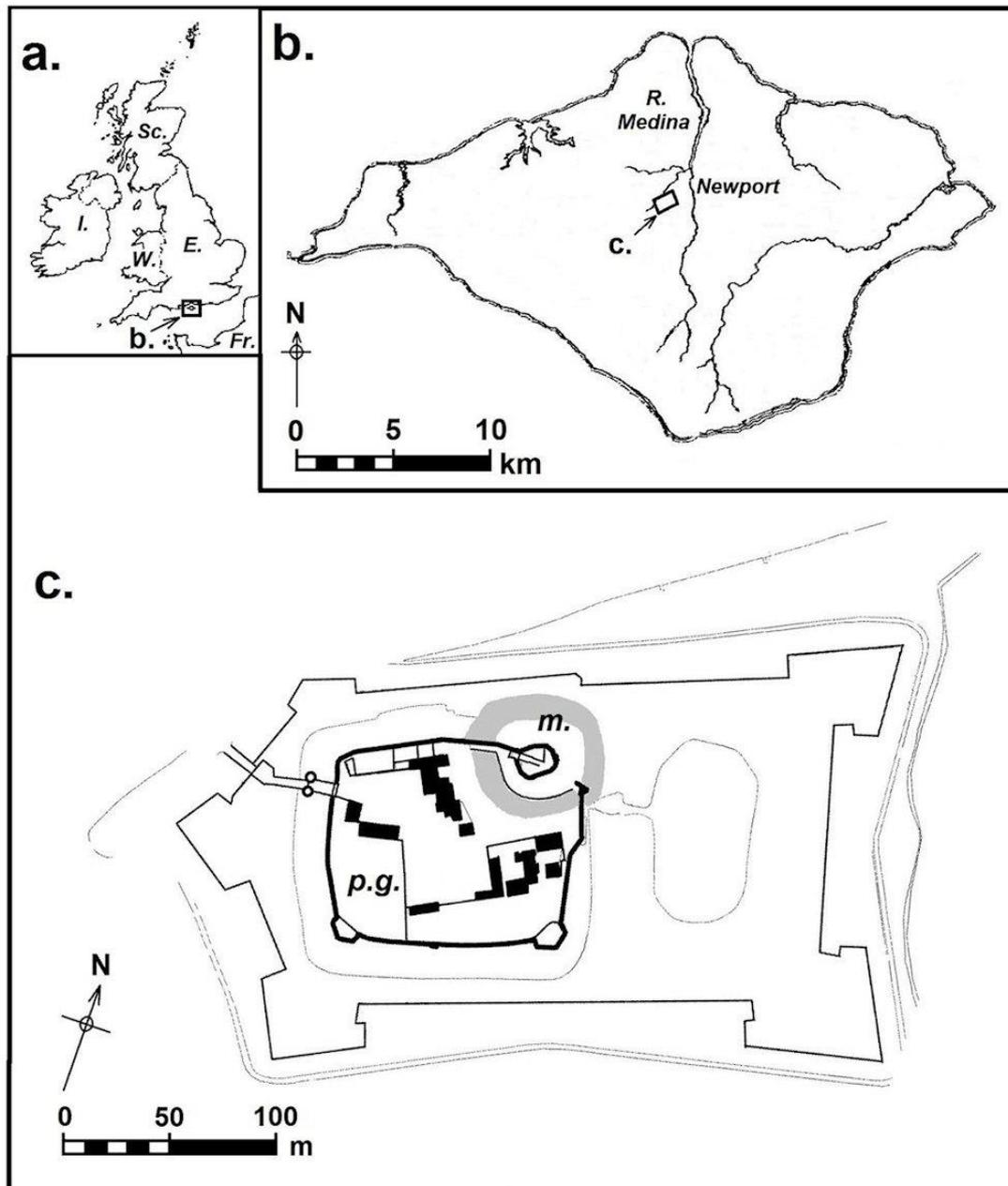


Figure 3: Location of the Isle of Wight, Carisbrooke Castle, and its Privy Garden.

(a): Britain and north-west France, showing location of Isle of Wight (b), England (E); Ireland (I); France (Fr); Scotland (S); Wales (W).

(b): Isle of Wight, showing location of Carisbrooke Castle (c.)

(c): Carisbrooke Castle with motte (m.) and Privy Gardens (p.g.)

The castle remained the defensive and administrative centre of the Isle until the mid-17th century, after its use at the end of the English Civil

War as the prison for Charles I (Britain's last executed king). Practical government was transferred gradually to Newport, the Isle's principal town, at the head of the Medina estuary; the castle continued as the official residence of the Isle's Governor until the mid-20th century. The castle's below-ground archaeological remains are protected by law as a Scheduled Ancient Monument, and most of its structures are similarly protected as Listed Buildings (English Heritage [1995](#)). The castle was taken into the care of the nation under the Office of Works in 1856, and has been managed as an ancient monument open to the public since 1944, currently by the nation's cultural heritage agency, English Heritage.

2.2 The excavation

During 2006 and 2008-9, eight small trenches were excavated by English Heritage archaeologists within the castle's Privy Gardens, in the south-west quadrant of the medieval castle (Figure 3c) under the direction of one of the authors (MR), to assess the impact on the archaeological remains of the area's reinstatement as a formal garden, to inform the design of this garden, and to enhance the understanding of the castle's history and development. This excavation (English Heritage Project 4992) revealed a previously unknown but large, high-status, stone-built cellared chamber-block built in the 12th century, extended during the 13th-14th centuries, kept and altered when adjacent structures were demolished in the 15th century, and finally razed to the ground late in the 16th century. A full report for the project will appear in the *Proceedings of the Hampshire Field Club and Archaeological Society*.

This small excavation produced numerous marine shells (Campbell [2013](#)), comparable with sizeable urban excavations (e.g. Campbell [2011](#)), supplementing the considerable numbers of shell-fish recovered in previous excavations at the castle, which included a small proportion of whelks (Wyles and Winder [2000](#)). One of several kitchen-middens (context 7325) had accumulated against one of the walls of the chamber-block prior to its 16th-century razing. It contained considerable roofing slate, ceramic building material, and edible marine molluscs such as oysters, whelks and cockles. It also contained 17th–early 18th century AD pottery and a pipe bowl of c. AD 1730-1780 from its reworking as a garden soil, so it is safest to consider the whelks to have been discarded early in the modern period (the project's Phase 5).

3. The Whelks from Carisbrooke

Kitchen-midden 7325 was relatively rich in whelks: the remains of at least 59 individuals were hand-retrieved. Whelk preservation was quite good: the four dimensions often measured on whelks (shell height, shell width, aperture height and aperture width) (Figure 4) were measurable or estimable to the nearest millimetre in 32 shells; post-depositional damage to the lip of the aperture in a further 16 meant only the shell height could be measured. Since archaeological whelks are uncommon, these whelks were subjected to full analysis along with most of the marine shells from the project (Campbell [2013](#)). Statistical analysis of the measurements was performed with Version 1.91 of the statistical freeware, PAST (Hammer *et al.* [2001](#)); results were considered significantly different from chance alone if the probability of a result was less than one in 20 ($P < 0.05$).

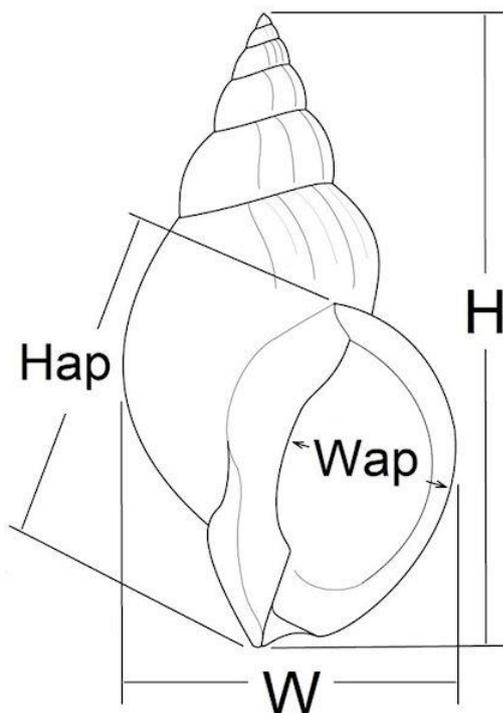


Figure 4: Dimensions (in mm) measured on the intact whelks (*B. undatum*) in midden 7325 at Carisbrooke. H: shell height; Hap: aperture height; W: shell width; Wap: aperture width. (Image credit: after Thomas and Himmelman [1988](#)).

3.1 Size

Are these whelks of a size likely to have been consumed? Usually a whelk's size is measured by its shell height (e.g. Hancock [1967](#), 3). The smaller of these whelks were not more fragmented than the larger: the 16 more broken shells were not statistically different from the 32 intact shells in average shell height (Mann-Whitney $U_{[31,15]}$: 208.5; $P(\text{same medians})$: 0.30) or shell height distribution (Kolmogorov-Smirnov test: $D_{[32,16]}$: 0.281; $P(\text{same distributions})$: 0.31). Therefore the dimensions of the intact shells were a reliable sample of all the whelks.

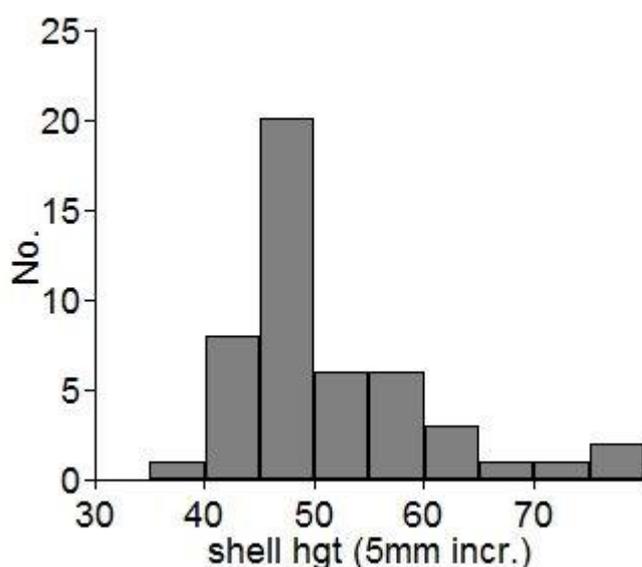


Figure 5: Distribution of shell height in the whelks from midden 7325 (N: 48).

The intact and more-broken whelks combined had shell heights that ranged from 37.7–79.0mm and averaged 51.4 ± 9.1 mm. The distribution of heights (Figure 5) was highly positively skewed (skewness statistic was 1.41, and 15% were over 60mm high). Whelks less than 40mm were really not acceptable for harvest (only one was less than 40mm); this is not very different from the modern European legal landing size of 45mm (EU [1998](#), 29). The sizes were similar to modern southern English whelks: those potted recently off Deal in Kent ranged from 31–89mm, averaging 54.3mm (Shelmerdine *et al.* [2006](#), 2).

3.2 The type of sea-bed harvested for whelks

Were these whelks all harvested from the same type of sea-bed, and (if so), what type? It is sometimes possible to use shapes of shells to assign them approximately to the place in the sea where they lived. An organism's shape varies with size (Gould [1966](#), 588). The stresses and strains on its body from physical forces in the environment vary with size because its weight, volume and surface area all alter with growth; therefore its body and its parts must alter in shape as the organism grows, to compensate for these changes in physical forces (McMahon [1975](#)). Variation of shape with size in living things is termed allometry (Huxley [1932](#), 2), and its study has a considerable history (Gayon [2000](#)). Marine molluscs, living an aquatic life, are inevitably subjected to fluid dynamics effects, which vary with size in complex ways (Vogel [1994](#), 87). Therefore marine molluscs usually grew allometrically, changing shape with size (Seed [1980](#)), both in the present (Gaspar *et al.* [2002](#)) and the past (Reitz *et al.* [1987](#)). Since the typical pattern of environmental forces varies between habitats, the manner in which shape varies with size also tends to vary between habitats, even within a particular species of shell (e.g. Baxter [1983](#)). If the manner in which shape varies with size is consistent within a sample of shells, they are likely to have all come from the same habitat.

The whelks from midden 7325 clearly exhibited allometric growth. The proportion of shell height to width (H/W) is sometimes employed to compare shapes between whelk populations (e.g. Thomas and Himmelman [1988](#), 227), but this ratio was not constant among the Carisbrooke whelks: it increased with size (Figure 6). When the relationship of the ratio H/W with shell height is fitted by the standard regression technique (ordinary-least-squares regression: Sokal and Rohlf [1995](#), 451), that relationship (the 'slope' of the line in Figure 6) was statistically very significantly greater than zero (slope: 0.0025 ± 0.0009 ; one-sample *t*-test: $t_{[30]}$: 2.78; *P*(no relationship): 0.0093).

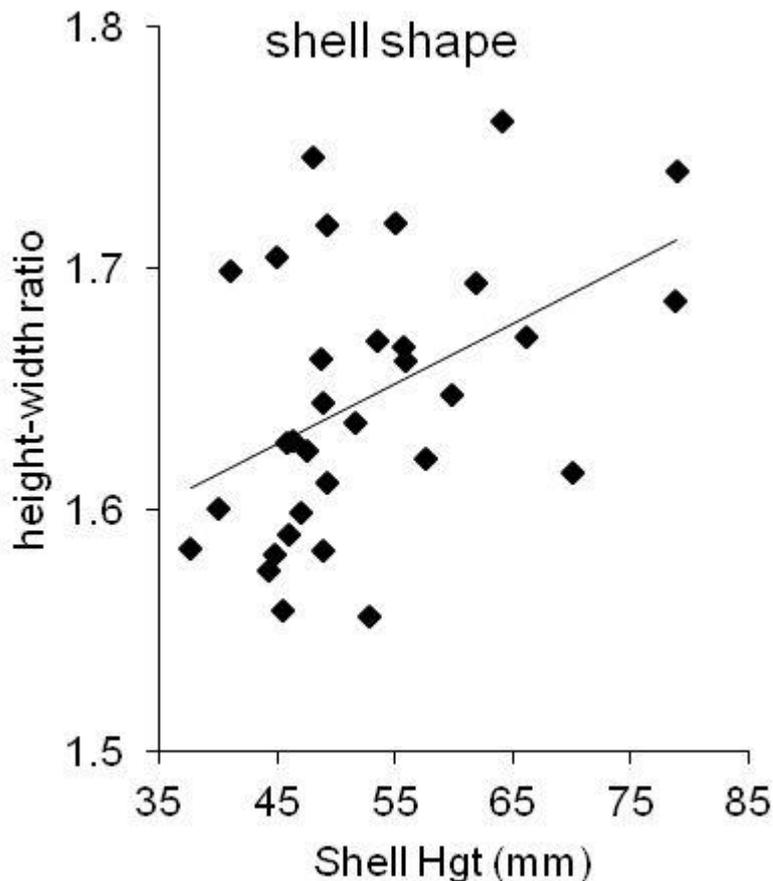


Figure 6: Variation of shell shape (height-width ratio, H/W) with shell size (shell height, H) in the whelks in midden 7325 (N: 36). Line: linear regression fitted by o.l.s.

Usually, the relationship between any two dimensions (x , y) of an organism is exponential ($y = A x^b$), the 'simple allometry' of Huxley (1932, 4-6). Relationships between dimensions are said to show 'isometry' if the exponent (b) is exactly one, and the ratio of two dimensions remains constant; the relationship is 'positively allometric' if (b) is more than one (y is growing faster than x), and 'negatively allometric' if (b) is less than one (Gould 1966, 594). If the relationship is not isometric, and proportions vary with size, graphs of the two dimensions are curved. Fitting linear relationships using linear regression techniques to allometric relationships can appear to produce good results (they can have values of Pearson's correlation statistic, R , quite near to one) but tend to over- or under-estimate in a systematic but complex way, and to produce results that are biologically nonsensical. For these whelks, using the standard linear regression technique (ordinary least-squares linear regression) on the relationship of width with height produced a formula that initially appeared to be a good model (R : 0.986):

$$W \text{ (mm)} = (2.92 \pm 0.93) + (0.551 \pm 0.017) \times (H)$$

However, this linear model demands these whelks have a width before they exist: for a shell height of zero, the formula calculates shell width is typically 2.92mm, and insists, for a shell height of zero, a shell width of zero is extremely improbable (one-sample t -test: $t_{[30]}$: 3.14; $P(W=0)$: 0.0038). Applying linear regression to whelk dimensions has produced similar bizarre results previously, indicating the relationships between dimensions were allometric (Thomas and Himmelman [1988](#), 227).

The exponential relationship between dimensions in 'simple' allometry becomes linear if the dimensions are transformed to their logarithms ($\log y = \log A + b \log x$) (Huxley [1932](#), 4-6). Linear regression techniques (e.g. Sokal and Rohlf [1995](#), 451-83) can then be used to 'fit' a straight line to the data. The slope of the fitted straight line is the allometric exponent (b). The deviations of the points from the fitted line are used to estimate the standard deviation of the slope (b), its standard error (Sokal and Rohlf [1995](#), 468). Whether the relationship is isometric can then be determined by using a one-sample t -test (Sokal and Rohlf [1995](#), 227) to find the probability that (b) is exactly one, using its standard error.

The most common linear regression technique, ordinary least-squares (o.l.s.), is designed for prediction; it does not fit a line as closely as possible to the data (Sokal and Rohlf [1995](#), 453), which requires techniques called Model II regressions in biometry (Sokal and Rohlf [1995](#), 457; see Warton *et al.* [2006](#) for a review). The most commonly used Model II technique is reduced major-axis (r.m.a.) (Hammer and Harper [2006](#), 54), because it has few built-in assumptions about distributions and uncertainties (Sokal and Rohlf [1995](#), 544). Therefore linear regression with r.m.a. fitting was used to determine whelk shell allometry (by fitting a straight line to the relationship between the base-10 logarithms of the shell dimensions, $\log_{10}(H)$ and $\log_{10}(W)$), and aperture allometry (using $\log_{10}(H_{ap})$ and $\log_{10}(W_{ap})$).

The allometric relationship of shell width with height was estimated as

$$\log_{10}(W) = (-0.093 \pm 0.051) + (0.928 \pm 0.031) \times \log_{10}(H)$$

This can be converted to give the estimate of the relationship in the original dimensions (mm):

$$W = (0.807 \pm 0.095) \times H^{(0.928 \pm 0.031)}$$

The relationship was negatively allometric: the exponent (0.928 ± 0.031) was significantly less than one (one-sample t -test: $t_{[30]}$: 2.32; $P(b=1)$: 0.027). Shell width tended to increase more slowly than height; the whelks tended to become relatively narrower as they grew.

All the whelks were well represented by this one allometric relationship. The impression given by the value for R (0.984) being very near one can be tested further by examining the residuals (the regression-estimated value of a dimension minus its true value) for each individual in a sample (Draper and Smith [1981](#), 145-50). The residuals for width-height relationship in the original dimensions had a mean (-0.03 ± 0.97) that was clearly not significantly different from zero (one-sample t -test: $t_{[31]}$: 0.031; $P(\text{mean}=0)$: 0.97). Their distribution was not significantly different from normal ($\chi^2_{[31]}$: 1.75; $P(\text{normal})$: 0.19), and their relationship with predicted width showed no clusters or trend with size (Figure 7).

The allometric relationship of aperture width and height was found to be

$$\log_{10}(\text{Wap}) = (-0.308 \pm 0.073) + (1.001 \pm 0.050) \times \log_{10}(\text{Hap})$$

or

$$\text{Wap (in mm.)} = (0.492 \pm 0.083) \times \text{Hap}^{(1.001 \pm 0.050)}$$

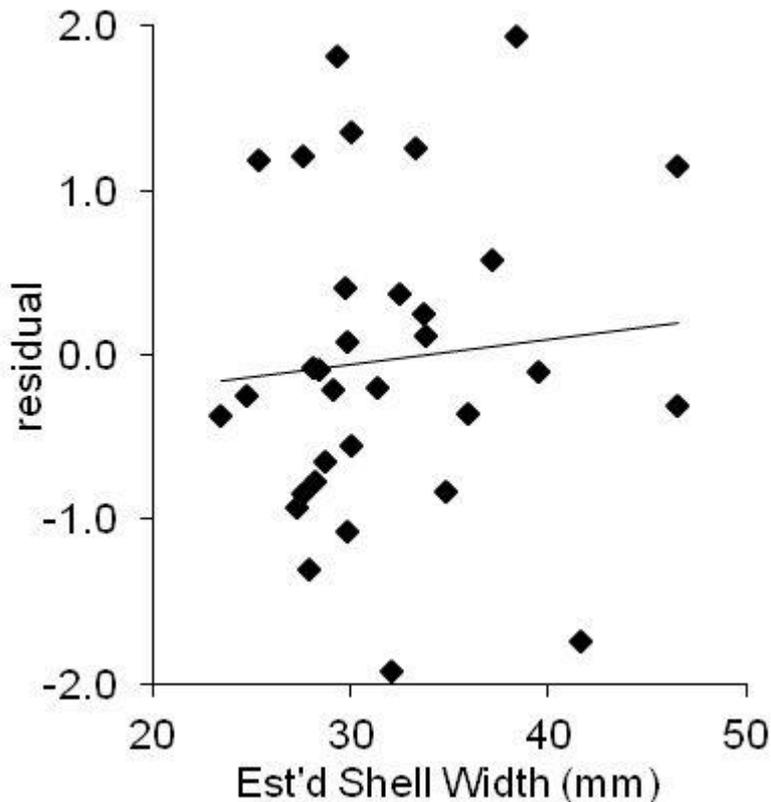


Figure 7: Relationship, with the estimated width values, of the residuals (estimated value, minus true value) in estimating shell width with the allometric formula for shell width derived for the whelks in midden 7325 (a 'versus plot') (N: 36). Line: linear regression fitted by o.l.s.

The aperture height-width allometry was isometric (the exponent was indistinguishable from one). The consistent aperture shape was confirmed by the ratio Hap/Wap, which averaged 2.03 ± 0.10 . Unlike the shell height-width ratio ([Figure 6](#)), Hap/Wap was similar regardless of shell size ([Figure 8](#)): when the relationship of Hap/Wap with shell height was fitted using o.l.s. linear regression, that relationship (the 'slope' of the line in [Figure 8](#)) was clearly not significantly different from zero (slope: 0.00095 ± 0.0018 ; one-sample t -test: $t_{[30]}: 0.53$; $P(\text{no relationship}): 0.60$). The Hap/Wap ratio seemed somewhat high compared with other whelks (e.g. Magnúsdóttir [2010](#), 18), indicating narrow apertures, perhaps to thwart being eaten by crabs (Thomas and Himmelman [1988](#)).

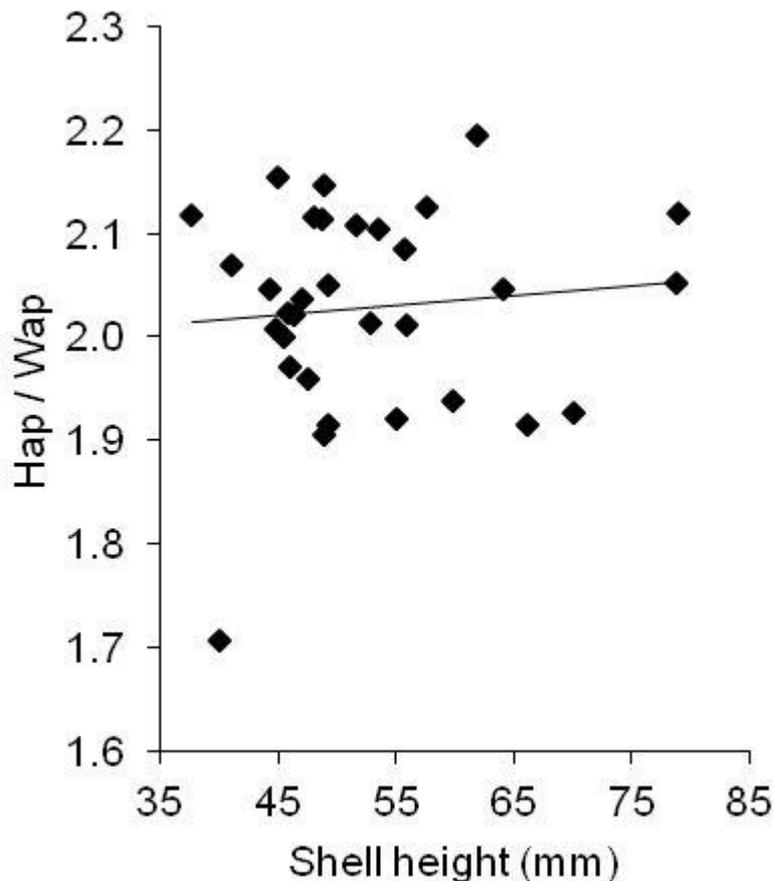


Figure 8: Relationship of aperture shape (Hap/Wap) with size (shell height) in the whelks from midden 7325 (N: 36); aperture shape does not change with shell size (cf. [Figure 6](#)). Line: linear regression fitted by o.l.s.

The shell morphology of the whelks demonstrated they are likely to have all been harvested from the same type of sea-bed. A single allometric relationship for both shell shape with size, and aperture shape with size, was a good characterisation of the shape and size of the individual whelks. Both allometric relationships were well characterised by the straight line, both values of R were close to one, and there were no scatters or clusters in the residuals. Whelk shape is very variable, even within a single large bay (e.g. Magnúsdóttir [2010](#), 25-26), so the consistent relationships show all these whelks were harvested from a very similar habitat. Since these whelks likely came from the same sea-bed, they were probably all harvested at the same time. It remains safest to assume they were harvested and discarded during the reworking of the midden as an early modern garden soil, rather than when it accumulated during the medieval period.

The allometric relationships showed the shells tended to become narrower with increasing size, but the aperture (through which the foot that attaches the whelk to the surface protrudes) kept a constant shape and grew in direct proportion with shell size. Keeping a foot in proportion with size as it increased suggests a need to remain attached, while making the shell narrower with size suggests a need for streamlining, so these whelks probably lived in fast or turbulent tidal flows, such as those known in the deeper parts of the channel north of Wight (Velegrakis [2000](#), 33).

3.3 Damage

Most of the whelks had unusual features on the lip of the aperture or (less commonly) to the outside of the last whorl (Figure 9). Damage could be slight: in ten whelks, a check in growth was marked by an abrupt step along the entire aperture, with the inner nacreous lining just visible on the surface (Figure 9a); four whelks had two or three such growth-checks followed by short periods of normal growth near the margin. Moderate damage was more common: in 15 whelks, the lip of the aperture had one or two cracks over 5mm long, or a chip over 3mm missing, but normal growth of the shell had resumed (Figure 9c). Damage could be severe: in 11 whelks, numerous cracks had propagated from the lip into the body-whorl, and large fragments of the lip or body-whorl had been detached, and in some cases re-cemented into the shell by the living animal (Figure 9e). Moderate or severe damage in the spire showed a whelk had survived damage when considerably younger (Figure 9g); 11 whelks had survived once before, seven had survived twice or three times, and one had survived four times; one unfortunate whelk had survived five episodes.

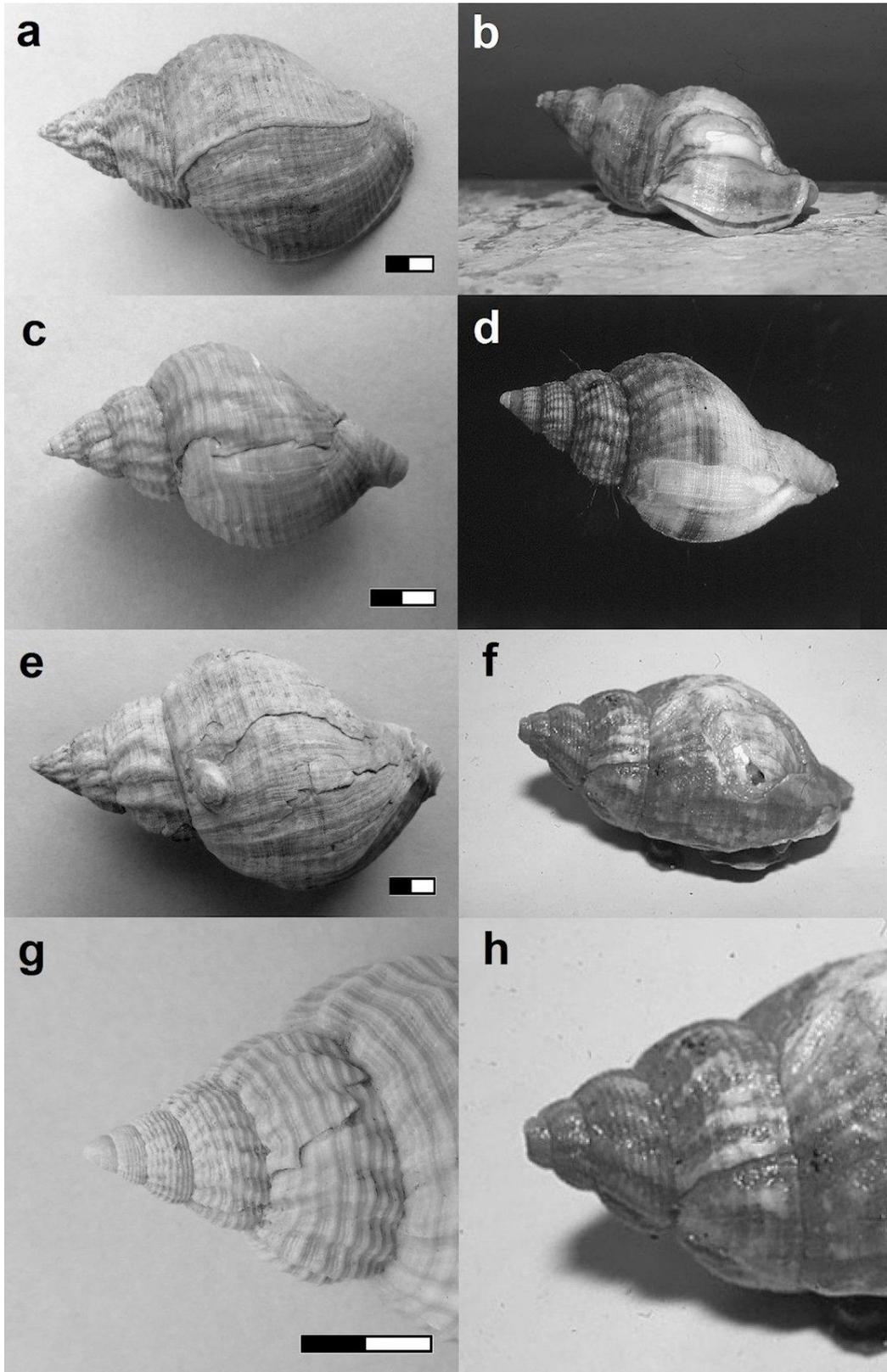


Figure 9: Examples of types of damage observed in archaeological whelk shells from Carisbrooke midden 7325 (a, c, e, g) and analogous damage in whelks beam-trawled from regularly trawled North Sea whelk beds (b, d, f, h; modified from figs 1 and 4 of Mensink *et al.* 2000). (a),(b): slight damage (growth-check to lip); (c),(d): moderate damage; (e),(f): severe damage to back of body-whorl; (g),(h): detail of spire showing repaired moderate or severe damage. Scale bar: 10mm.

Repaired shell damage is characteristic of whelks subjected to intensive bottom-trawling (Cadée *et al.* [1995](#), 338), and analogous shell damage was done by bottom-trawling in modern whelks (Mensink *et al.* [2000](#), 56). While the slight damage could be caused by infection, attack by a predator, or some other trauma, it is common in bottom-trawled whelks (Figure 9b) (Mensink *et al.* [2000](#), 55). The moderate and severe types of damage are characteristic of bottom-trawling (Figs 9d, 9f), and absent in whelks harvested by potting (Mensink *et al.* [2000](#), 55). Repeated slight damage is also a feature of whelks that are regularly bottom-trawled (Figure 9h).

3.4 Infestation

Some of the whelks bore traces of marine organisms that had colonised their shells during life (Figure 10). Of the 48 shells intact or complete enough to measure shell height, one had been bored by the bristle-worm *Polydora ciliata* (Figure 10a), two had bryozoan mats, one had a sand-worm tube, one had the calcareous byssus from the attachment of a saddle oyster (*Anomia ephippium*) (Figure 10b), one had infestation by the burrowing sponge *Cliona* (Figure 10c) and four had shells of juvenile oysters ('spat') (Figure 10d). Like oysters, the large solid shells of whelks are regularly infested by other marine organisms (Hancock [1967](#), 4) and all these organisms had also infested oysters in the same deposit (Campbell [2013](#), 22). Oysters in the deposit had the oval form of regularly dredged deeper-water oysters (Campbell [2013](#), 22), and whelks are attracted to dead or damaged molluscs in areas damaged by bottom-fishing (Ramsay *et al.* [1998](#)), so these whelks had probably colonised a dredged deeper-water oyster bed. Infestation of whelks by oyster spat was unexpected, since spat tends to settle on stable surfaces, often among other oysters (Bayne [1969](#)), and would tend to avoid settling on one of its predators.

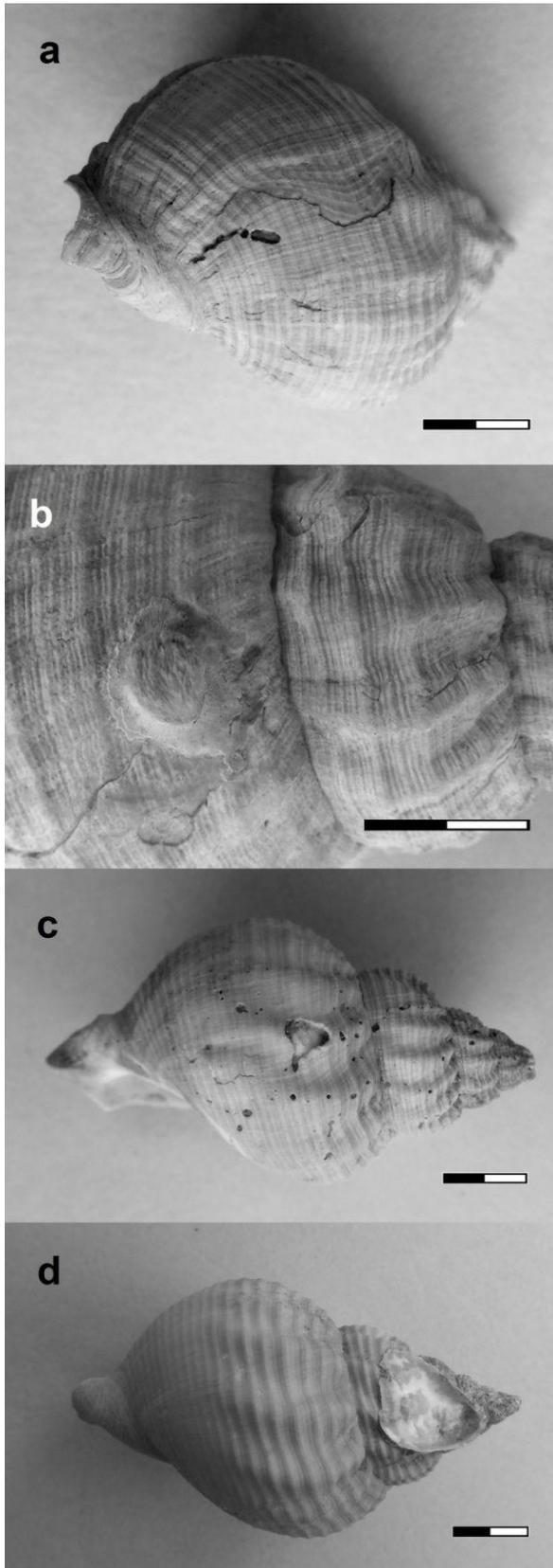


Figure 10: Examples of biological infestation of whelks from Carisbrooke midden 7325. (a): burrow of serpulid worm *Polydora ciliata*; (b): calcareous byssus from attachment of saddle-oyster *Anomia ephippium*; (c): linear pattern of surface perforations from the sponge *Cliona*; (d): lower valve of juvenile oyster *Ostrea edulis* ('spat'). Scale bar: 10mm.

4. Conclusion

These whelks were likely harvested by bottom-fishing. The size distribution was similar to that for modern southern English whelks. The very consistent size-shape relationships suggest they were all dredged from a similar habitat, probably in fast tidal flows. Their damage pattern is characteristic of trawling, and some were trawled repeatedly. It is also likely these whelks were dredged from a bed of oysters. The whelks were infested in a similar manner as many of the oysters in the same deposit, and the infestation included oyster spat, which tend to prefer other oysters.

This would appear to be the first archaeological instance of bottom-fishing for whelks being diagnosed via shell damage, and the first archaeological evidence for whelk harvesting being incidental to oystering. Direct evidence for whelk harvesting might be present in other archaeological shell-fish. Direct evidence was found in medieval oyster shells for harvesting with tongs (Dupont [2010](#)). Damage as a result of trawling could not be differentiated from that due to natural causes in dog-cockles (Ramsay *et al.* [2001](#)) or scallops (Schejter and Bremec [2007](#)), but might be distinguishable in razor-clams (Gaspar *et al.* [1994](#)). Bottom-fishing damaged carpet shells (venerids) but had little effect on *Spisula*, *Donax* or *Macra* (Gaspar *et al.* [2002](#)).

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