NAFC Marine Centre

Size variation in populations of the common whelk, *Buccinum undatum*

Richard Shelmerdine, Jennifer Adamson, Chevonne Laurenson, Beth Leslie

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Introduction

The common whelk, *Buccinum undatum* L. 1758, (known locally as the Buckie) is common in the subtidal down to 200 m in the northern Atlantic. The major European countries exploiting whelks include Belgium, France, Iceland, Ireland, and the UK with the main traditional markets in Europe found in England, France, and the Netherlands. The fishery for this species boomed in the 1990s with an increase in demand from the Far East, mainly South Korea. The influence of the Far East market has a significant effect on the fishery in the UK. This was evident in the Channel Islands with the collapse of the Far East market in 1998 and 1999 which resulted in increased catch per unit effort (CPUE) until the market stabilised in 2001 and exports increased to the highest recorded levels [1].

Figure 1: The operculum from a *B. undatum* with a coin of 24 mm diameter shown for scale. Red lines show examples from four of the growth rings.

Buccinum undatum is an important inshore shellfish fishery species in Shetland which started in the 1980s. The UK fishery is managed by a minimum landing size (MLS) which is set at the EU level of 45 mm shell length. Due to pressure from local fishermen, the Shetland Shellfish Management Organisation (SSMO) increased the MLS for *B. undatum* to a shell length of 75 mm within the six mile limit around Shetland. Similar increases in the MLS have been suggested for the southern Irish Sea fishery [2], the Channel Islands [1], and for the Japanese fishery of *Buccinum isaotakii* [3]. Management of *B. undatum* fisheries is further complicated by the fact that this species has a low fecundity, an entirely benthic reproductive strategy with a closed population (i.e. a lack of a planktonic larval phase with little or no migration between populations resulting in a low genetic diversity), fast early growth with a relatively slow overall growth, late maturation, and a gregarious nature. These life history traits, combined with ease of capture, make this species susceptible to recruitment overfishing [4-6]. This is of increasing importance in physically isolated areas such as Shetland.

Previous studies have discussed large-scale geographic variation (e.g. between countries) in *B. undatum* with respect to shell morphology, size at sexual maturity, and genetic variation. This study aims to show that variation in length, age, and projected growth rates in *B. undatum* exist at a smaller scale (e.g. within the six mile limit around Shetland) as well as at a large-scale of between countries and questions whether micro-management of a fishery could enhance the sustainability of the *B. undatum* fishery in Shetland.

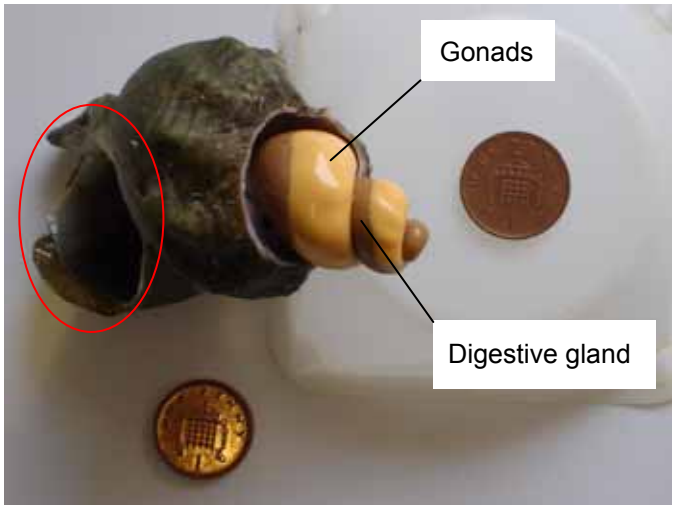

Figure 2: The gonads of a female *B. undatum* after breaking the shell apex with a vice. The aperture is circled in red and two coins of diameter 20 mm are shown for scale.

Buccinum undatum size variation

Methods

Buccinum undatum were sampled from local fishermen from within three areas; east Shetland (landed at Scalloway: 60º08.00'N 001º16.37'W; June 2006), west Shetland (landed at Whalsay: 60º20.30'N 001º01.43'W; August 2006), and south England (landed at Deal: 51º12.40'N 001º24.06'E; February 2006). Each sample represented the catch prior to discarding individuals smaller than the MLS. After landing, all animals were frozen for later analysis. Only shells and corresponding opercula were obtained from south England.

All animals were thawed at least three hours prior to analysis. Individual total weight (g) was recorded using an AND EK-400H top balance weighing to 0.01 g. Shell length (SL), to the nearest millimetre, and aperture thickness (AT), to the nearest 0.1 mm, were measured using vernier callipers. Operculum, where present, were gently removed, rinsed under fresh water, and left to dry overnight on paper towels for later age determination (Figure 1). Growth rates were estimated using the von Bertalanffy growth equation:

$$L_t = L_\infty (1 - e^{-K(t - t_0)})$$

where L_t is the length at age t, L_∞ is the asymptotic maximum length, K is the growth rate coefficient, and t_0 is the hypothetical age at which the length would be zero.

All flesh was removed from the shell by gently pulling on the foot of the whelk and weighed. When this was not possible, a bench vice was used to break the shell and prise out the flesh (Figure 2). Each animal was sexed and signs of imposex, were noted. Yield of each individual *B. undatum* was calculated as the percentage of the weight of flesh divided by the total weight.

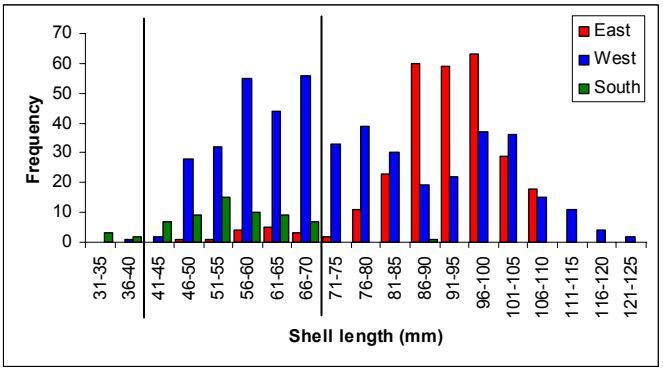

Figure 3: Length-frequency distributions of *B. undatum* caught in east and west Shetland, and south England. Vertical lines represent MLS of 45 mm and 75 mm.

Results

A total of 808 *Buccinum undatum* were analysed with west Shetland representing 57.7%, east Shetland 34.5%, and south England 7.8%. East Shetland was found to have the largest mean shell length of 91.95 mm (range 50 to 110 mm) with the largest animal recorded in west Shetland, measuring 122 mm (mean 76.24 mm, range 39 to 122 mm) and the smallest animal recorded from south England, measuring 31 mm (mean 54.30 mm, range 31 to 86 mm). The latter sample was found to have a significantly lower shell length compared with Shetland areas. West Shetland showed two distinct peaks (bimodal) in the length-frequency distribution with the larger peak (58 to 69 mm) found to be at a shell length less than the MLS of 75 mm (Figure 3). Landings on the west coast, above the MLS, showed a peak between 97 and 102 mm. The peak in length-frequency distribution from east Shetland (88 to 99 mm) was substantially larger than the MLS for that region, as was the peak from the south of England (49 to 57 mm). Both East and South regions showed a more unimodal length-frequency distribution (Figure 3). Male *B. undatum* were significantly larger (SL) than females but were not found to differ between east and west Shetland.

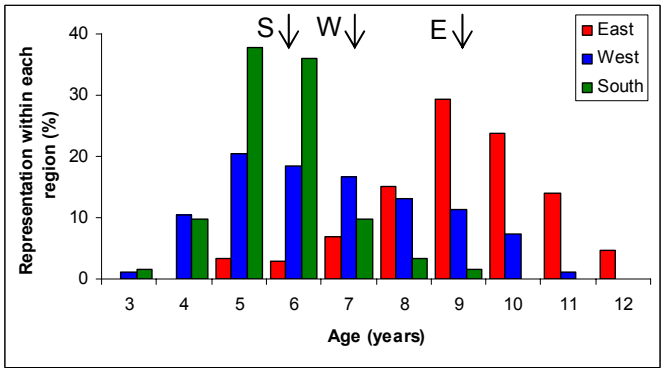

Figure 4: Variation in age between east (E) and west (W) Shetland, and south England (S) with downward arrows showing the mean values.

Age differed significantly between samples with older *B. undatum* recorded from east Shetland and younger animals recorded in west Shetland and south England (Figure 4). Length at age was also found to differ significantly between samples. Similar growth rates were found in female and male *B. undatum* from Shetland according to the fitted von Bertalanffy growth curves (Figure 5a and 5b, respectively and Table 1). Similar curves were obtained for males and females in east Shetland and for males in west Shetland although the von Bertalanffy growth curve was not found to be a good representation of female *B. undatum* from west Shetland. Although it was not possible to sex the animals from South England, the fitted von Bertalanffy growth curve was a good representation of the data (Figure 5c and Table 1). Extrapolating from the von Bertalanffy equations it was possible to estimate the age at which *B. undatum* would be recruited into the fishery within each area (Table 2). Little difference was seen between the sexes within each area with *B. undatum* found to recruit into the fishery on the west coast of Shetland at a slightly older age than those on the east coast.

Differences between samples were found in aperture thickness in relation with shell length and age (Figure 6)

but not sex. Mean aperture thickness in east Shetland was found to be 43% thicker than west Shetland and 36% thicker than south England. This increased thickness was noted at an earlier age (seven years) in east Shetland compared to an equivalent thickness in the west of Shetland at ten years of age (Figure 6).

Table 1: Parameters used in calculating the von Bertalanffy growth curves for each area.

Location and sex	L_∞ (mm)	K	t_0
Shetland, female	101.10	0.39	3.19
Shetland, male	102.04	0.40	3.20
East Shetland, female	104.87	0.30	2.17
East Shetland, male	99.02	0.39	2.66
West Shetland, female	-185.67	-0.03	-3.65
West Shetland, male	157.52	0.09	-0.32
South England	66.05	0.39	0.96

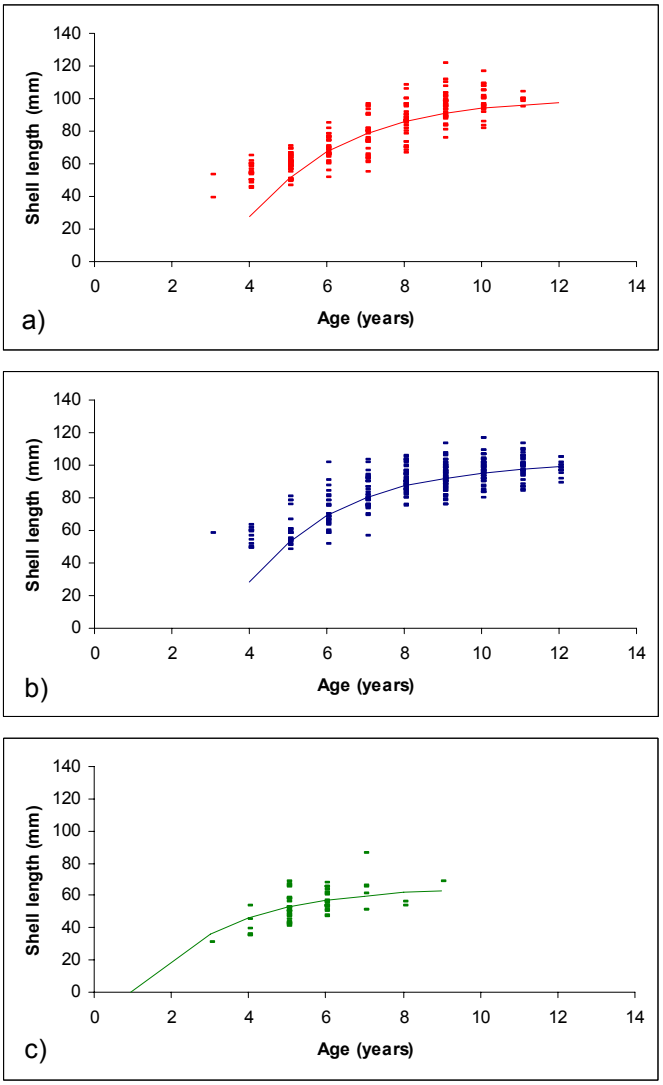

Figure 5: Length at age data for female (a) and male (b) *B. undatum* caught in Shetland and those caught in the south of England (c) with fitted von Bertalanffy growth curves.

East Shetland had a significantly greater mean flesh weight per age to that from west Shetland (Figure 7). A similar pattern was noted when examining yield of individual *B. undatum* with a significantly greater yield in the east (mean 54.4%) to that in the west (mean 48.1%) of Shetland.

Imposex was not found to be prevalent in either east (1.4% of sample) or west (6.7% of sample) Shetland.

Table 2: Estimated age at which *B. undatum* attains the MLS from the von Bertalanffy growth equations.

Location and sex	MLS (mm)	Age (years)
East Shetland, female	75	6.3
East Shetland, male	75	6.4
West Shetland, female	75	6.7
West Shetland, male	75	6.9
South England	45	3.9

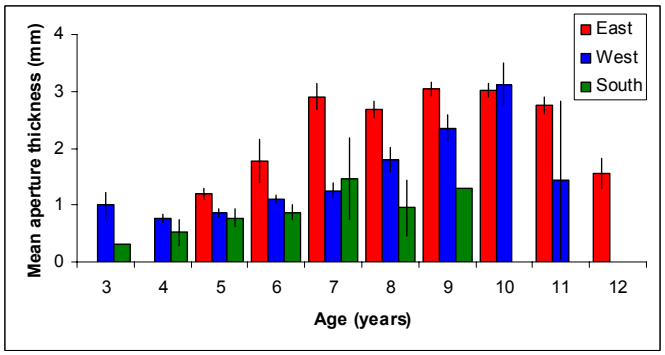

Figure 6: Aperture thickness in relation with age for *B. undatum* caught in east and west Shetland, and south England with 95% confidence intervals shown.

Discussion

Significant differences were noted between east and west Shetland for all measured parameters. Whelks in east Shetland were found to have a unimodal length-frequency distribution with a mean age of nine years corresponding to a mean individual flesh weight of 94.7g. In comparison, whelks in west Shetland were found to have a bimodal length-frequency distribution with a mean age of seven years corresponding to a mean individual flesh weight of 48.1 g.

The first mode in a bimodal length-frequency distribution would arise due to the permanent presence of a large number of recruits in the environment accompanied by a high mortality rate of small individuals with the second mode resulting from a process in which mortality decreases with increasing size. The absence of the first mode from the east coast sample would suggest an increased predation pressure which is supported by an increase in mean shell thickness at an earlier age to that found on the west coast (Figure 6). Shell thickness is a good indicator of predation pressure with thin shelled animals found where predators are relatively scarce [7]. Predators of *B. undatum* include several invertebrate

species such as crabs, lobsters, and starfish, as well as Teleost and Elasmobranch species [7, 8]. Both unimodal and bimodal distributions have been reported previously for whelk populations [2, 6, 9, 10] with differing geographical locations leading to differences in mortality, growth, and reproduction. The first mode of the length-frequency distribution of the west coast sample showed a good potential for recruitment to the fishery. The first mode would take five to six years of growth with whelks recruited into the fishery after an estimated seven years of growth (six for the east coast).

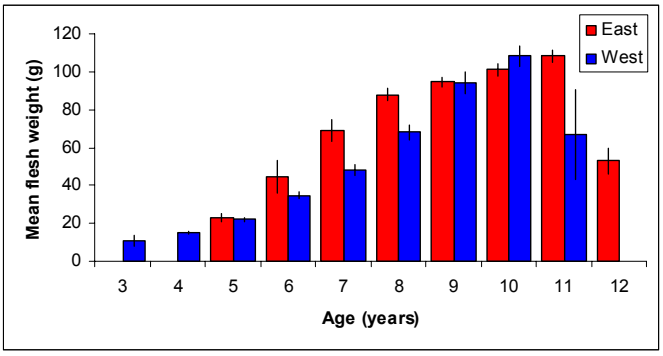

Figure 7: Mean flesh weight at age for *B. undatum* caught in east and west Shetland with 95% confidence intervals shown.

Although the estimated von Bertalanffy growth curves seemed to be a good fit to the data, the values obtained for maximum length (L_∞), the growth rate coefficient (K), and the theoretical time at length zero (t_0) were not found to be similar to those from previous studies [4, 9, 11, 12]. The greatest inconsistency of the present data would be the values of t_0 which ranged from -3.7 to 2.7 years compared with a minimum of -0.81 years in the Isle of Man [9] to 0.28 years in the southern Irish Sea [4]. Only male whelks from west Shetland were found to have a t_0 value of -0.32 years and were also found to have a similar K value of 0.09 to previous studies [4]. Variation in the von Bertalanffy parameters between the present study and the existing literature may be due to dominant or missing age classes within the sample. The youngest animal caught on the east coast was five years of age (three years for west Shetland and south England) with animals of nine and ten years of age dominating the catch in east Shetland (five and six years for south England with little age-class domination in west Shetland, Figure 4). Care should be taken when interpreting the growth estimates for Shetland in this study.

Implications for the Fishery

This study has shown that small-scale regional variation of *B. undatum* exists between east and west Shetland, not only between these areas but also between Shetland and south England. The whelk fishery in Shetland is a relatively new one which commenced in the 1980s. In comparison, the fishery in south England is more established with landings data available for Kent from 1947 [11]. It has been suggested that the fishery for whelks would lead to a smaller size at sexual maturity [13] and that discarding individuals smaller than the MLS would favour smaller, slower growing individuals [4]. However, the effects of such a size reduction would only become evident over a prolonged period due to the slow growth rate of this species. Sustainable management of the *B. undatum* fishery over large spatial scales is not practical due to the life history traits of this species. Small-scale geographic variations in whelk populations have been reported for the Isle of Man, the Gulf of St Lawrence, the southern Irish Sea, and in various areas around the UK coastline. To enhance the sustainable management of these areas, micro-management measures should be examined. Such measures could establish different MLS for specific areas within a region, although such measures would have to be reviewed on a region by region basis to assess their practicalities. This study has shown that there is a potential for micro-management measures in Shetland but further research should be conducted examining spatial variation of growth rates and size at maturity in *B. undatum* before such plans could be developed.

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(Full details of references on request)

NAFC Marine Centre, Port Arthur, Scalloway, Shetland ZE1 0UN, UK.
Tel: +44 (0)1595 772000 Fax: +44 (0)1595 772001 Email: info@nafc.uhi.ac.uk Web: www.nafc.ac.uk