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Size variation of the common whelk, *Buccinum undatum*, over large and small spatial scales: Potential implications for micro-management within the fishery

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Abstract

The common whelk, *Buccinum undatum*, was sampled from three areas; east and west Shetland, and the south coast of England. The largest whelk measured 122 mm shell length (SL) and was recorded from west Shetland (mean 76 mm) with the smallest animal recorded from south England, measuring 31 mm (mean 54 mm). Both east and south areas showed a peak in length–frequency distributions greater than the minimum landing size (MLS). The peak in the west was found below the MLS, which was the only site to show a bimodal length–frequency distribution. Fisheries recruitment was estimated to occur at 6 years of age for east, 7 for west, and 4 for south regions using estimates from von Bertalanffy growth curves. Imposex was not found to be prevalent in Shetland. Significant differences were noted between east and west Shetland, and between Shetland and south England, for all measured parameters of: SL, growth, age, flesh weight, and individual yield. These results suggest that a large-scale MLS for *B. undatum* is not practical when local fisheries are in differing states of maturity, as seen in Shetland and south England, and that micro-management within the fishery should be considered on a region by region basis to assess the practicality of such a management measure.

Keywords: *Buccinum undatum*; Minimum landing size; Shellfish fisheries; Shetland; Spatial variation; Whelk

1. Introduction

The common whelk, *Buccinum undatum* L. 1758, is a neogastropod mollusc common in the subtidal to 200 m depth in the northern Atlantic (Thomas and Himmelman, 1988). 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 (Nasution and Roberts, 2004). The fishery for this species boomed in the 1990s with an increase in demand from the Far East, mainly South Korea (Fahy et al., 2005).

B. undatum is an important inshore shellfish fishery species in Shetland which started in the 1980s. Landings of *B. undatum* in Shetland have fluctuated since 2000 with a recorded peak of 203 tonnes, declining to 88 tonnes in 2006 (Leslie et al., unpublished report). Landings per unit effort remained constant throughout this period with the exception of 2005 and 2006 where a slight decrease was recorded (Leslie et al., unpublished report). 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), through its powers under The Shetland Islands Regulated Fishery (Scotland) Order 1999 (Order No. 194), increased the MLS for *B. undatum* to a shell length of 75 mm within the 6-mile limit around Shetland. Similar increases in the MLS have been suggested for the southern Irish Sea fishery (Fahy et al., 1995, 2000), the Island of Jersey, Channel Islands, (Morel and Bossy, 2004), and for the Japanese fishery of *Buccinum isaotakii* (Kira, 1959) (Ilano et al., 2003). 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 (Valentinsson et al., 1999; Nasution and Roberts, 2004; Weetman et al., 2006). These life history traits, combined

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with ease of capture, make this species susceptible to recruitment overfishing (Fahy et al., 1995; Valentinsson et al., 1999; Nasution and Roberts, 2004) which is of increasing importance in physically isolated areas (Weetman et al., 2006). A decline in *B. undatum* populations has been noted in the Dutch Wadden Sea (Cadée et al., 1995), southern Scotland, Ireland, and England (Nicholson and Evans, 1997), and the southern North Sea (ten Hallers-Tjabbes et al., 1996; Nicholson and Evans, 1997) with Cadée et al. (1995) reporting on the extinction of *B. undatum* from the Dutch Wadden Sea. Cadée et al. (1995) and ten Hallers-Tjabbes et al. (1996) noted that such declines, particularly near dense shipping areas, were due to a combination of the whelk fisheries and imposex from tributyltin (TBT) antifouling paints.

Within the 6-mile limit around Shetland, spatial variation in size distributions have been found for both velvet crabs, *Necora puber* (L. 1767), and scallops, *Pecten maximus* (L. 1758) (NAFC Marine Centre, unpublished data). For *B. undatum*, previous studies have discussed large-scale geographic variation (e.g. between countries; Nicholson and Evans, 1997; Fahy et al., 2000; Morel and Bossy, 2004; Weetman et al., 2006) with respect to shell morphology, size at sexual maturity, and genetic variation. This study aims to test that variation in length, age, and projected growth rates in *B. undatum* exist at a smaller scale (e.g. within the 6-mile limit around Shetland) as well as at a large-scale, of between countries, and questions whether micromanagement of a fishery could enhance the sustainability of the *B. undatum* fishery in Shetland.

2. Materials and methods

B. undatum were sampled from local fishermen, using baited pots, from within three regions; east Shetland (landed at Scalloway: 60°08.00′N 001°16.37′W; May 2006), west Shetland (landed at Whalsay: 60°20.30′N 001°01.43′W; August 2006), and south England (landed at Deal: 51°12.40′N 001°24.06′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 3 h prior to analysis. Individual total weight (g) was recorded to the nearest 0.01 g. Shell length (SL), measured 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 for later age determination, as carried out by Santarelli and Gros (1985). Growth rates were estimated using the von Bertalanffy growth equation:

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

where L_t is the length at age t, L_∞ the asymptotic maximum length, K 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. Each animal was sexed and signs of imposex, as described by Tétreault et al. (2000), were noted. Yield of each individual *B. undatum* was calculated as the percentage of the weight of flesh divided by the total weight. Analysis of variance was used to test for differences and, although a prerequisite for the test is that the data be normally distributed, it is widely accepted that an analysis of variance is a robust test and so can be carried out on non-normal distribution data (see Underwood, 1997 for a detailed description).

3. Results

A total of 808 *B. undatum* were analysed with west Shetland representing 57.7%, east Shetland 34.5%, and south England 7.8%. East Shetland had the largest mean shell length of 91.95 mm (range 50–110 mm) with the largest animal recorded in west Shetland, measuring 122 mm (mean 76.24 mm, range 39–122 mm), and the smallest animal recorded from south England, measuring 31 mm (mean 54.30 mm, range 31–86 mm). The latter sample had a significantly lower shell length compared with Shetland samples (two-way ANOVA, $F_{2,803} = 179.00$, $P < 0.001$). West Shetland showed a distinct bimodal length–frequency distribution with the first, and largest, peak (58–69 mm) found to be at a shell length less than the MLS of 75 mm (Fig. 1). 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 (88–99 mm) was substantially larger than the MLS for that region, as was the peak from the south of England (49–57 mm). Both east Shetland and south England showed a more unimodal length–frequency distribution (Fig. 1). Male *B. undatum* were significantly larger (SL) than females (two-way ANOVA $F_{1,803} = 19.65$, $P < 0.001$) but were not found to differ between the samples from east and west Shetland (two-way ANOVA, $F_{1,803} = 2.52$, $P = 0.113$).

Age differed significantly between samples (two-way ANOVA, $F_{2,604} = 210.38$, $P < 0.001$) with older *B. undatum* recorded from east Shetland and younger animals recorded in west Shetland and south England (Fig. 2). Length at age was also found to differ significantly between samples (ANCOVA, $F_{2,603} = 43.50$, $P < 0.001$). Similar growth rates were found in male and female *B. undatum* from east Shetland according to the

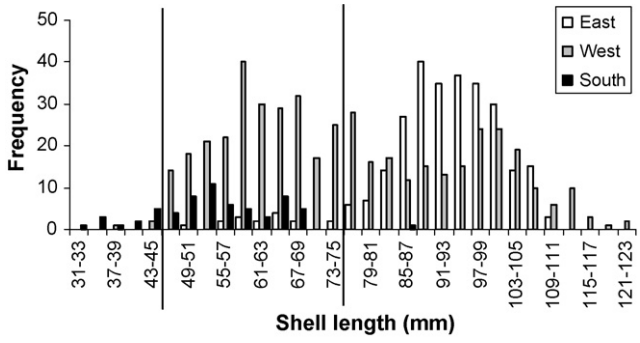

Fig. 1. Variation in length–frequency distributions between samples in east ($n = 279$) and west ($n = 466$) Shetland and south England ($n = 63$). Vertical lines represent the MLS for England (45 mm) and Shetland (75 mm).