

# Size at Sexual Maturity of the Shetland Buckie *Buccinum undatum*

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## Introduction

The common whelk, *Buccinum undatum*, known locally as the buckie, has been an important fishery to the inshore fleet in Shetland since the 1980s. The end destination for buckies is in Korea, and the market often fluctuates due to the unstable financial situation of the country. At one time a local processing factory cooked buckies, de-shelled and then froze the meat before transportation to Korea, but now most of the catch is shipped to buyers or processors on mainland Scotland.



Figure 1: Fishing for buckies using a typical pot – a modified 25 litre plastic drum.

The Shetland Shellfish Management Organisation (SSMO) set the fishery minimum landing size (MLS) of buckies to 75 mm shell length, on the basis that fishermen were concerned that the national MLS of 45 mm was far too small to support a sustainable fishery in Shetland.

Relatively few studies have been carried out on the reproduction of buckies, despite their importance as a European fishery. An understanding of the sizes at which a fishery becomes reproductively mature is essential for management considerations. This project investigates the reproductive biology of the buckie population in Shetland and in particular calculates the size and age at which the population becomes sexually mature.

## Methods

### Biological material

Approximately 60 specimens were obtained from commercial fishermen each month from November 2000 until November 2001 (with the exception of August 2001). Specimens were frozen until ready for dissection.

Individuals were allowed to defrost overnight within a fridge prior to dissection as this facilitated easier removal of the tissue from the shell.



Figure 2: The common whelk or buckie.

The total shell length and total wet weight were recorded. Individuals were then removed from their shell by pulling them firmly from the shell in the direction of the shell coil until the shell muscle became detached. When this was not possible the shell was cracked open using a bench vice. The total flesh wet weights (minus the operculum - a small calcareous disc that protects the animal when it withdraws into its shell) and gonad weights, after careful removal from the digestive gland, were recorded for each buckie. In male specimens the penis was removed from the body using scissors and measured. All measurements were taken using vernier callipers to the nearest millimetre below. Wet weights were obtained after specimens had rested for two minutes on dry paper towels and then were weighed to the nearest one hundredth of a gram. Buckies were aged by counting the growth rings on the operculum.

During dissection, conditions of imposex (abnormal growth of male sexual characteristics in females due to

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tributyl-tin poisoning from antifouling paints) and penis shrinkage (due to the presence of parasites) were observed and noted using characteristics described by other authors.

## Sexual maturity

The size at which individuals become sexually mature was investigated using gonad weights, a gonad index and a penis index plotted against shell length. This information gives an indication of the size at which individuals begin to mature.

The average size at first reproduction is defined by the size at which 50 % of all individuals within a population are considered mature and is a practical gauge for setting the minimum landing size in fisheries management. This was determined for male and female buckies by using a penis index (PI) and gonad index (GI) respectively:

$$PI = \text{penis length} / \text{shell length} \times 100$$

where an individual with a PI of greater than 50% was considered mature.

$$GI = \text{gonad weight} / \text{somatic weight} \times 100$$

where somatic weight was the total wet weight minus the gonad weight, and an individual with a GI of greater than 2 was considered mature for females.

The proportion of individuals considered mature at each length was calculated so that a logistic curve could be fitted to the data. The 50 % point then indicates the size at sexual maturity of the population. Small buckies sampled for use in the logistic curves, were only obtained in the month of July 2001, and the consequences of this are explained in the discussion.

Growth curves for both males and females were ascertained from shell lengths and the ages of individuals obtained from growth rings on the operculum. Sizes at sexual maturity were then used to obtain the age that buckies become sexual mature. The reproductive cycle of the buckie population was determined by investigating the gonad index (GI) of individuals throughout the year.

## Results

### Size at Sexual Maturity

The size at which buckies showed sexual maturity began at a shell length of around 80mm for both males and females, as indicated by the rapid increase in both gonad weights and gonad indices with respect to shell length (Figure 3 & Figure 4, for males and females respectively).

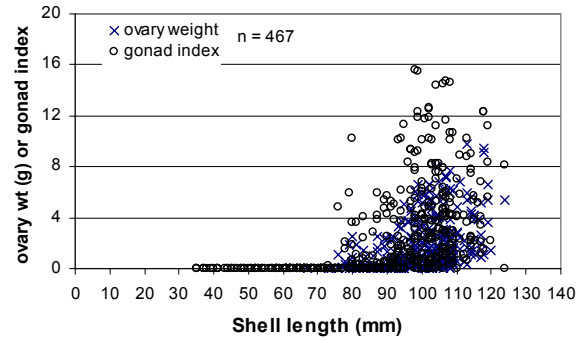


Figure 3: Gonad weights and indices (gonad wt divided by somatic wt) female buckies against shell length.

Females had much heavier gonad weights than males (Figure 3 and Figure 4). An ovary weight of more than 2 g or a female gonad index of greater than 2 was seen generally in individuals with shell lengths of over 80 mm.

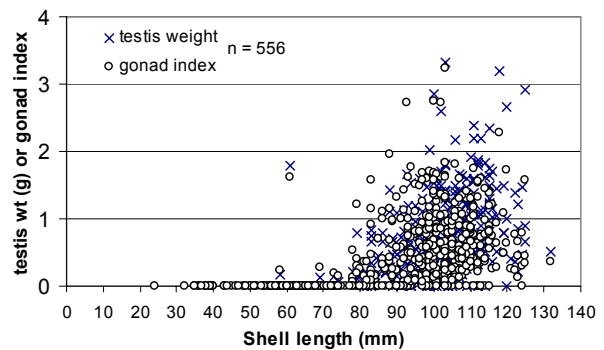


Figure 4: Gonad weights and indices (gonad wt divided by somatic wt) of male buckies against shell length.

The testis weight of males was often very small, particularly in smaller individuals. Gonad index of greater than 1 was generally only seen when a shell length of 80 mm was attained (Figure 4).

Male buckies with a penis index of greater than 50 % and hence considered mature, occurred in the majority of individuals over 80 mm. The smallest sized male buckie that was mature was 73 mm (Figure 5).

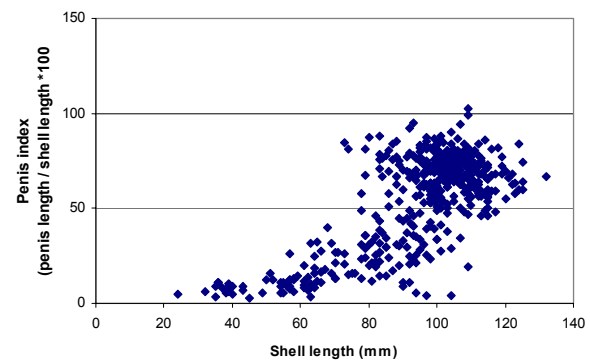


Figure 5: Penis index plotted against shell length.

Logistic curves fitted to the penis index and gonad index data for both male and female data are shown in Figure

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6. The average sizes of sexual maturity were calculated to be 86 mm and 104 mm for males and females respectively (Figure 6).

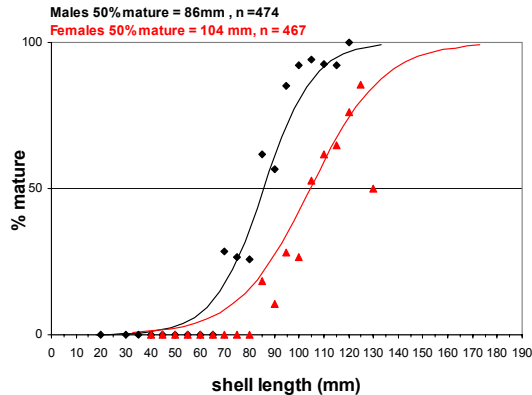


Figure 6: Percentage size at maturity data points and the fitted logistic curve for male (black) and female (red) buckies.

## Reproductive cycle

Female buckies showed a distinct peak in gonad index during October and November (Figure 7). Males showed a smaller peak in the same months. The lowest gonad index for both sexes occurred during January, after which they gradually increased through the year. The female gonad index had larger confidence limits than the males, indicating greater variation.

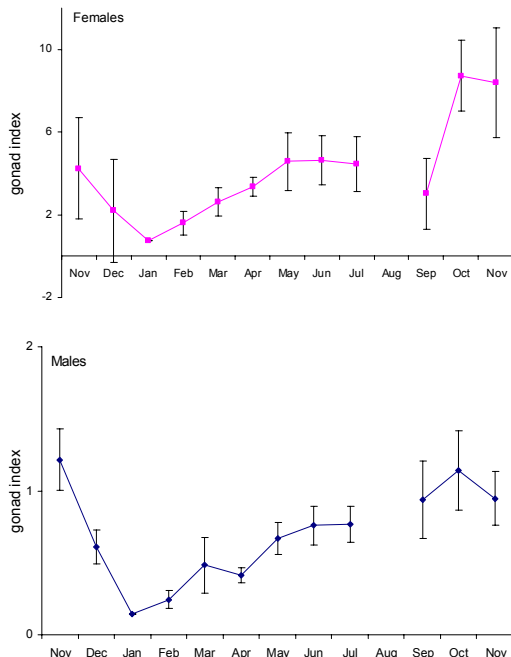


Figure 7: Mean gonad index of female and male buckies throughout the year, bars indicate 95% confidence intervals.

## Growth

Growth rates were very similar for male and female buckies as shown by the fitted von Bertalanffy growth curves (Figure 8), although males showed a slightly

larger maximum length (134.5 mm) than females (130.9 mm). From the growth rings on the operculums, a sexually mature male of 86 mm was determined to be just over 5 years and a sexually mature female of 104 mm was determined to be just over 8 years.

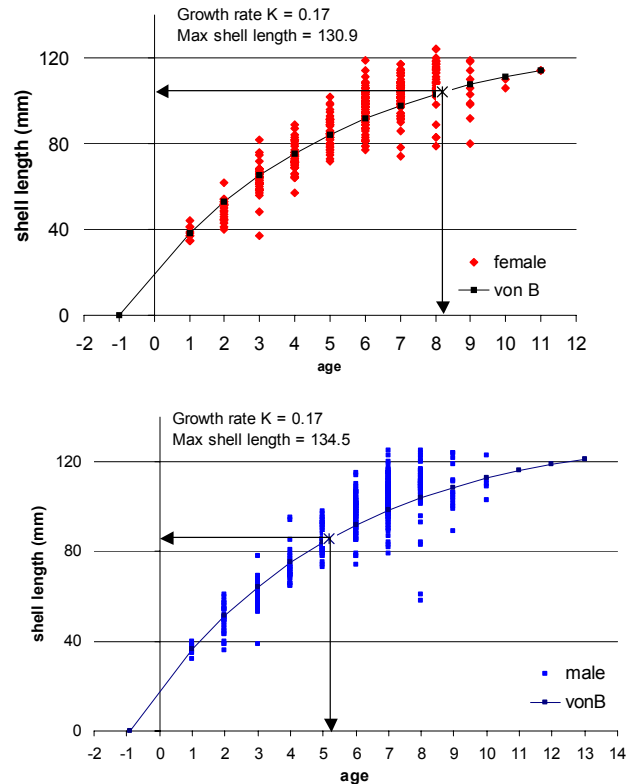


Figure 8: Age at length data (points) and fitted von Bertalanffy growth curves (lines) for female (top graph) and male buckies (lower graph). Arrows show the ages and sizes at sexual maturity.

## Discussion

### Size at sexual maturity

The size at which buckies become sexually mature was shown to be at a shell length of around 80 mm from gonad studies. The average size that sexual maturity occurs was shown to be 104 mm and 86 mm for females and males respectively, using logistic curves fitted to gonad and penis index data.

Unfortunately the sampling period for the smaller buckies was during July and not during the months when gonads were at their fullest (October and November). Because of this, the absolute value of maturity found for females can not be relied upon fully, however it is still reasonable to assume that females mature at a larger size than males.

It is common practice in other buckie fisheries elsewhere to use only males and the penis index to

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determine the size of sexual maturity of the fishery, and assume that females mature at the same size as males. The penis index is by far the quickest and most efficient way to measure size at sexual maturity of buckies. In addition the penis index can be calculated at any point during the year, without the necessity of restricting sampling to the breeding period, which is outside the normal fishing season. However, this study has indicated that female populations may mature at a larger size than males.

The UK minimum landing size of 45 mm for buckie fisheries is lower than the majority of the estimated sizes at sexual maturity from populations anywhere in the world. Whilst the minimum landing size of 75 mm, set by the Shetland Shellfish Management Organisation, is far above the national legal size, it is still too small to allow a significant proportion of the buckie population to breed before being captured. It is therefore suggested that a new minimum landing size of *at least* 86 mm is introduced to account for the sizes at sexual maturity found in this study. The size at sexual maturity of buckie populations can vary considerably across small geographical areas. Initial investigations carried out by current author indicate that such spatial variations do occur around Shetland (see C. Simpson MSc Thesis in NAFC library), and this may have consequences in the implementation of minimum landing sizes for the fishery.

### *Reproductive cycle*

In general the ovaries weighed more than the testes and the weights were more variable. This is easily explained by the fact that buckies produce large yolky eggs that are laid within protective capsules where larvae undergo all their development until a juvenile stage. Individual females at slightly different stages in their egg development will therefore show large variations in ovary weight. The gonad indices peaked during October and November for both males and females, indicating that gonads are at their fullest at this time of year. The reduction in gonad index after November indicates that the gonads were spent, and that breeding and spawning (release of eggs and sperm) had taken place. The spawning and mating period of buckies in Shetland is therefore in October / November.

A reduced level of fishing throughout the winter in Shetland coincides with the onset of breeding in October and November. Buckies are not so attracted to baited pots and this can be explained by a reduction in feeding during their mating period.

### *Growth*

Growth curves plotted from the length at age data showed that males and females have very similar growth rates. Other research on growth has not

differentiated between males and females. Male buckies in Shetland reached a size at sexual maturity at 5 years of age, and females at over 7 years. The maximum sizes obtained from the growth curves are considerably larger than those for Ireland; 101-116 mm, France; 112.5mm and England; 68mm. Growth rates are similar to Ireland, but slightly less than Isle of Man. Therefore growth of Shetland buckies is at a similar rate to Ireland but slower than Isle of Man, but with a larger maximum size than anywhere else documented.

### *Imposex and Penis Shrinkage*

During dissection of individual buckies, the condition imposex was frequently observed. Imposex is an environmentally induced abnormality to the reproductive organs of the females. In some species this condition can cause sterility, with severe implications for the reproduction of the population. However imposex does not appear to cause sterility in buckies, although it does affect the growth rates of juveniles substantially. Shetland buckies take 5 to 8 years to become sexually mature, so any effect on growth rates could have serious consequences on recruitment to the population.

Penis shrinkage due to parasites was evident in a number of individuals and appeared to occur in higher incidences in particular areas. During normal mating the male individual must fertilise the female internally, requiring the penis to reach up into the female's shell. Penis shrinkage will have a physical impediment on reproduction and therefore population growth and warrants further investigations.

### *Summary*

The mating period of buckies in Shetland is during October and November and during this period buckies feed much less. Reproductive indices indicate that male populations become mature at 86mm, corresponding to an age of 5 years. Indications are that female populations become sexually mature at a larger shell length of 101 mm, corresponding to an age of over 7 years. These animals are slow growing molluscs and at present the legal minimum landing size of 75 mm in Shetland is below the sizes at sexual maturity shown in this study. These factors together with the occurrence of imposex and penis shrinkage in the population are important reproductive issues that should be addressed in the management of the fishery.

### *Acknowledgments*

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