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Age composition and growth rates of queen scallops *Aequipecten opercularis* (L.) around the Isle of Man.

Belinda J. Vause, Bryce D. Beukers-Stewart and Andrew R. Brand.

Port Erin Marine Laboratory,
University of Liverpool,
Port Erin,
Isle of Man,
IM9 6JA,
British Isles.

Introduction

Landings of the queen scallop *Aequipecten opercularis* (L.) have fluctuated widely around the Isle of Man since the fishery began in 1969. These fluctuations have been attributed to large variability in recruitment. Regardless it remains the second most valuable species accounting for nearly 30% of all fish and shellfish landings in 2002. There are no regulations on the fishery, however, it predominantly operates between June and October (the closed season for the great scallop *Pecten maximus* (L.)) and it is not economically viable to land individuals less than 55 mm in shell height. Stock abundance has been well monitored with fisheries independent stock surveys since 1992 but the age structure and growth rates of the populations have received little attention. The aim of this study was two-fold. Firstly, to ascertain the best method of age determination, and, secondly to investigate seasonal and spatial variation in age composition and growth rates of the exploited queen populations around the Isle of Man. Three methods of determining age composition were used and compared: reading of the annual growth rings from untreated shells, reading of the annual growth rings from treated shells and length frequency analysis.

Methods

A sample of 150 queen scallops were collected during stock surveys in June and October 2004 from 3 fishing grounds; South PSM, East Douglas and Laxey. An additional sample of 500 queen scallops were collected from South PSM and kept alive in the aquarium. Queen scallops can be difficult to age as their annual growth bands are not always clear. A sub-sample of 150 of the live sample were tagged and aged to the best of our ability in

their original state. These animals were then sacrificed and their shells were treated in order to make the annual growth rings more visible. The left (upper) valve was cleaned of epifauna and epiphytes, treated with 5% NaOCl, washed with 98% ethanol, rinsed with water then dried at 60 ^{o}C for 12 hours. These individuals were then aged again and the results compared to determine if this treatment assisted in the ageing procedure. The remainder of the live sample are being kept in the aquarium for 12 months to validate the formation of an annual growth ring. The 6 frozen samples were treated as above, measured and aged. Ageing the scallops was conducted by three independent readers, before and after treatment, and size was recorded as shell height (mm). Length frequency analysis was conducted using Bhattacharya's method on the size data to mathematically determine age composition. The results from these three methods of age determination were compared.

Results

Method Analysis: It was more difficult and less precise to determine the age of queen scallops before treatment compared to after treatment. An average of 84% (SE 4.6) of untreated shells were considered to be readable by the three readers as opposed to nearly 100% after treatment. In addition, differences between the readers decreased after treatment (precision index before treatment 29.7, after treatment 23.6). A significant difference was found between the ages determined before and after treatment (Kolmogorov-Smirnov test $Z=-4.206$, $P<0.001$) and regression analysis showed that ageing before treatment was biased towards the lower ages ($y=0.77 + 0.54$). Further results will be presented comparing length frequency analysis with these results.

Age Compositions: The age distribution at South PSM was relatively even for the first 3 cohorts with approximately 20% 1 year olds, 30% 2 year olds, 30% 3 years olds, then decreasing to 13% 4 year olds 6% 5 year olds, as would be expected with natural and fishing mortality. East Douglas also had individuals present in each year class but 3 and 4 year olds were most abundant. At these two grounds there was little seasonal variation in the age compositions of the populations. The age composition at Laxey was dominated by 1 year olds, which accounted for 64% in June and 94% in October. In 2003 there was exceptionally high recruitment at Laxey, which have survived to produce this strong year class: prior to this recruitment at Laxey was poor.

Growth Rates: Von Bertalanffy growth curves were fitted to the treated shell data and mean size at age was calculated to investigate seasonal, temporal and spatial variation in growth. Generally mean size at age increased between June and October for 1, 2 and 3 year olds but not 4 and 5 year olds and at this point the growth curves plateaued. This was expected as the majority of growth takes place over the summer period and growth slows down considerably with age. The difference between mean size of 1 year olds in June and October was 8.3 mm at South PSM, 3.2 mm at East Douglas and 13.6 mm at Laxey. Spatial variation between the three grounds was apparent. In June, Laxey had the smallest 1 year olds of the three grounds, yet the largest 3 and 4 year olds. In contrast, East Douglas had the largest one year olds but the smallest 3-5 year olds and South PSM was in between. Despite spatial variation of the size of one year olds, the growth curves

on the three different grounds intercepted at 2 years old which is when individuals are approximately 55 mm.

Discussion

Despite the time taken to prepare shells we recommend this method over using live specimens because of the improvements in readability, precision and potentially accuracy (see laboratory experiment). If length frequency analysis is found to give comparable results to prepared shells however, this would be a much more cost effective method because these data can be collected quickly and easily in the field.

Differences between the queen scallop age compositions on the different grounds appear to be the product of both variable recruitment and the effects of fishing. Several years of poor recruitment at Laxey has resulted in very low abundances of 2 year olds and older. The increase of 1 year olds in the age composition between June and October may be explained by the increase in size due to summer growth and thus the increase in catch efficiency. Analysis of fishing effort on all grounds around the Isle of Man (from a voluntary logbook scheme) shows that for the season of 2003 Laxey incurred 0%, South PSM 15% and East Douglas 33% of total effort. There was no fishing at Laxey because poor recruitment in previous years resulted in a low abundance of economically viably sized queens. This lack of fishing disturbance may explain the fast growth of these 1 year olds at Laxey, whilst East Douglas had the highest fishing effort and the slowest growing 1 year olds. Fishing pressure may also explain the size distribution of the older cohorts. Fishing gear is selective towards larger individuals so higher effort may drive down mean size at age once a cohort is available to the fishery.

This increased knowledge of population dynamics and monitoring methods will be used to provide management advice aimed at ensuring the sustainability of the fishery.