THE AGE STRUCTURE AND DECLINE OF THE FRESHWATER MUSSEL *ELLIPTIO COMPLANATA* IN WEBATUCK CREEK IN AMENIA, NEW YORK

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Abstract. Pearly mussels (*Unionacea*) live buried in rivers, lakes, and streams around the world and have both economic and ecological value. The pearly mussel populations of the world are declining, for reasons that remain partly unknown. We examined the age structure of a population of *Elliptio complanata* in Webatuck Creek, New York to determine why successful recruitment has not been observed in more than 15 years. We collected specimens from a 475m reach using stratified and adaptive sampling methods. The shell of each animal was measured, sectioned, and stained using Mutvei's solution. We then counted annual growth rings to determine each animal's approximate age. Age ranged from 33 to 95 years old, and 94% of the animals were more than 50 years old. Animals 50 to 60 years old were the most abundant, making up 42% of the population. There was no correlation between shell length and animal age. The data suggest that the decline in *Elliptio* recruitment began approximately 50 years ago, and the last successful recruitment event was more than 20 years ago. Further studies are necessary to determine the specific cause of the decline and whether it is possible for the population to recover.

INTRODUCTION

Pearly mussels (*Unionacea*) live buried in the sediments of rivers, lakes, and streams around the world and have both economic and ecological value. There are approximately 1,000 known species, 300 of which occur in North America, and they can live to be more than 100 years old (Strayer and Jirka 1997). Historically, pearly mussels have been harvested and their shells used for pearl buttons and as nuclei for cultured pearls (Strayer and Jirka 1997). Unionids constitute a large portion of benthic biomass and are thought to play a significant role in particle processing, nutrient release, and sediment mixing in areas of high abundance (Strayer et al. 2004). Mussels have also proven useful as bioindicators.

The pearly mussel populations of the world are declining and threatened, both directly and indirectly, by human activity. Over-harvesting resulting from high commercial demand has severely depleted mussel populations across the US. However, it seems that other human activities resulting in habitat loss, increased siltation, and climate change, pose a more imminent threat to mussel populations in the 21st century (Strayer et al. 2004). Removal of vegetation from riparian areas causes increased siltation and destabilization of substrate, both of which destroy mussel habitat (Arbuckle and Downing 2002). Impoundment and channelization can change flow regimes. Besides destroying habitat, major changes in water flow can destabilize mussel position, which is imperative for proper filtration (Arbuckle and Downing 2002). Global warming and climate change also threaten mussel populations. Changes in water temperature are predicted to desynchronize the highly sensitive recruitment process and affect growth rate (Hastie et al. 2003).

Mussel growth is reflected in the shell structure as yearly and sub-yearly growth rings. Substantial variations in growth rate are recorded in the shell as disparities in yearly and daily growth increments (Schöne et al. 2004). In addition to being used to determine approximate age, studies have also shown that growth increments and average growth rates can be used to reconstruct historical environmental conditions and map past environmental perturbations (Jones et al. 1989; Schöne et al. 2004). For example, Fritz and Lutz (1986) studied annual growth rings and showed that growth rate decreased after mussels were relocated to a polluted area.

In this study we established the relative health and age distribution of a declining mussel population. We collected *Elliptio complanata* from Webatuck Creek in Amenia, New York, and sectioned them to determine the average age of each mussel, and the approximate date of the last successful recruitment event. We also used the data to determine whether there is a correlation between mussel age and shell length. Based on previous observations we hypothesized that the last successful recruitment event at this site was more than 15 years ago, therefore, none of the mussels will be less than 15 years old. We expected the mussels to have an unequal age distribution, with a large decline in the number of juveniles prior to the last recruitment event. We hope that this investigation will provide the preliminary data that is needed to determine the cause of the decline of *Elliptio* in Webatuck Creek and the surrounding region.

MATERIALS AND METHODS

Study Site

Webatuck Creek is a tributary of the Housatonic River, located in Amenia, NY. The creek drains over 200 km^2 of forested areas and agricultural fields. We collected animals from a 475m x 15m reach beginning ~10m from the creek's mouth and extending upstream. The stream is shaded by a dense riparian zone and has a coarse substratum. At the time of collection the stream was < 1.5m deep with high water flow due to recent rain (Strayer 1999).

Sampling Technique

Mussels were collected in late June to early July 2006. We used adaptive and stratified random sampling techniques to obtain a representative sample of the Elliptio population in the reach. All samples were collected using 0.5m x 0.5m quadrats. Each quadrat was first searched visually, and then excavated to approximately 0.1m (4 inches). We separated the contents of each quadrat using 8mm and 3.35mm sieves and searched by hand for the presence of juveniles. We used adaptive sampling at 10 locations along the entire length of the reach, totaling 32 quadrats, and a stratified technique to sample a 17m x 13m pool within the reach where Elliptio were known to be abundant.

Section Preparation (cutting and staining)

Mussel length was measured using calipers. We prepared the section by cutting the shell of each animal from the umbo to the ventral margin, perpendicular to the growth rings using a Buehler 11-1180 ISOMET™ low speed saw and a diamond blade. The newly exposed surface was mounted to a microscope slide using quick-dry epoxy. After drying, we re-mounted the specimen to the saw and made the final cut. All sections were 0.75mm.

Sectioned specimens were stained using Mutvei's solution (Schöne et al 2005). We immersed the sections in the solution in staining dishes, and heated them for 1.5 hours. After staining, sections were rinsed and allowed to air-dry. We counted the growth rings of each section on three separate occasions, using a compound light microscope at 400x magnification.

Data Analysis

The three ring counts were used to calculate the mean age for each mussel, which was used to create a histogram of the age distribution of the sample population. Individual mean ages were also plotted against the length of each animal to determine whether a correlation exists between the two variables. All data were analyzed using Excel.

RESULTS

We collected a total of 51 mussels and determined that this representative population has a highly skewed age distribution. Mussel ages ranged from 33 to 95 years and 94% of the population was over 50 years old (Figure 1). Animals between the ages of 50 and 60 were the most abundant, making up 42% of the population. There was no correlation between mussel age and shell length (Figure 2).

DISCUSSION

The absence of *Elliptio* juveniles in Webatuck Creek indicates that reproduction among the individuals of this population has ceased within the past 50 years. The mean ages of the sample population suggest that the decline began in the 1950s, with the last successful recruitment event occurring in the 1980s. Although there was no correlation between mussel age and shell length, it has been shown that these animals experience asymptotic growth, with maximum rates occurring in the first 6 – 8 years (Strayer et al 1981). Given the lack of juveniles in our sample, we are missing the data needed to define this growth curve.

The cause for the observed population decline is unknown. One compelling explanation is the presence of *Orconectes rusticus* (rusty crayfish) in Webatuck Creek. These crayfish are invasives that actively compete with native species. Klocker and Strayer (2004) showed that these crayfish prey on *Elliptio* juveniles between 3 and 9.9mm in length. However, it is unlikely that these crayfish are responsible for the complete elimination of juveniles from the population. *Elliptio* are also highly sensitive to changes in their aquatic environment. Studies show that these mussels prefer to live in clusters in flow refuges found in the creek (Strayer 1999). Changes in water flow resulting in a decrease in the size or a complete loss of these refuges may have contributed to the population decline. Alternatively, increased use of fertilizers in adjacent crop fields may have resulted in increased rates of eutrophication in the creek. Eutrophication lowers the amount of dissolved oxygen available in the water and sediment where juveniles live (Kalff 2002). Sparks and Strayer (1998) showed that *Elliptio* juveniles are highly sensitive and show negative behavioral responses to decreased levels of dissolved oxygen. It is also possible that the dissolved oxygen concentration of the water is not sufficient to support the mussels' host fish species. Host fish are an essential part of the *Elliptio* reproductive process and without them, although the mussels may still produce juveniles, it is highly unlikely that a recruitment event will be successful.

Further studies are needed to determine the specific cause (or causes) of the *Elliptio* decline in Webatuck Creek and whether or not it is possible to rescue the population. Future investigations should also consider how the *Elliptio* population in Webatuck Creek compares to that of nearby rivers. Are other rivers experiencing the same decline? If so, do the estimated dates of the decline coincide? It would also be interesting to learn how the age distribution of the *Elliptio* population compares to that of other mussel species found in the creek.

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APPENDIX

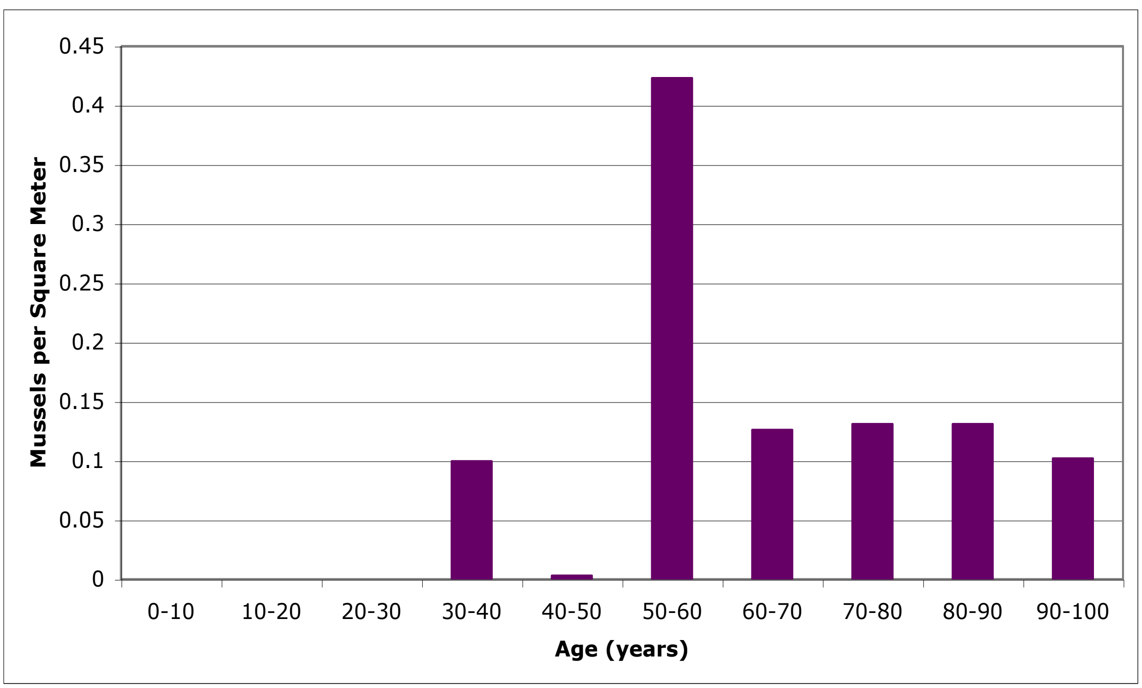

FIGURE 1. Age distribution per square meter of the *Elliptio complanata* population in Webatuck Creek in Amenia, NY. (n = 51)

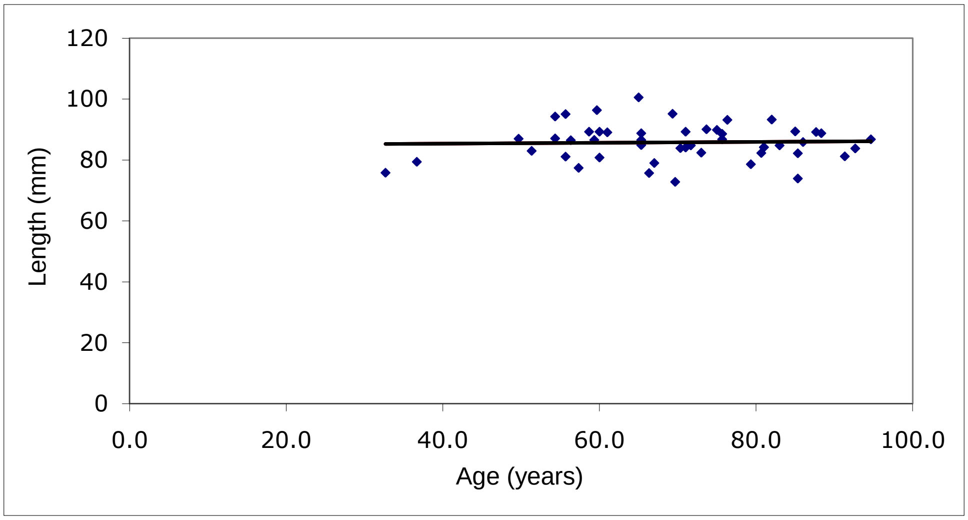

FIGURE 2. Correlation between mussel age and shell length for a sample of *Elliptio complanata* collected from Webatuck Creek in Amenia, NY. ($r^2 = 0.0011$, $p = 0.82$, $n = 51$)