First Step in Understanding Striped Bass Maternal Contribution: Larval Otolith Formation and Growth

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Abstract

Otolith studies have become more prevalent in recent years as use has expanded from only aging to examination of migration patterns and fidelity to natal habitats. The otolith of Striped Bass, *Morone saxatilis* (Walbaum; 1792), is used for all of these purposes, yet its formation and early development have not been documented. We were able to identify the timing and formation of the three otolith pairs during late egg stage, yolk-sac larvae, and post yolk-sac larvae. The sagittal otoliths were first to appear, forming shortly before hatch and were observed growing larger throughout the larval stage. The lapilli otoliths formed within the first 24 hours post hatch. The asterisci otoliths were difficult to locate, but seemed to form between 4 and 15 days post hatch. At hatch the sagittal otoliths appear circular, and by 5 days post hatch seem to gain some dimensionality. At 15 days post hatch the sagittal otolith began to elongate along the anterior/ posterior axis. This knowledge of the when the otoliths form will affect any microchemical analysis done in in the first year of life, especially as the asterisci otoliths form around first feeding, and should be taken into account when choosing an otolith for analysis.

Species History

Striped bass are an anadromous species, meaning that they live in saltwater and spawn in freshwater, however some spend their entire lives in freshwater. Striped bass is an important species economically as it has both commercial and recreational fishery in North Carolina . These fish are so desired that there are two fish hatcheries located in North Carolina, the Edenton National Fish Hatchery in Edenton and the Watha State Fish Hatchery in Watha. The hatcheries collect adult fish, breed them and then raise the young for stocking. Striped bass have been stocked throughout the United States, even as far west as San Francisco in 1876.

Figure 1: Sampling stations at the Edenton National Fish Hatchery in Edenton, NC. Red drop pins are 2012 locations while yellow diamonds denote 2013 ponds.

Methods

Striped bass adults and progeny were collected from two hatcheries within North Carolina, the Watha State Fish Hatchery and the Edenton National Fish Hatchery (Fig 1). Mothers from four different rivers across coastal North Carolina were used for this study. The progeny are photographed and the otoliths removed. The otoliths are removed using a bleach dissolution or dissection depending upon age (Figure 2) and photographed. The photographs are then used to measure fish total length (TL), and total otolith length (TOL) and the relationship between the two analyzed.

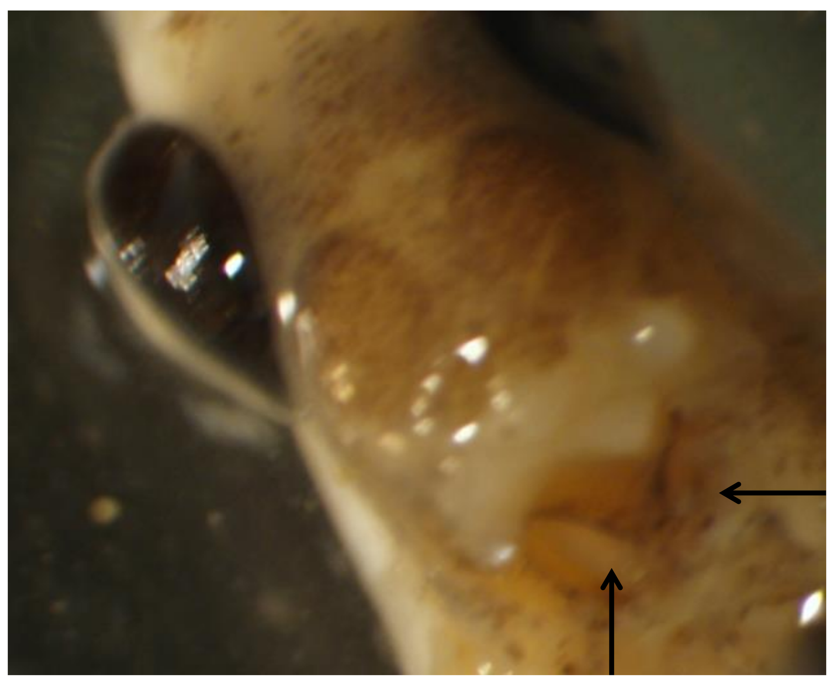


Figure 2: The head of a 47 day old fish out of a Watha State Fish Hatchery pond showing otolith placement (the arrow).

Results

Through this research we have discovered when the sagittal and lapillial otoliths, the vestibular structure, and when the sulcus become apparent (Table 1; Figure 3). There is a quadratic relationship between TOL and TL during yolk-sac larval stage (Figure 4A), while it becomes a linear relationship when examining the entire larval period (Figure 4B). The relationship between Age and TOL is linear (Figure 4C).

Table I: The important developmental stages of the otolith and ear canal/ cavity by age.

Age (dph)	Development	Picture
0	Sagittal otoliths form	Figure 3 A
.5	Lapilli al otolith, ear cavity and vestibular structure begin forming	Figure 3 B
2	Clear vestibular structure	Figure 3 C
4-5	First feeding mark	Figure 3 D
4-15	Asteriscus forms	Figure 3 E
15	Sulcus becomes apparent	Figure 3 F

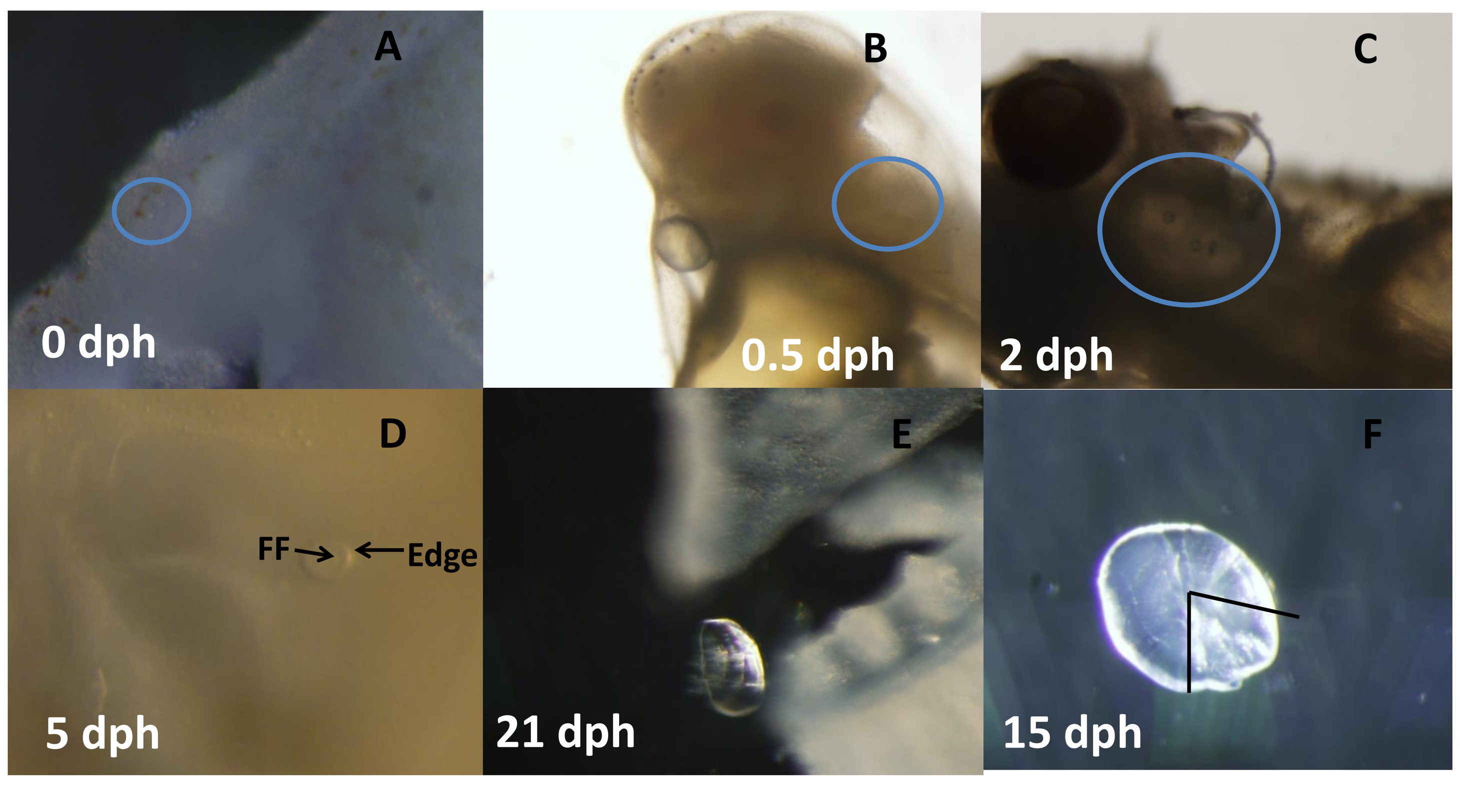
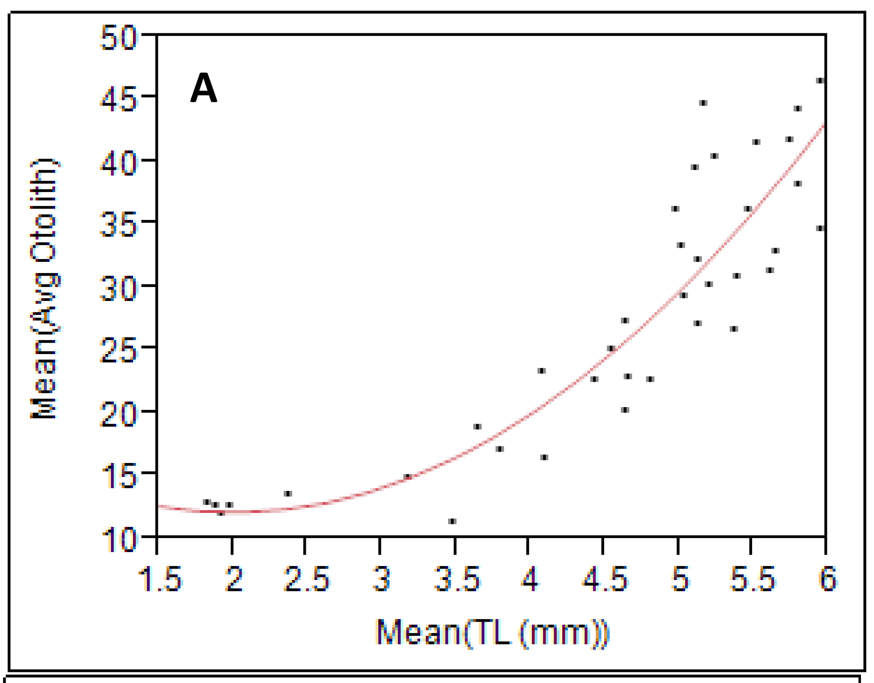
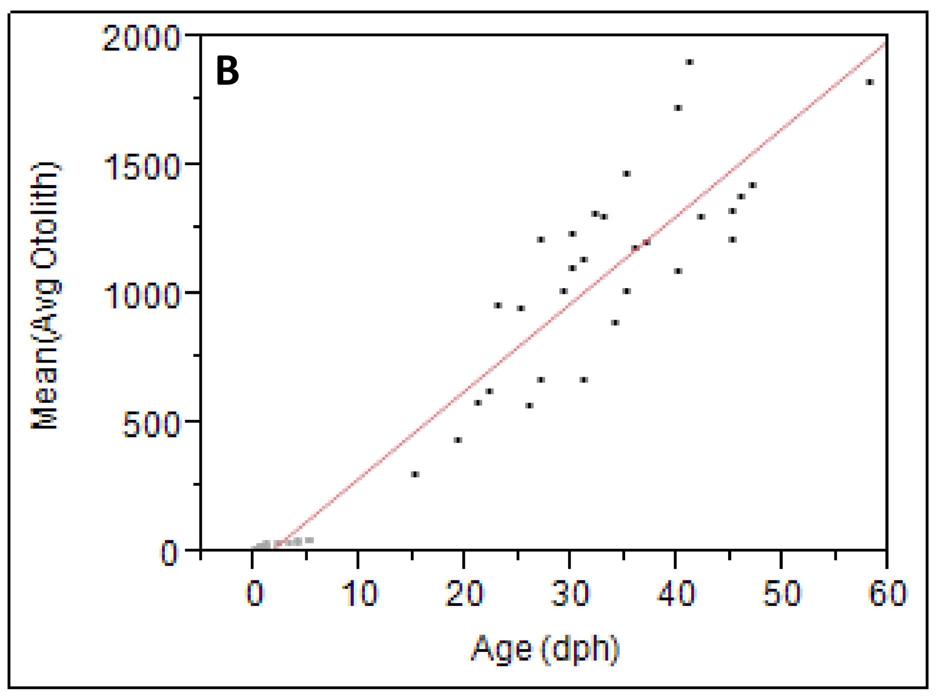


Figure 3: The progressing development of ear canal and otolith formation and development corresponding to Table I. Blue circles denote areas of interest. In D, FF stands for first feeding while edge is the edge of the otolith. In F, the black 'V' outlines the sulcus.





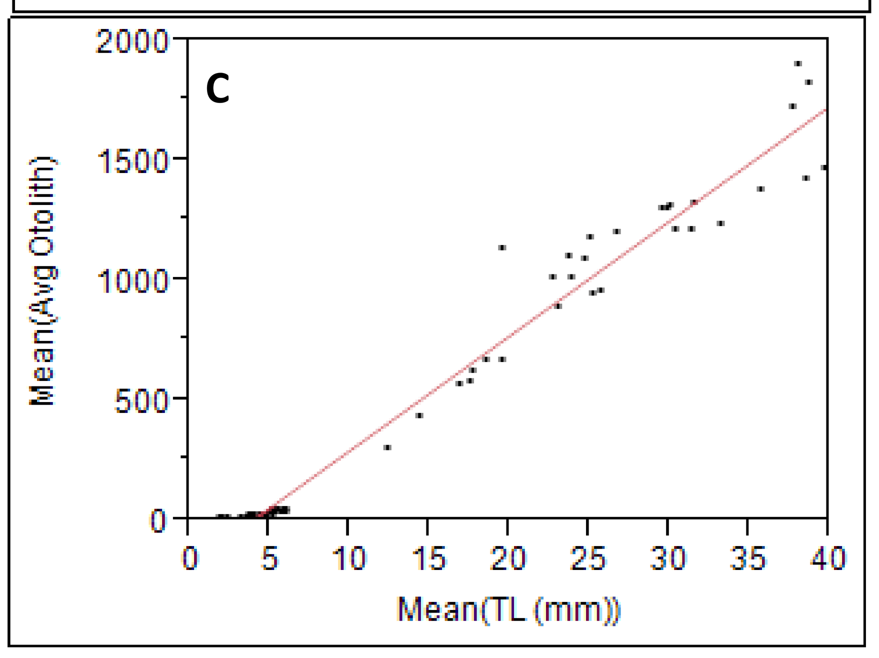


Figure 4: A is the quadratic relationship between TL and TOL for yolk-sac larvae (0-5 dph), $r^2 = 0.807$, n = 37, p = < 0.0001. B is the linear relationship between TL and TOL for all larval striped bass, $r^2 = 0.971$, n = 67, p < 0.0001. C is a linear relationship between age and TOL, $r^2 = 0.930$, n = 67, p < 0.0001.

Implications

Both the sagittal and lapillus otoliths form close to hatching while the asteriscus does not form until after the yolk-sac stage. This has implications for microchemical analysis as it is likely that there will be a different signature at the core between the otolith pairs as the sagittal and lapillus may contain maternal contribution. There was no difference between the rivers for fish or otolith length which may a result of cross-stocking. While the growth rates may vary between wild and hatchery raised fish, the relationship between fish length and otolith size should not change. Data between 5 and 15 dph is lacking which might change the relationship between TL and TOL of the entire larval otolith group from linear to quadratic.

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