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I am submitting herewith a thesis written by Reggie Eric Sawyers entitled "Comparison of Transverse and Sagittal Otolith Sectioning for Aging Wild Rainbow Trout from East Tennessee Streams." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Richard J. Strange
Major Professor

We have read this thesis
and recommend its acceptance:

J. Larry Wilson

James W. Habera

Accepted for the Council:

Anne Mayhew
Vice Chancellor and
Dean of Graduate Studies

(Original signatures are on file with official student records.)

COMPARISON OF TRANSVERSE AND SAGITTAL OTOLITH SECTIONING FOR AGING WILD RAINBOW TROUT FROM EAST TENNESSEE STREAMS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Reggie Eric Sawyers

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DEDICATION

This thesis is dedicated to my parents, James T. and Dolores A. Sawyers, who have always encouraged me to pursue my interests and provided me with invaluable educational opportunities.

ACKNOWLEDGEMENTS

Working on this project has been a very rewarding experience, and I would like to thank those who helped me along the way. First, I want to thank my major professor, Dr. Richard Strange, for making this opportunity available to me. I appreciate his guidance, encouragement, support, and friendship.

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I thank Craig Phillips, Joe Castleman, and J. R. Candlish for their assistance in the field, and my good friend, Jason Lupardus, for his countless hours of polishing and reading otoliths. Without them I would have no results. I am also grateful to Ann Reed at the University of Tennessee for providing statistical consultation.

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ABSTRACT

Rainbow trout (*Oncorhynchus mykiss*) are important sport fish that contribute to the economy and tourism in East Tennessee. Reliable aging techniques are needed to obtain accurate knowledge of their growth and productivity, which is necessary for making proper management decisions. Scales have historically been used for aging rainbow trout, but recent studies indicate that ages obtained from otoliths are more accurate. Preparing transverse otolith sections for aging is costly and time-consuming. Sagittal otolith sectioning is a more efficient alternative to transverse sectioning. Sagittal otolith sectioning has been examined for aging wild rainbow trout from the Southern Appalachians, but the need for better data on older fish (≥ age 5) exists. To address this need, two readers independently aged transverse and sagittal otolith sections from 682 wild rainbow trout from 10 East Tennessee streams. Aging accuracies for otoliths ground to the sagittal midplane were 99%, 84%, and 94%, respectively for ages 0-2, but declined from 85% to 20% for ages 3-6. Despite this decline, ages from sagittal otolith sections underestimated true fish ages (obtained from transverse otolith sections and previously validated with known-age fish) by only one year. Although ages obtained from otoliths ground to the sagittal midplane were less reliable than transverse-section ages for older fish in this study, they are still more reliable than scale ages.

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CHAPTER I

INTRODUCTION

Accurate age and growth data are vital to understanding the life history and population dynamics of fish (Jones 1992; Carlander 1987). The most reliable method of estimating the ages of fish requires the identification of a pattern of growth from a bony structure (Beamish and Chilton 1982). Historically, counting scale annuli has been the primary method of age determination in bony fish since their first extensive use for this purpose in 1930 (Carlander 1987). Over time, the accuracy of ages obtained from scales was questioned, and the need for more reliable methods was recognized (Carlander 1987).

Otoliths are calcified structures that are found in the inner ear of teleost fish and are often called 'ear stones'. Three pairs of otoliths occur in the vestibular apparatus of fish and are commonly termed the lapillus, sagitta, and asteriscus (Secor et al. 1991; Figure 1). The sagittae function in sound reception and equilibrium maintenance (Popper and Lu 2000). They are typically the largest of the otoliths and are most commonly used for aging fish (Campana and Neilson 1985; Secor et al. 1991). Because there is variation among the size and morphology of otoliths among fish species, no generalized method of otolith preparation exists for aging studies (Brothers 1987).

Macrostructural otolith analysis is the examination of annual concentric opaque and translucent zones, commonly termed "annuli". The formation of these zones has historically been attributed to factors such as seasonal temperature cycles, wet and dry periods, nutrition and feeding, and spawning cycles. Beckman and Wilson (1995) conducted an extensive literature review in the search for commonalities among these

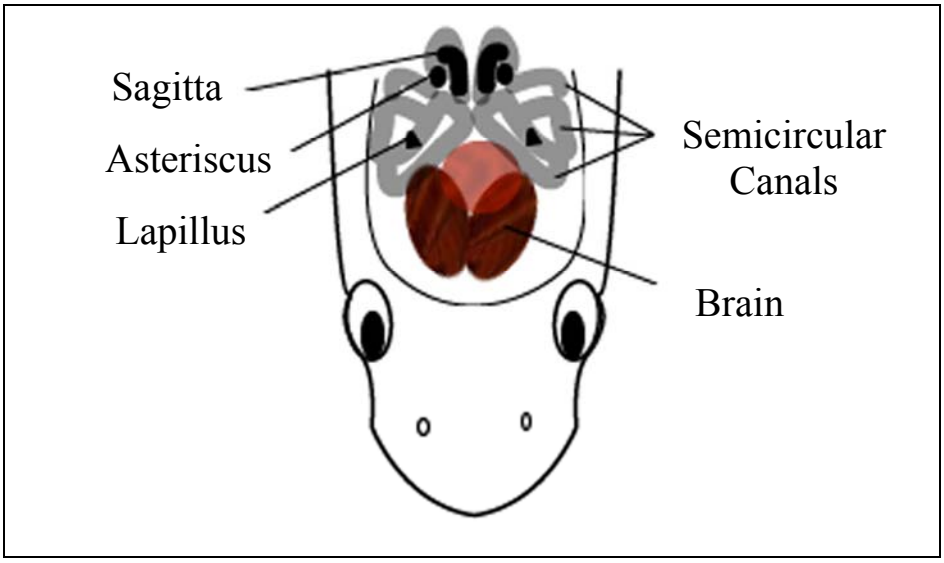


Figure 1. Dorsal view of the vestibular apparatus showing the location of the three pairs of otoliths. (Adapted from Secor et al. 1991; illustration from Cooper 2003).

factors in the timing of otolith zone formation. They discovered that most of the data were either based on single populations, were inconsistent, or lacked supportive evidence. In addition, they revealed flaws in methodology and inconsistent use of descriptive terminology. They determined the most common growth trend to be the seasonal formation of translucent and opaque zones, with opaque zones typically forming during the spring and summer months.

Otoliths have been used to age fish since Reibisch first observed annular ring formation in *Pleuronectes platessa* in 1899 (Jones 1992). Their use for age estimation has become more common due to evidence that suggests that counting annuli in otoliths can provide more accurate age data than scales (Neilson and Geen 1981; Beamish and Chilton 1982; Beamish and McFarlane 1987; Hining et al. 2000; Cooper 2003). However, many researchers continue to rely on scale annuli counts because of the relative

ease of collection and preparation and because this method does not require the fish to be sacrificed (Carlander 1987). Unlike scales, otoliths continue to grow even when somatic growth slows (Beamish and McFarlane 1987; Pereira et al. 1995) and do not resorb as the fish becomes stressed (Simkiss 1974; Campana and Neilson 1985; Beamish and McFarlane 1987; Jones 1992).

Valid and reliable aging techniques are needed in order to obtain accurate knowledge of their growth and productivity, which is necessary for making proper management decisions. Beamish and McFarlane (1983) stress the importance of validating a technique that is used to age fish or estimate fish ages. In their review of 500 studies, they found that only 65% had attempted to validate the aging technique. They suggested that all age classes in a population can only be validated by mark-recapture studies or the use of known-age fish.

Two recent studies used known-age fish to validate otolith ages for rainbow trout in the Southern Appalachians. Hining et al. (2000) used oxytetracycline (OTC) in a mark-recapture study which compared scale and otolith ages in rainbow trout up to age 5 in two high-elevation (950 m) Southern Appalachian streams. This study compared annuli counts from scales, transverse-sectioned otoliths, and sagittal-sectioned otoliths. A later study conducted by the Tennessee Wildlife Resources Agency (TWRA) and the University of Tennessee (UT) compared scale and otolith ages of wild rainbow trout in 12 East Tennessee streams (Cooper 2003). Otolith ages were determined from transverse-sectioned otoliths and validated against known-age fish (adipose fin clipped as age 0 and recaptured up to age 3) from five of the streams. Both studies revealed that scales often underestimated rainbow trout age beyond age 2, while otoliths were over

90% accurate (correctly identified age) and precise (ages obtained by different readers agreed). These results confirm that otoliths provide the most reliable means for aging wild rainbow trout from southern Appalachian streams.

Otoliths can be viewed whole or sectioned for aging (Secor 1991). Hining et al. (2000) found that using whole otoliths may underestimate rainbow trout ages because the first two annuli were often overlooked because of calcium deposition on the proximal surface (sulcus). This is common in older, slow-growing fish (Beamish and Chilton 1982) such as trout in the Southern Appalachians (Habera and Strange 1993; Hining et al. 2000; Cooper 2003); therefore it is usually necessary to section otoliths in order to interpret the annuli for aging.

A common method of preparing otoliths is sectioning at the transverse midplane (cross-sectioning; Figure 2). This involves embedding the otoliths in resin blocks, removing a thin section from the transverse midplane, and hand-polishing. This method has been validated for aging rainbow trout in East Tennessee streams (Cooper 2003), but it is a very time-consuming process when dealing with large numbers of otoliths. Hall (1991) found that grinding otoliths of stunted brook trout (*Salvelinus fontinalis*) to the sagittal midplane (Figure 3) was a simpler and more efficient method. Sagittal sections were prepared in 10% of the time required to prepare transverse sections and were easier to read because of greater distances between annuli in the sagittal plane (Hall 1991). However, grinding otoliths by hand may produce an uneven plane and loss of detail (Neilson and Geen 1981).

Hining et al. (2000) reported 87% agreement between ages for transverse-sectioned and sagittal-sectioned otoliths from 46 rainbow trout up to age 5. Each of the six

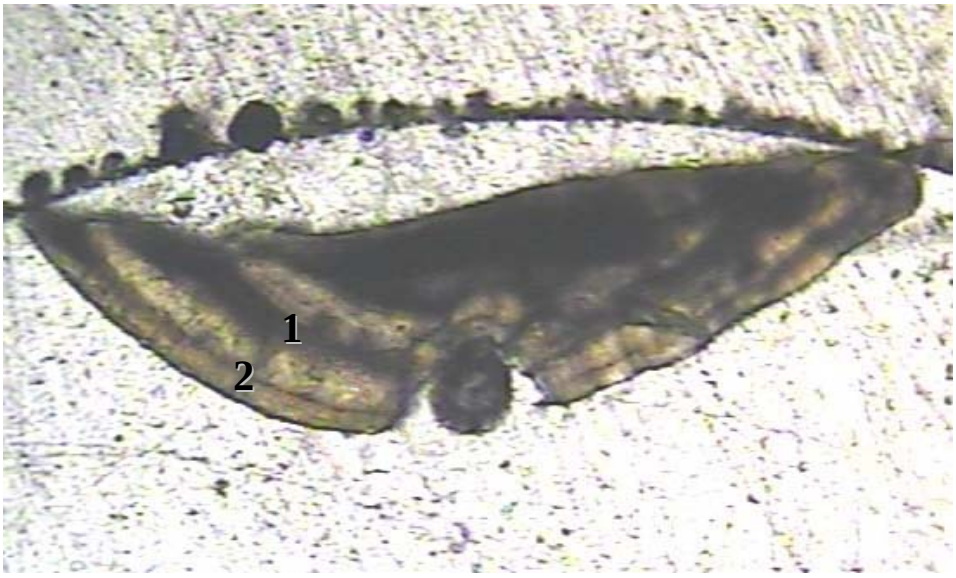


Figure 2. Photo of a transverse otolith section from an age-2 rainbow trout.

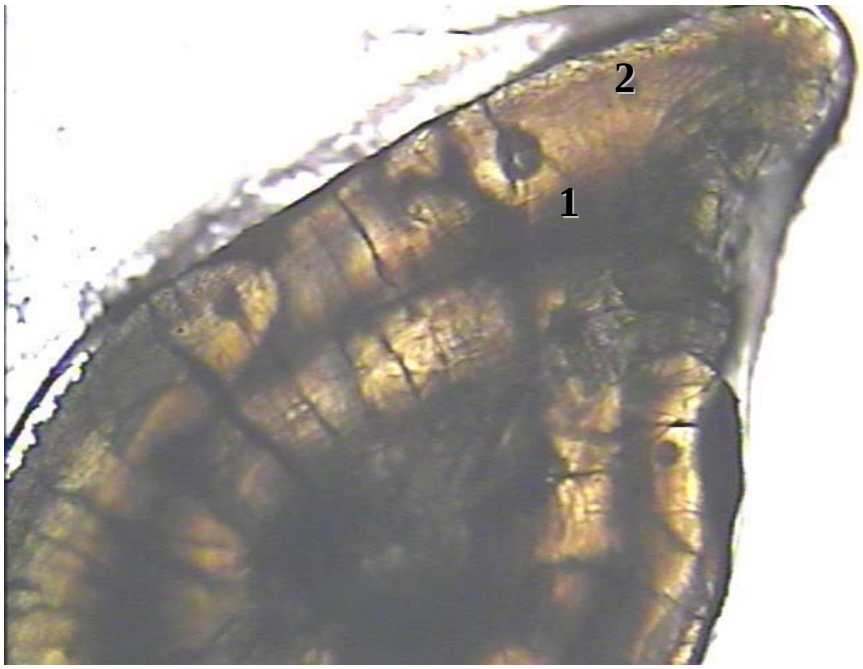


Figure 3. Photo of a sagittal otolith section from the same age-2 rainbow trout (Figure 2).

disagreements involved only one year. Hining et al. (2000) concluded that annuli counts using the sagittal method provide accurate and precise age data for wild rainbow trout in the Southern Appalachians, and suggested the need for further scale/otolith validation studies from other geographic areas. Important limitations to the Hining et al. (2000) study were that only two populations from relatively small, high elevation (950 m), low alkalinity (< 15 μS/cm) streams were evaluated and the sample size for fish older than age 3 was small (N=11). Wild rainbow trout also occur in larger, more productive streams at lower elevations in the southern Appalachians (including Tennessee), but otolith-derived ages from these populations are lacking.

The objectives of this research were to: (1) determine otolith ages of wild rainbow trout from 10 different populations in East Tennessee, including those inhabiting larger and typically more productive streams, and (2) validate the use of annuli counts taken from sagittal otolith sections to determine if this method can provide accurate age estimates for wild rainbow trout (potentially exceeding age 5).

CHAPTER II

METHODS

2.1 Study Streams

Wild rainbow trout (N=760) were collected from 10 East Tennessee streams (Figure 4; Table A1). The study streams were selected to represent the existing variability in geography and productivity and potential variability in wild trout growth and longevity. Temperature (^{o}C), conductivity (μS/cm), pH, and alkalinity (mg/L $CaCO_3$) were recorded for each sampling location (Table A2). Otolith ages were previously validated using known-age fish during October 1998 - October 2002 in five of these streams (Bald River, Beaverdam Creek, Doe Creek, North River, and Tellico River).

2.2 Fish Collection

Each of the 10 study streams was qualitatively sampled between June and October of 2004 and 2005 using gasoline or battery-powered backpack electroshockers. Only battery-powered backpack electroshockers were used to sample South Fork Citico Creek because of its location in a wilderness area. Annulus formation was complete during this time (Hining et al. 2000), making age determination more accurate.

Five individuals from each 25.4-mm (1-inch) size class present were targeted for each stream each year (Table A3). Stocked rainbow trout were present in some study streams and were easily identifiable by coloration, fin condition, and size. These fish were not of interest and were returned to the stream upon capture. Some larger size classes were not represented in every stream, suggesting growth differences related to stream

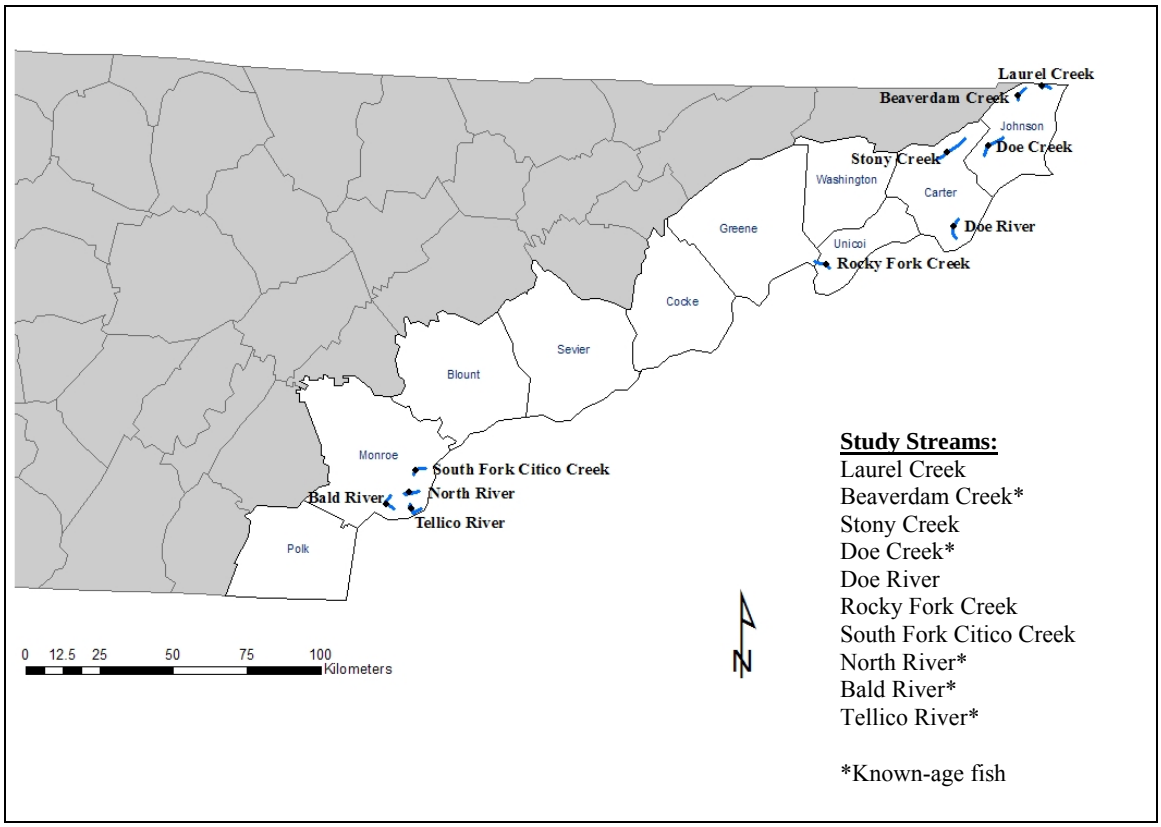


Figure 4. Location of 10 study streams in East Tennessee.

productivity. Stream length sampled in each case varied according to collection success but generally did not exceed 1 km. Captured fish were measured for total length (mm) and categorized by size class. The fish were transported on ice to the lab for otolith removal within 24 hours.

2.3 Otolith Removal

Prior to otolith removal, total lengths for all fish were re-measured to the nearest millimeter. Otoliths were extracted using the "up through the gills method" (Secor et al. 1991), cleaned of attached tissue and fluid, and allowed to air dry. Each pair of otoliths was stored in a small plastic vial, labeled with a stream identification code and a fish identification number, and held at room temperature (Brothers 1987).

2.4 Otolith Preparation

One otolith from each pair was selected at random for transverse sectioning (Figure 5). The remaining otolith was hand-ground to the sagittal midplane. The otolith selected for transverse sectioning was embedded in epoxy in a silicone mold and allowed to polymerize for 12 hours (Beamish 1979; Secor et al. 1991). Embedding in epoxy prevents fragmenting of thin sections and facilitates handling and mounting (Beamish 1979). A thin transverse section was cut from the block at the midplane with a Struers Minitom saw, which uses diamond impregnated, water-cooled grinding disks.

Otolith sections were mounted on glass slides by using a thermosetting plastic resin (Crystal Bond) (Neilson and Geen 1981; Secor et al. 1991). Otolith sections were hand polished using 600-800 grit silicon carbide wet sandpaper (Secor et al. 1991) until the annuli became readable. The remaining otolith was mounted sulcus side up on a glass slide (Figure 6) with thermosetting plastic resin and hand-ground to the sagittal midplane

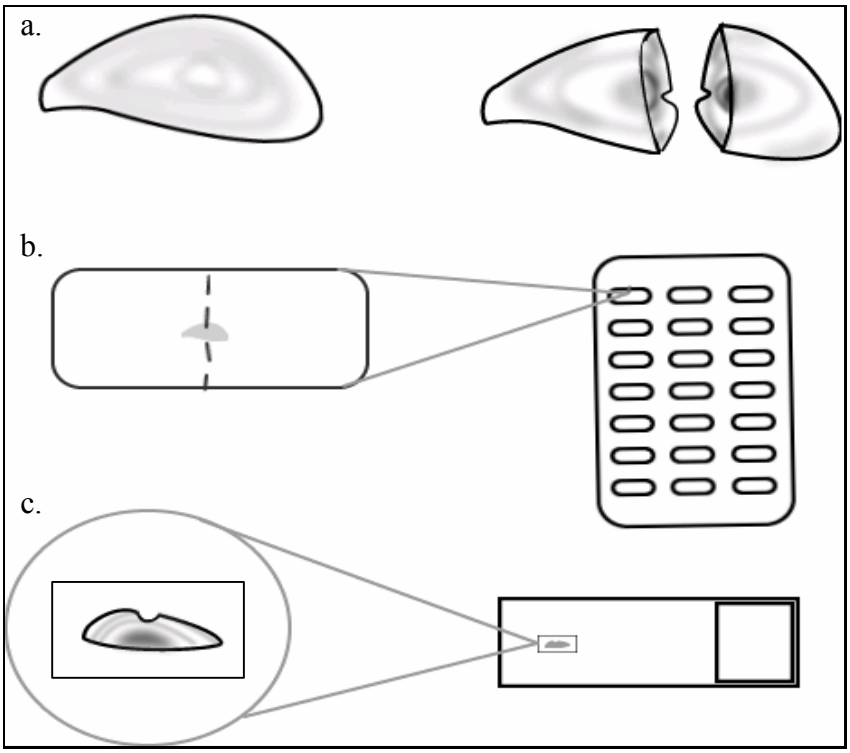


Figure 5. Procedure for preparing transverse otolith sections in *O. mykiss*. (a) whole otolith and sectioning plane (b) whole otolith placed in silicon mold of epoxy resin and hardener (c) transverse section mounted on a slide (Cooper 2003).

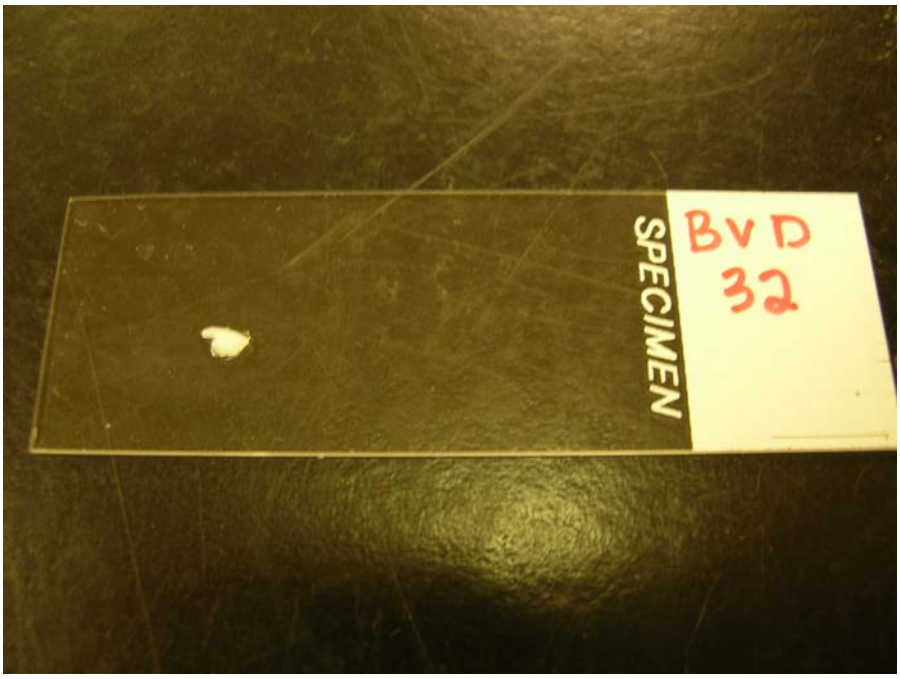


Figure 6. Whole otolith mounted sulcus-side up on a slide prior to hand-grinding to the sagittal midplane.

using 600-1000 grit sandpaper (Secor et al. 1991; Hining et al. 2000).

2.5 Otolith Aging

Both otolith preparations were examined under transmitted light for distinct opaque and translucent zones. Opaque zones were considered annuli and counts for each otolith were recorded. Immersion oil was frequently used to clarify annuli. Annuli counts were made by two independent readers, without reference to other otoliths or to the length of the fish. In the event of a disagreement between readers over annuli counts, the otolith in question was later re-examined by both readers until an agreement was reached. Unreadable otoliths were discarded (N=10). Annuli counts were compared for each sectioning technique for each fish, and agreement was recorded.

2.6 Age Validation

Cooper (2003) validated transverse-sectioned otolith and scale ages using known-age fish from Bald River, Beaverdam Creek, Doe Creek, North River, and Tellico River. All age-0 rainbow trout collected during TWRA's annual monitoring efforts in those streams were marked with adipose fin clips in 1997 or 1998 (Habera et al. 1999). Forty-three marked fish were recaptured in subsequent monitoring efforts (at ages 1-3), thus providing known-age fish for validation purposes. Examination of scales and otoliths from these fish indicated that annular marks were produced on both structures. However, ages obtained from otoliths always agreed with the actual ages, whereas scale ages became increasingly less reliable as actual age increased (Cooper 2003).

2.7 Statistical Analysis

Statistical analyses were performed using SPSS® version 14.0. Pearson's correlation was used to test the strength of the relationship between transverse and sagittal otolith final ages. A chi-square test was used to determine if agreement rates between higher-($\geq$ 30 mg/L $CaCO_3$) and lower-($<$ 30 mg/L $CaCO_3$) alkalinity streams were independent. Stony Creek, Beaverdam Creek, Laurel Creek, Doe Creek, and Doe River were considered higher-alkalinity streams. Rocky Fork, Bald River, North River, Tellico River, and South Fork Citico Creek were considered lower-alkalinity streams. A nonparametric Kolomogorov-Smirnoff test was used to check for significant differences in cumulative age frequencies between transverse and sagittal ages. Mean lengths at capture obtained from transverse sections were compared between higher- and lower-alkalinity streams using univariate analysis of variance (ANOVA). All tests and comparisons were assessed at the α=0.05 significance level.

CHAPTER III

RESULTS

Otoliths were obtained from 760 rainbow trout captured in the 10 East Tennessee study streams (Appendix B). Eleven fish were discarded because the otoliths could not be located during removal or the transverse sections were unreadable. Four fish were discarded because their unusually large size and atypical otolith appearance suggested they were immigrants from a tailwater river (likely stocked as fingerlings). Because neither reader had experience counting annuli on sagittal otoliths, both readers practiced this technique on 36 Stony Creek fish (STN 1-36). Transverse sections from these fish were also used to train the secondary reader. These otoliths were not included in preparation technique analyses. An additional 30 sagittal otoliths were either unavailable or unreadable. Unavailable otoliths were the result of accidental breakage or, in the case of young-of-the-year specimens, the inability to locate one or both otoliths during removal. In situations where only one otolith from a fish was available, it was transverse sectioned. Final ages were obtained for 710 transverse sections and 690 sagittal sections. A total of 682 paired otoliths were available for age comparison between methods.

3.1 Reader Agreement

Reader agreement was high for both methods (Table A4). The two readers initially agreed on sagittal ages 87% of the time, which was slightly higher than transverse agreement (85%). Sagittal agreement was above 80% through age 2, then generally declined through age 6 (0%; N=1). Transverse agreement was 80% or higher through age 3 and for age 6, but declined for ages 4 (61%) and 5 (64%). Mean age differences

when readers disagreed ranged from 1.0-1.2 years for transverse sections and from 1.0-1.1 years for sagittal sections (Table A4). Age differences between the two readers never exceeded two years for either method. An age difference of two years occurred eight times for transverse sections and four times for sagittal sections.

3.2 Preparation Method Comparability

Cooper (2003) validated transverse-section otolith ages for rainbow trout in East Tennessee, therefore transverse-section ages were considered to be the actual ages in this study. Ages obtained from transverse sections and sagittal sections will hereafter be referred to as transverse ages and sagittal ages, respectively. Sagittal ages agreed with transverse ages in 595 of 682 comparisons (87%; Table A4). Agreement was highest for ages 0-3 (84-99%; Table A4). Agreement declined considerably at ages 4 (68%), 5 (64%), and 6 (20%). Sagittal aging errors tended to be overestimates for ages 0 and 1 and underestimates for ages 3-6 (Table A5). All age differences were one year, except for age-2 fish, which produced differences up to two years (N=3).

There was a strong correlation between sagittal and transverse ages (R=0.946). A hypothetical slope of 1.0 would exist if sagittal ages were plotted against transverse ages and always agreed. A regression of sagittal age and transverse age for this study produced a calculated slope of 1.0 (SE=0.013) and was not significantly different from the hypothetical slope. A Kolmogorov-Smirnov test showed that the age distributions obtained by the two methods were not significantly different ($P > 0.99$). Pearson's chi-square indicated that agreement between methods was not different between higher- and lower-alkalinity streams (2.91, P=0.088).

3.3 Age and Growth

Final ages determined from transverse-section annuli counts of 745 samples were used for age and growth analysis (Appendix C). Fish up to age 6 were identified (Figure 7) and four or five-year-old fish were present in all streams. Age-5 fish were present in seven streams and age-6 fish were present in five streams. Fish lengths (Figure 8) ranged from 60 mm to 394 mm. Large fish (i.e., those >254 mm) occurred most frequently in Stony Creek and Doe Creek (Table A3). Fish over age 3 occurred most frequently in Rocky Fork and North River.

Growth was considerably variable across all populations. For example, a 254-mm fish ranged from one to six years of age (Figure 8). Trout in Stony Creek had the highest growth rates and those in South Fork Citico Creek and Rocky Fork exhibited the lowest growth rates. Mean lengths at capture (Table A6) for Stony Creek were significantly higher than all other streams at ages 1 (202 mm), 2 (268 mm) and 3 (319 mm). Mean lengths at age for Rocky Fork and South Fork Citico Creek were significantly lower than all populations at ages 1 (120 mm, 137 mm, respectively) and 2 (166 mm, 178 mm, respectively). Rocky Fork also had the lowest mean length at age 3 of any stream (196 mm). A comparison of mean lengths at age between higher- ($\geq$ 30 mg/L $CaCO_3$) and lower-alkalinity streams revealed no difference at age 0 and significant differences between the two stream groups for ages 1-6 (Figure 9).

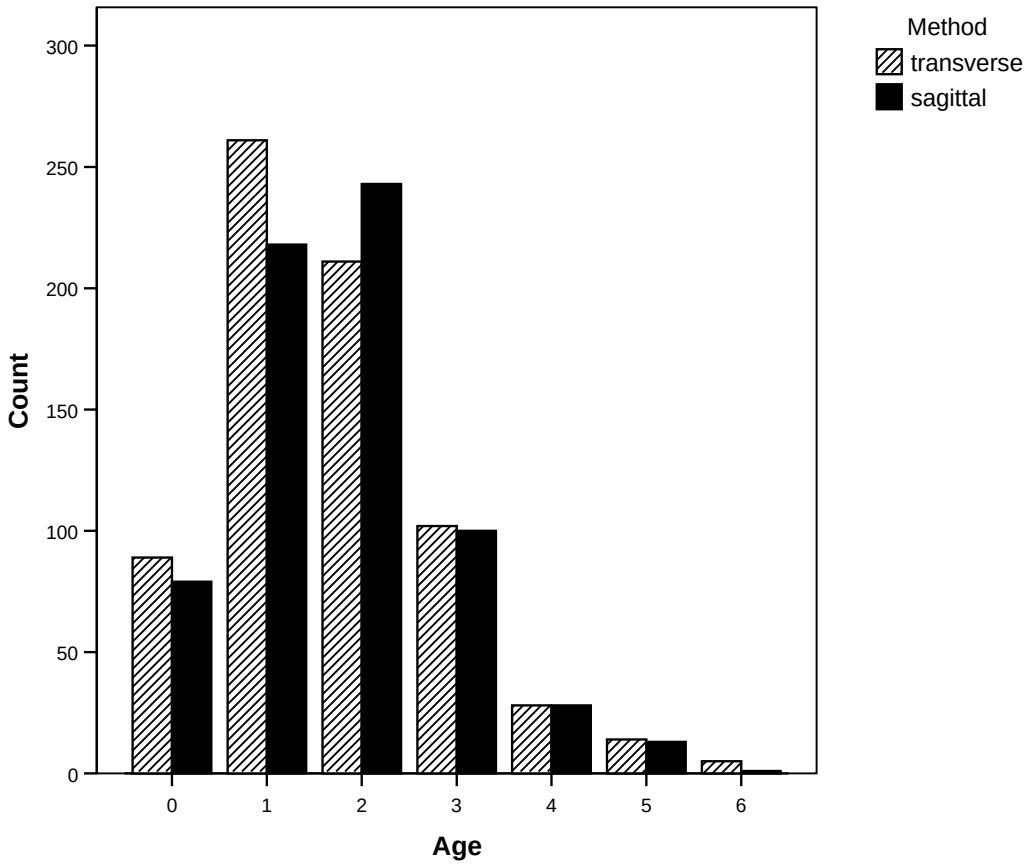


Figure 7. Age frequencies from transverse and sagittal otoliths from 10 populations of *O. mykiss* in East Tennessee.

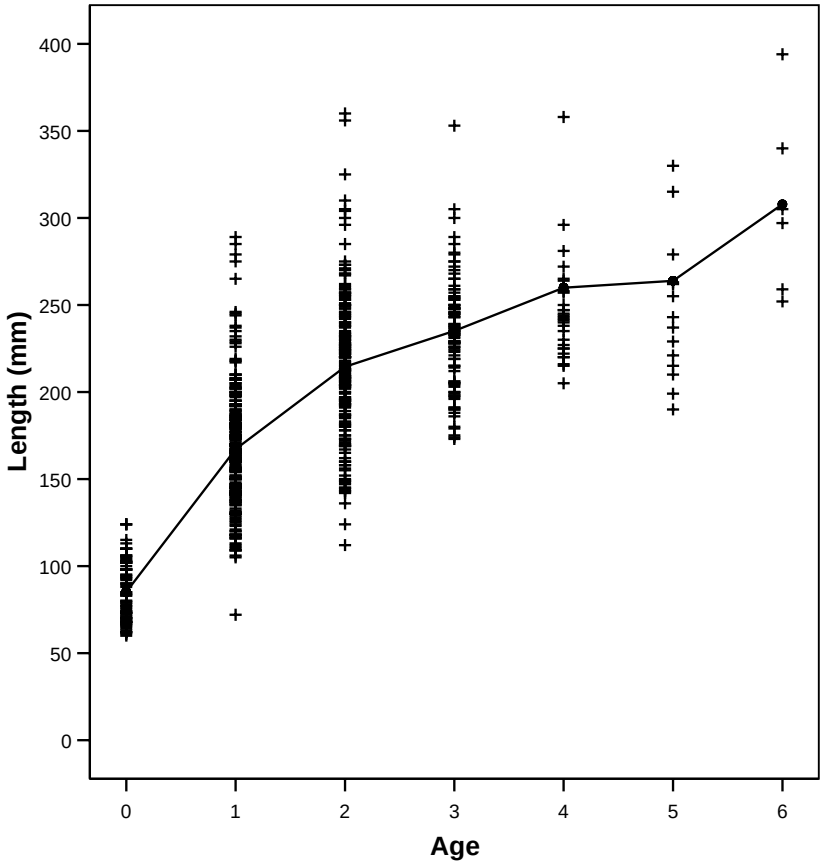


Figure 8. Mean length at age based on transverse otolith sections for *O. mykiss* from 10 populations in East Tennessee.

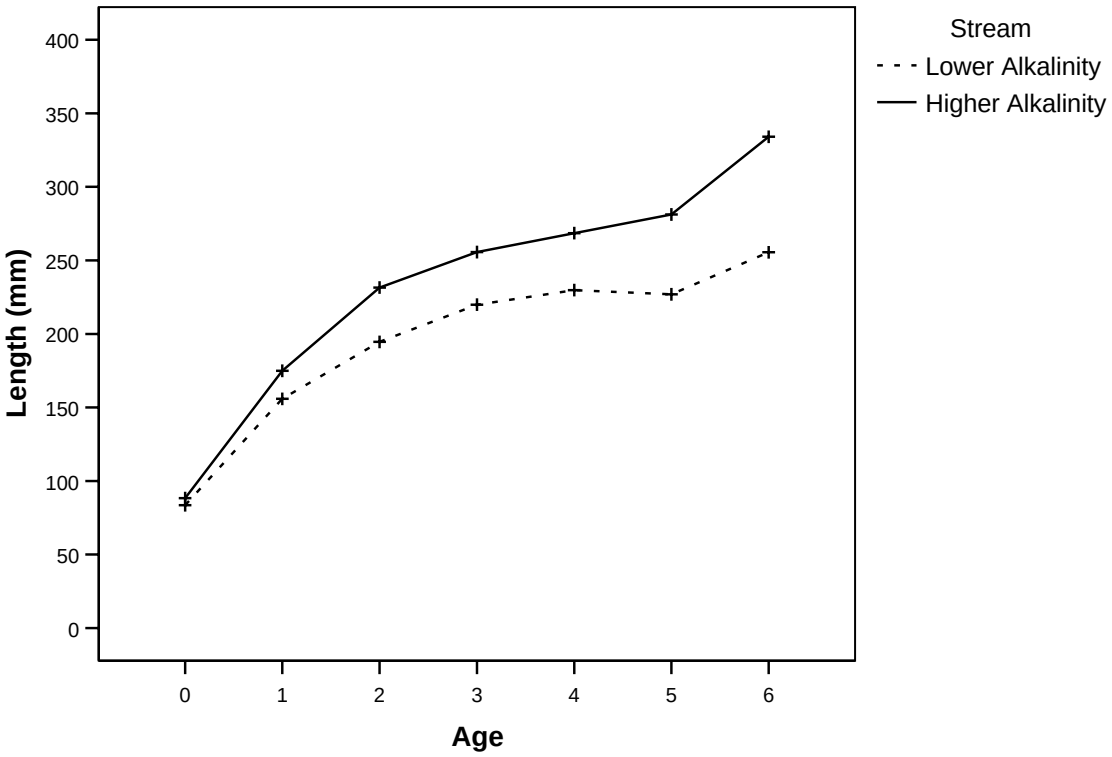


Figure 9. Mean length at age comparison between higher- (≥ 30 mg/L $CaCO_3$) and lower- (< 30 mg/L $CaCO_3$) alkalinity streams based on transverse otolith sections for *O. mykiss* from 10 populations in East Tennessee.

CHAPTER IV

DISCUSSION

4.1 Preparation Method Comparability

Otoliths are inherently more accurate for aging fish than scales (Neilson and Geen 1981; Beamish and Chilton 1982; Beamish and McFarlane 1987; Hining et al. 2000; Cooper 2003), but the time required to prepare transverse sections is a serious drawback. Several studies have acknowledged the potential of sagittal sectioning as a more efficient means to obtain accurate fish ages (Hall 1991; Hining et al. 2000). Results from this study suggest that the sagittal method may not be as reliable as transverse sections for aging wild rainbow trout from East Tennessee streams (particularly in older fish), but it is still a useful aging technique.

Overall, sagittal ages agreed with transverse ages 87% of the time in this study, which was the same as the sagittal/transverse agreement rate reported by Hining et al. (2000). The two studies differ, however, in the number of comparisons involving older fish. Hining et al. (2000) compared sagittal ages with transverse ages for fish up to age 5, and examined only six age-4 and one age-5 fish. This study included 29 age-4 and 14 age-5 fish representing a variety of streams, as well as five age-6 fish. However, the relatively low proportion of fish over age 3 in this study (7%) suggested that these older fish were not common in East Tennessee streams.

Age agreement between methods in this study declined as age increased beyond age 3. In older fish, sagittal ages tended to underestimate ages obtained from transverse sections, but never more than one year. This suggests that sagittal ages may not be as

reliable as transverse ages for older fish, but are still more reliable than scales (Hining et al. 2000; Cooper 2003). The 1.0 slope that was generated by regressing transverse and sagittal ages was clearly influenced by the large number of fish in age classes 0-3, for which agreement was much better than that for fish in age classes 4-6.

Reader agreement (precision) was lower (85%) than that reported by Cooper (2003; 95%) for transverse sections. In some otoliths (typically from higher-alkalinity streams), the first annulus was consistently mistaken as being part of the nucleus by one of the readers. This became evident when the two readers began to reconcile conflicting annuli counts, demonstrating the importance of using a two-reader system in maintaining the accuracy of the aging method.

Annuli were often less distinct in otoliths from higher-alkalinity streams (Figure 10) compared to those from lower-alkalinity streams (Figure 11). This may reflect differences in growth rate or the length of the growing season between the two stream types. This did not seem to negatively affect the agreement rate between sagittal- and transverse-section ages in higher-alkalinity streams to the extent that was anticipated.

The outer annulus in sagittal otolith sections from older fish was difficult to interpret because it was barely visible, discontinuous, or sometimes appeared to be part of the margin; thus one or both readers were hesitant to acknowledge these as annuli. In fact, readers never initially agreed on an age-6 fish based on sagittal age. After realizing that transverse sections consistently showed one more annulus in these fish, we were convinced that our hesitancy to acknowledge the outer annulus in sagittal otoliths may have resulted in a lower agreement rate.

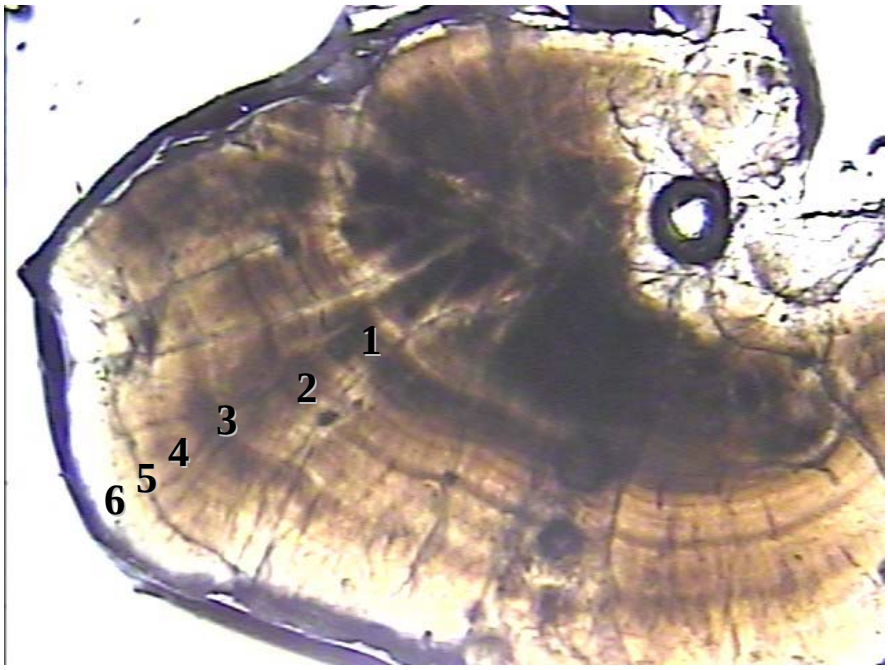


Figure 10. Photo of a sagittal otolith section from an age-6 rainbow trout from Doe Creek (a higher-alkalinity stream).

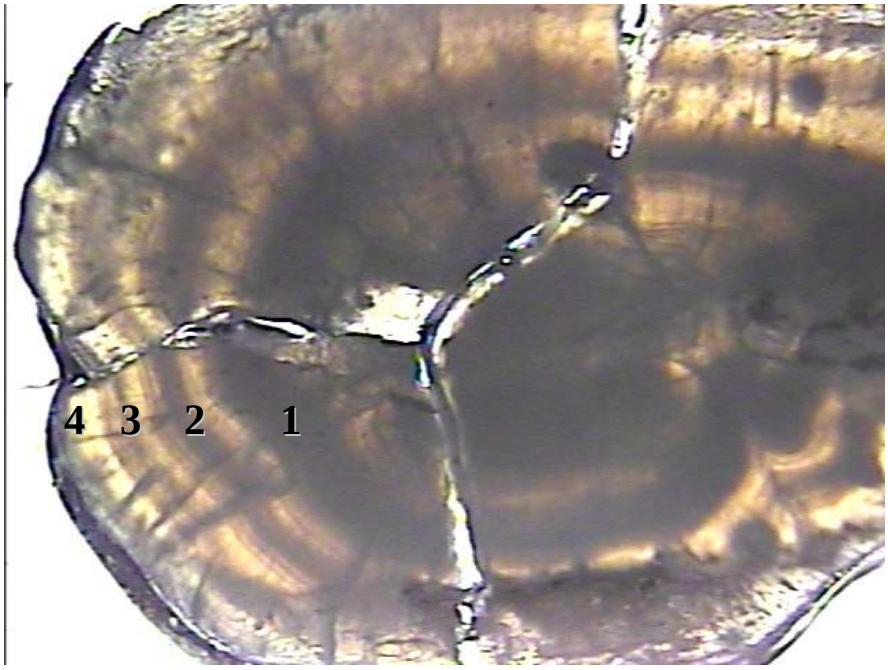


Figure 11. Photo of a sagittal otolith section from an age-4 rainbow trout from North River (a lower-alkalinity stream).

Preparing transverse otolith sections took considerably more time than preparing sagittal sections. For example, preparing one mold of 21 otoliths took a minimum of 26 hours. This reflects the time required to embed otoliths in epoxy, allowing the epoxy to cure, cutting transverse sections, and mounting them on slides. Preparing otoliths for sagittal sectioning simply required mounting the whole otolith on a slide, which took approximately 20 minutes for 21 otoliths. The time spent polishing transverse sections or hand-grinding sagittal sections varied according to the thickness of the transverse-section cut or to the thickness of a whole otolith, but was typically less than five minutes.

Hining et al. (2000) reported that identification of one or both of the first two annuli was obscured on whole otoliths by calcium deposition on the proximal surface. Annuli were usually distinct in the anterior, dorsal, and posterior portions of sagittal otoliths. They were easier to read at the anterior tip, especially in older fish, because of the greater distance between annuli. Hall (1991) aged brook trout using annuli counts taken from the anterior tip for this reason.

Through experimentation, two techniques somewhat improved the visibility of annuli for transverse and, to a greater extent, sagittal otolith sections when their annuli counts were questionable. Shining light through otoliths while viewing them on a black background gave them the appearance similar to that of a film negative (Figure 12). This was accomplished by rotating the mirror of the dissecting scope so that the black edge was directly below the otolith. The fiber optic lighting system provided enough indirect light once the mirror was rotated to transmit the light through the otolith. It was also determined that flipping the slide over and viewing the bottom of the otolith from beneath the slide (Figure 13), was quite beneficial in interpreting annuli. This was

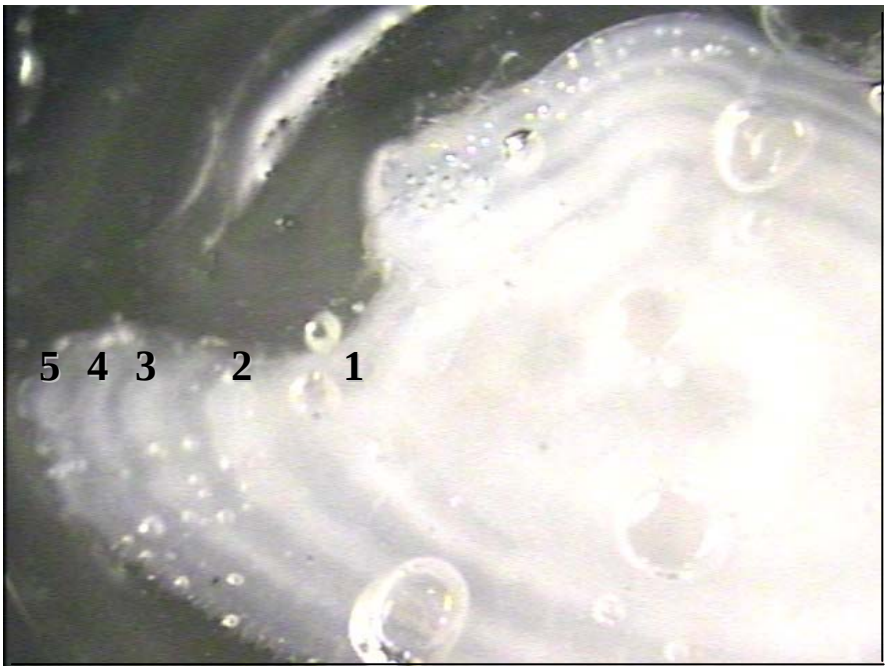


Figure 12. Photo of a sagittal otolith section from an age-5 North River rainbow trout viewed on a black background.

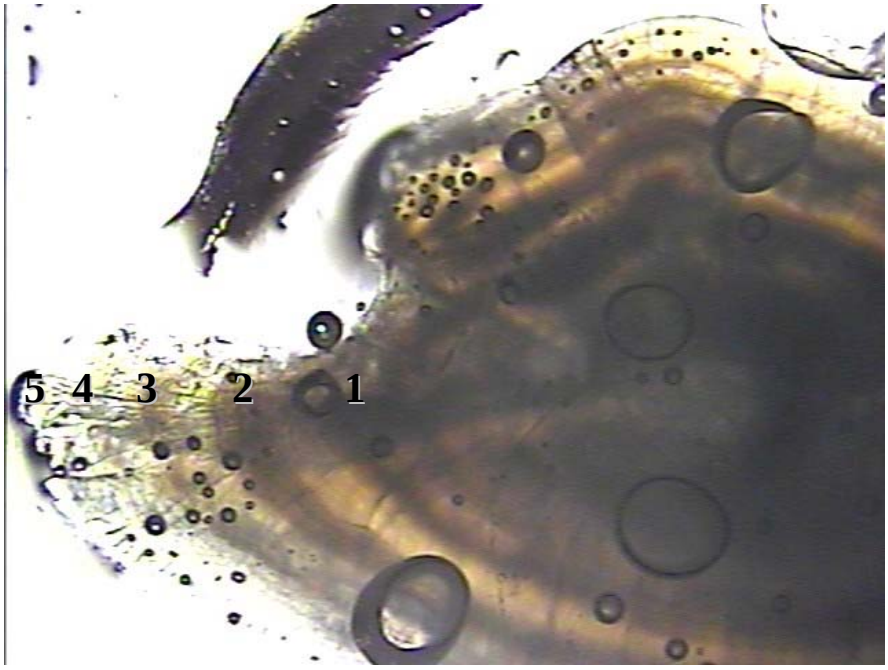


Figure 13. Photo of a sagittal otolith section from the same age-5 North River rainbow trout (Figure 12) viewed with the slide flipped over.

probably because of the difference in the way light transmitted through the thicker portion of the otolith.

The results of this study indicated that annuli counts obtained from otoliths ground to the sagittal midplane were reliable for aging wild rainbow trout up to age 3 from a variety of East Tennessee, and perhaps other, Southern Appalachian streams. Furthermore, the sagittal method was more efficient than transverse sectioning for obtaining fish ages. The outer annulus in sagittal sections from older fish (over age 3) was sometimes difficult to interpret and may have factored in underestimating age by one year in these fish. Although wild rainbow trout over age 3 were uncommon in this study, researchers should consider the risk of potential age underestimates in these fish when using sagittal otolith sections for aging. Additionally, some of the age differences between readers (reduced precision) were caused by errors such as misinterpreting either the outer annuli in otoliths of some older fish, or the first annulus in otoliths of some fish from higher-alkalinity streams. Avoidance of these errors could potentially improve the reliability of sagittal sections for aging older fish.

4.2 Age and Growth

The soft ($\leq$ 20 mg/L $CaCO_3$), poorly buffered waters, limited invertebrate productivity (Cada et al. 1987), and harsh environmental conditions (Harshbarger 1978) that characterize Southern Appalachian streams typically yield low wild trout abundances (<20 kg/ha; Habera and Strange 1993). There are mixed conclusions regarding the extent to which stream fertility affects fish production (Chapman 1978;Harshbarger 1978; Kwak and Waters 1997); however, a positive relationship appeared to exist in this study based on growth rates.

Study streams were considered fertile (and likewise more productive) if alkalinity was 30 mg/L $CaCO_3$ or greater (Table A1). The least-fertile streams (10-15 mg/L $CaCO_3$) were Bald River, North River, Tellico River, South Fork Citico Creek, and Rocky Fork. These streams are influenced by the underlying crystalline geology characteristic of Southern Appalachian streams (Habera and Strange 1993). Stony Creek, Doe Creek, Doe River, Beaverdam Creek, and Laurel Creek are some of the most fertile and productive trout streams in East Tennessee; they are influenced by the limestone geology of the valleys through which they flow. Higher-alkalinity streams had significantly higher mean lengths at capture than lower-alkalinity streams for ages 1-6, suggesting that growth is better in these streams.

Cooper (2003) attributed the presence of fewer fish over age 3 (N=12, or 3%) to drought conditions that prevailed during 1998-2002. In contrast, we collected 49 fish (6%) between ages 4 and 6. This may be due to sampling differences between the two studies, successful post-drought recovery, or a combination of the two. The largest numbers of fish over age 3 were collected in Rocky Fork (N=11) and North River (N=12), which are also two of the slowest-growing populations (Table A6). Although the oldest fish collected in South Fork Citico Creek were age 4, the growth curve for this stream does not plateau, indicating that older fish may be present but were not collected. These results suggest that the trout populations in these streams are stunted.

The 10 study streams fall under two types of fishing regulations. Bald River, North River, Beaverdam Creek, and South Fork Citico Creek are subject to wild trout angling regulations (three-fish creel, 229-mm minimum size, and gear restricted to single hook artificial lures) (Habera et al. 2005). The remaining study streams have no size limit on

rainbow trout, a seven-fish creel, and no gear restrictions (except for single hook artificial lure restrictions in Rocky Fork). Regardless of age, larger or more abundant fish would typically be preferred by anglers. Fish over age 3 are fairly uncommon (6%) and not sizeable enough (250-mm mean length) to justify significant changes to the existing management strategies for most of the study streams. Additionally, minimum size limits can cause a shift to a modal size just below the minimum limit, increasing intra-specific competition which can result in stunting or reduced recruitment to legal size (Nobel and Jones 1993). An alternative management strategy for North River and South Fork Citico Creek would be to liberalize the wild trout angling regulation, perhaps lowering the size limit to 178 mm (or removing it) and raising the creel limit to five fish. This strategy would transfer most of the harvest to more abundant size groups and could increase production of larger wild rainbow trout in these streams (Habera et al. 2005).

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APPENDICES

APPENDIX A

Table A1. Sample sizes and size ranges for *O. mykiss* for the 10 study streams.

Stream	County	n	Discarded samples	Size range (mm)
Stony Creek[a]	Carter	71	5	75-358
Doe River	Carter	75	0	60-330
Doe Creek	Johnson	88	4	68-394
Beaverdam Creek	Johnson	70	2	125-297
Laurel Creek	Johnson	80	1	73-279
Rocky Fork	Unicoi	66	1	62-233
Bald River	Monroe	86	1	67-285
North River	Monroe	88	0	62-279
Tellico River	Monroe	62	1	67-255
South Fork Citico Creek	Monroe	70	0	66-234
Total		760	15	60-394

[a] Thirty-six fish from Stony Creek (STN 1-36) were used to develop experience reading transverse and sagittal sections; these fish were not used for preparation method analysis.

Table A2. Site locations and water quality data for the 10 study streams in East Tennessee.

Stream	County	2004/2005						
		Coordinates		Site Length	Temp	Conductivity		Alkalinity
		Upper	Lower	(m)	(°C)	(µS/cm)	pH	(mg/L CaCO3)
Stony Creek	Carter	36.41590 N 82.07318 W	36.39785 N 82.10956 W	550/650	17.8/18.6	88/136	7.7/7.2	65/85
Doe River	Carter	36.14512 N 82.10537 W	36.17104 N 82.08112 W	1000/550	17.8/17.6	72/76	7.2/7.2	35/30
Doe Creek	Johnson	36.42543 N 81.93966 W	36.40955 N 81.96110 W	1200/1150	15.3/16.9	149/147	7.6/7.5	100/85
Beaverdam Creek	Johnson	36.57219 N 81.85432 W	36.58019 N 81.83622 W	750/1200	16.2/18.3	52/59	7.3/7.2	45/35
Laurel Creek	Johnson	36.58388 N 81.75034 W	36.60489 N 81.75325 W	600/1100	17.4/20.9	81/123	7.4/7.6	80/75
Rocky Fork	Unicoi	36.04836 N 82.56119 W	36.03825 N 82.54826 W	600/1100	12.3/18.6	16/10	6.9/7.0	10/15
Bald River	Monroe	35.28502 N 84.17318 W	35.28664 N 84.18333 W	700/1000	17.8/18.5	12/65	6.8/6.9	10/15
North River	Monroe	35.31923 N 84.09135 W	35.32725 N 84.12962 W	750/1150	17/19.7	19/22	6.9/6.9	15/15
Tellico River	Monroe	35.27397 N 84.08840 W	35.32513 N 84.14049 W	1000/900	15.6/21.7	13/47	6.9/6.8	10/15
South Fork Citico Creek	Monroe	35.39343 N 84.07751 W	35.39739 N 84.07494 W	300/850	13.4/18.9	15/15	6.7/6.7	10/10

Table A3. Number of *O. mykiss* collected in each size class for each of the 10 study streams.

	Size class (mm)													
Stream	51	76	102	127	152	178	203	229	254	279	305	330	356	381
Stony Creek	0	5	7	2	10	10	11	7	8	4	2	1	4	0
Doe River	6	3	0	10	11	10	10	18	4	1	1	1	0	0
Doe Creek	3	6	7	12	10	9	12	12	9	3	4	0	0	1
Beaverdam Creek	0	0	1	9	12	10	10	14	10	4	0	0	0	0
Laurel Creek	1	0	4	11	12	11	12	15	12	2	0	0	0	0
Rocky Fork	9	1	11	13	9	9	13	1	0	0	0	0	0	0
Bald River	5	4	6	4	16	20	13	13	4	1	0	0	0	0
North River	6	4	4	11	16	15	11	16	4	1	0	0	0	0
Tellico River	3	6	0	3	10	12	19	8	1	0	0	0	0	0
South Fork Citico Creek	5	6	11	10	10	13	10	5	0	0	0	0	0	0
Total	38	35	51	85	116	119	121	109	52	16	7	2	4	1

Table A4. Agreement between two readers for ages derived from transverse and sagittal otolith sections from *O. mykiss* (N=682), along with agreement between final ages for the two methods.

	Transverse-Section			Sagittal-Section			Transverse/Sagittal		
Final Age[a]	N	Agreed (%)	Mean difference[b]	N	Agreed (%)	Mean difference[b]	N	Agreed (%)	Mean difference[c]
0	89	86 (97)	1.0	80	80 (100)	0.0	76	75 (99)	-1.0
1	261	232 (89)	1.2	222	213 (96)	1.1	253	213 (84)	-0.9
2	211	168 (80)	1.1	246	211 (86)	1.1	206	193 (94)	0.0
3	102	88 (86)	1.0	100	69 (69)	1.0	100	85 (85)	0.6
4	28	17 (61)	1.2	28	20 (71)	1.0	28	19 (68)	1.0
5	14	9 (64)	1.2	13	7 (54)	1.0	14	9 (64)	1.0
6	5	4 (80)	1.0	1	0 (0)	1.0	5	1 (20)	1.0
Total	710	604 (85)	1.1	690	600 (87)	1.0	682	595 (87)	-0.1

[a] Age ultimately agreed upon by the two readers for each otolith. Transverse/sagittal comparisons involved final ages for each structure.

[b] For cases where there was a difference between readers (absolute values).

[c] For comparisons between methods, transverse-section age was considered correct, thus sagittal-section age underestimates resulted in negative values.

Table A5. Number of *O. mykiss* assigned to each age class based on ages determined from transverse and sagittal otolith sections.

	Sagittal Age						
Transverse age	0	1	2	3	4	5	6
0	75	1					
1	2	213	38				
2	2	4	193	6	1		
3			12	85	3		
4				9	19		
5					5	9	
6						4	1

Table A6. Mean length at capture of *O. mykiss* (N=756) for each population based on transverse otolith age.

		Mean length at capture (mm)						
Stream	n	0	1	2	3	4	5	6
Stony Creek	71	101	202	268	319	358	--	340
Doe River	75	69	166	223	249	265	330	305
Doe Creek	88	91	164	238	253	256	315	394
Beaverdam Creek	70	--	169	233	243	269	--	297
Laurel Creek	80	88	166	216	258	242	254	--
Rocky Fork	66	74	120	166	196	219	207	--
Bald River	86	90	169	210	245	--	237	--
North River	88	79	155	202	223	239	257	256
Tellico River	62	82	181	210	225	232	--	--
South Fork Citico Creek	70	88	137	178	206	228	--	--
All Streams	756	85	167	214	233	246	246	308

APPENDIX B

Table B1. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=75) from Stony Creek collected on 25 Jun 2004 and 15 Jul 2005.

Sample ID[a,b]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
STN-1	259	2	2	2	2	2	2
STN-2	257	2	2	2	2	2	2
STN-3	161	1	1	1	1	1	1
STN-4	160	1	2	2	1	1	1
STN-5	296	2	2	2	2	2	2
STN-6	85	0	0	0	0	0	0
STN-7	209	2	2	2	1	1	1
STN-8	244	1	1	1	1	1	1
STN-9	257	2	2	2	2	2	2
STN-10	235	1	1	1	1	1	1
STN-11	187	1	1	1	1	1	1
STN-12	190	1	1	1	2	2	2
STN-13	192	1	1	1	1	1	1
STN-14	170	1	1	1	1	1	1
STN-15	200	1	1	1	2	2	2
STN-16	199	1	1	1	2	2	2
STN-17	184	1	1	1	1	1	1
STN-18	184	1	1	1	1	1	1
STN-19	210	1	1	1	2	1	1
STN-20	106	0	0	0	0	0	0
STN-21	160	1	1	1	1	1	1
STN-22	110	0	0	0	0	0	0
STN-23	217	1	1	1	1	1	1
STN-24	208	1	1	1	3	3	3
STN-25	89	0	0	0	0	0	0
STN-26	78	-	-	not available	-	-	not available
STN-27	98	0	0	0	0	0	0
STN-28	75	0	0	0	0	0	0
STN-29	238	1	1	1	2	2	2
STN-30	257	2	2	2	2	2	2
STN-31	305	2	2	2	2	2	2

[a] Stream IDs that include 'x' were collected in 2005.
[b] STN-1 through STN-36 were not included in preparation method analyses.

Table B1. Continued.

Sample ID[a,b]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
STN-32	340	6	6	6	6	6	6
STN-33	358	4	4	4	-	-	not available
STN-34	353	2	3	3	3	3	3
STN-35	265	1	1	1	1	1	1
STN-36	275	2	1	1	1	1	1
STN-x1	410	-	-	discarded	-	-	discarded
STN-x2	285	1	1	1	1	1	1
STN-x3	360	2	2	2	2	2	2
STN-x4	356	3	2	2	3	3	3
STN-x5	300	3	3	3	3	3	3
STN-x6	305	4	3	3	4	4	4
STN-x7	170	1	1	1	1	1	1
STN-x8	202	1	1	1	1	1	1
STN-x9	110	0	0	0	0	0	0
STN-x10	102	0	0	0	0	0	0
STN-x11	244	2	2	2	2	2	2
STN-x12	245	1	1	1	1	1	1
STN-x13	202	1	1	1	1	1	1
STN-x14	171	1	1	1	1	1	1
STN-x15	185	1	1	1	1	1	1
STN-x16	177	1	1	1	1	1	1
STN-x17	219	1	1	1	1	1	1
STN-x18	218	1	1	1	1	1	1
STN-x19	187	1	1	1	1	1	1
STN-x20	230	1	1	1	1	1	1
STN-x21	245	2	2	2	0	0	0
STN-x22	208	1	1	1	1	1	1
STN-x23	103	0	0	0	0	0	0
STN-x24	124	0	0	0	0	0	0
STN-x25	141	1	1	1	1	1	1
STN-x26	157	1	1	1	1	1	1

[a] Stream IDs that include 'x' were collected in 2005.
[b] STN-1 through STN-36 were not included in preparation method analyses.

Table B1. Continued.

Sample ID[a,b]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
STN-x27	163	1	1	1	1	1	1
STN-x28	190	1	1	1	1	1	1
STN-x29	198	1	1	1	1	1	1
STN-x30	143	1	1	1	1	1	1
STN-x31	226	1	1	1	1	1	1
STN-x32	161	1	1	1	1	1	1
STN-x33	110	0	0	0	0	0	0
STN-x34	268	2	2	2	3	2	2
STN-x35	289	3	1	1	3	1	1
STN-x36	275	2	2	2	2	2	2
STN-x37	467	-	-	discarded	-	-	discarded
STN-x38	462	-	-	discarded	-	-	discarded
STN-x39	510	-	-	discarded	-	-	discarded

[a] Stream IDs that include 'x' were collected in 2005.
[b] STN-1 through STN-36 were not included in preparation method analyses.

Table B2. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=70) from Beaverdam Creek collected on 01 Jul 2004 and 12 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
BVD-1	150	1	1	1	1	1	1
BVD-2	140	1	1	1	1	1	1
BVD-3	148	2	2	2	2	2	2
BVD-4	165	1	1	1	2	2	2
BVD-5	207	1	1	1	1	1	1
BVD-6	220	2	2	2	2	1	2
BVD-7	248	2	2	2	2	2	2
BVD-8	135	1	1	1	1	1	1
BVD-9	215	NR	NR	discarded	2	2	2
BVD-10	165	1	1	1	-	-	not available
BVD-11	253	2	2	2	2	2	2
BVD-12	179	1	1	1	1	1	1
BVD-13	169	1	1	1	1	1	1
BVD-14	187	1	1	1	2	2	2
BVD-15	195	1	1	1	1	2	2
BVD-16	258	4	4	4	3	3	3
BVD-17	248	3	3	3	-	-	not available
BVD-18	237	3	3	3	2	2	2
BVD-19	169	2	2	2	2	3	2
BVD-20	200	1	1	1	1	1	1
BVD-21	271	2	2	2	2	2	2
BVD-22	225	2	2	2	2	2	2
BVD-23	238	3	3	3	3	3	3
BVD-24	181	1	1	1	1	1	1
BVD-25	160	1	1	1	1	1	1
BVD-26	169	1	1	1	2	1	2
BVD-27	219	3	3	3	2	2	2
BVD-28	238	2	2	2	2	2	2
BVD-29	235	3	3	3	2	2	2
BVD-30	192	2	2	2	2	2	2
BVD-31	246	3	3	3	3	3	3

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B2. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
BVD-32	267	2	2	2	2	3	2
BVD-x1	265	3	3	3	3	2	3
BVD-x2	211	-	-	not available	-	-	not available
BVD-x3	281	4	3	4	4	4	4
BVD-x4	247	5	4	4	5	4	4
BVD-x5	230	2	2	2	2	2	2
BVD-x6	143	1	0	1	2	1	1
BVD-x7	151	1	1	1	1	1	1
BVD-x8	210	2	1	1	2	2	2
BVD-x9	170	1	0	1	1	1	1
BVD-x10	189	2	0	1	1	1	1
BVD-x11	297	6	5	6	4	5	5
BVD-x12	174	1	1	1	1	1	1
BVD-x13	220	2	1	2	-	-	not available
BVD-x14	155	1	1	1	1	1	1
BVD-x15	145	1	1	1	1	1	1
BVD-x16	166	1	1	1	1	NR	discarded
BVD-x17	221	2	1	2	2	2	2
BVD-x18	296	4	3	4	4	4	4
BVD-x19	186	1	1	1	1	1	1
BVD-x20	261	3	2	2	3	2	2
BVD-x21	220	2	1	2	2	1	2
BVD-x22	169	1	1	1	1	1	1
BVD-x23	203	3	2	2	3	2	3
BVD-x24	170	1	1	1	2	1	2
BVD-x25	125	1	1	1	1	1	1
BVD-x26	141	1	1	1	1	1	1
BVD-x27	245	2	2	2	2	2	2
BVD-x28	238	2	2	2	2	2	2
BVD-x29	264	4	4	4	4	3	4
BVD-x30	185	1	1	1	1	1	1

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B2. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
BVD-x31	285	2	2	2	2	2	2
BVD-x32	250	2	2	2	2	2	2
BVD-x33	239	2	2	2	2	2	2
BVD-x34	256	2	2	2	2	2	2
BVD-x35	255	2	2	2	2	2	2
BVD-x36	255	3	3	3	3	2	3
BVD-x37	237	2	1	1	2	2	2
BVD-x38	130	1	1	1	1	1	1

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B3. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=80) from Laurel Creek collected on 01 Jul 2004 and 12 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
LRL-1	212	2	2	2	2	2	2
LRL-2	182	2	2	2	2	2	2
LRL-3	165	2	2	2	2	2	2
LRL-4	160	2	2	2	2	2	2
LRL-5	268	3	3	3	3	3	3
LRL-6	227	2	2	2	2	2	2
LRL-7	192	1	1	1	2	2	2
LRL-8	208	2	2	2	2	2	2
LRL-9	203	1	1	1	2	2	2
LRL-10	193	1	1	1	2	2	2
LRL-11	206	2	2	2	2	2	2
LRL-12	183	1	1	1	2	2	2
LRL-13	158	2	2	2	2	2	2
LRL-14	109	1	1	1	-	-	not available
LRL-15	111	1	1	1	1	1	1
LRL-16	184	1	1	1	1	2	2
LRL-17	155	1	1	1	1	1	1
LRL-18	228	2	2	2	-	-	not available
LRL-19	195	1	1	1	1	1	1
LRL-20	228	2	2	2	2	2	2
LRL-21	173	2	2	2	2	2	2
LRL-22	230	2	2	2	2	2	2
LRL-23	140	1	1	1	1	2	2
LRL-24	73	0	0	0	-	-	not available
LRL-25	275	3	3	3	3	3	3
LRL-26	268	2	2	2	2	2	2
LRL-27	260	2	2	2	2	2	2
LRL-28	256	2	2	2	2	2	2
LRL-29	220	2	2	2	2	2	2
LRL-30	254	2	2	2	2	2	2
LRL-31	130	1	1	1	1	1	1

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B3. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
LRL-32	131	1	1	1	1	2	2
LRL-33	154	1	1	1	1	1	1
LRL-34	142	1	1	1	1	1	1
LRL-35	230	2	2	2	2	2	2
LRL-36	279	1	1	1	2	2	2
LRL-x1	279	3	3	3	3	3	3
LRL-x2	246	3	1	2	0	1	2
LRL-x3	228	2	2	2	2	2	2
LRL-x4	243	4	3	4	4	4	4
LRL-x5	242	2	1	2	1	2	2
LRL-x6	255	5	4	5	4	4	4
LRL-x7	270	3	3	3	3	3	3
LRL-x8	250	2	1	2	2	2	2
LRL-x9	232	2	2	2	2	2	2
LRL-x10	206	3	2	2	2	2	2
LRL-x11	224	2	1	2	2	2	2
LRL-x12	180	1	1	1	1	1	1
LRL-x13	102	0	0	0	1	0	discarded
LRL-x14	180	1	0	1	1	1	1
LRL-x15	215	3	3	3	2	2	2
LRL-x16	202	1	1	1	1	1	1
LRL-x17	163	1	0	1	0	1	1
LRL-x18	173	1	0	1	1	1	1
LRL-x19	241	4	2	4	3	2	3
LRL-x20	136	2	0	2	0	0	0
LRL-x21	224	2	1	2	2	2	2
LRL-x22	141	1	0	1	0	0	0
LRL-x23	193	1	1	1	1	1	1
LRL-x24	150	1	1	1	1	1	1
LRL-x25	167	1	1	1	1	1	1
LRL-x26	243	6	5	5	5	5	5

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B3. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
LRL-x27	162	1	0	1	1	1	1
LRL-x28	138	1	1	1	1	1	1
LRL-x29	123	1	0	1	2	2	2
LRL-x30	142	2	1	2	2	2	2
LRL-x31	177	1	1	1	2	1	1
LRL-x32	149	NR	NR	discarded	1	1	1
LRL-x33	200	2	1	2	2	2	2
LRL-x34	213	2	1	2	2	2	2
LRL-x35	147	3	1	1	2	1	1
LRL-x36	170	1	0	1	1	1	1
LRL-x37	204	2	1	2	2	1	2
LRL-x38	257	3	2	3	3	2	3
LRL-x39	263	5	3	5	5	4	5
LRL-x40	240	2	1	2	2	2	2
LRL-x41	245	3	2	3	3	3	3
LRL-x42	232	2	1	2	2	2	2
LRL-x43	270	2	1	2	2	2	2
LRL-x44	253	3	3	3	3	3	3

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B4. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=88) from Doe Creek collected on 22 Jul 2004 and 15 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
DCR-1	300	2	2	2	3	4	3
DCR-2	223	2	2	2	2	3	2
DCR-3	250	2	2	2	3	NR	discarded
DCR-4	325	2	2	2	2	2	2
DCR-5	247	4	4	4	4	4	4
DCR-6	272	3	3	3	3	3	3
DCR-7	228	3	3	3	3	3	3
DCR-8	232	1	1	1	NR	NR	discarded
DCR-9	394	6	6	6	5	5	5
DCR-10	210	1	1	1	2	2	2
DCR-11	113	0	0	0	0	0	0
DCR-12	151	1	1	1	1	1	1
DCR-13	224	2	2	2	2	2	2
DCR-14	232	2	2	2	2	2	2
DCR-15	231	2	2	2	2	3	2
DCR-16	138	1	2	1	2	2	2
DCR-17	219	3	3	3	3	3	3
DCR-18	182	1	1	1	1	2	1
DCR-19	165	1	1	1	1	2	1
DCR-20	130	1	1	1	2	2	2
DCR-21	209	2	2	2	2	2	2
DCR-22	195	2	2	2	2	2	2
DCR-23	187	2	2	2	2	2	2
DCR-24	165	1	1	1	1	1	1
DCR-25	159	-	-	not available	1	1	1
DCR-26	162	1	1	1	1	1	1
DCR-27	200	1	1	1	1	1	1
DCR-28	145	1	1	1	1	1	1
DCR-29	105	0	0	0	0	0	0
DCR-30	98	0	0	0	0	0	0
DCR-31	72	0	0	0	0	0	0

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B4. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
DCR-32	100	0	0	0	0	0	0
DCR-33	68	0	0	0	-	-	not available
DCR-34	94	0	0	0	0	0	0
DCR-35	83	0	0	0	0	0	0
DCR-36	142	1	1	1	1	1	1
DCR-37	135	-	-	not available	-	-	not available
DCR-38	98	0	0	0	0	0	0
DCR-39	73	0	0	0	0	0	0
DCR-40	98	0	0	0	0	0	0
DCR-41	191	2	2	2	2	2	2
DCR-x1	273	2	1	2	1	1	1
DCR-x2	246	2	1	2	2	2	2
DCR-x3	236	2	3	3	3	3	3
DCR-x4	222	2	1	2	2	2	2
DCR-x5	222	2	2	2	2	2	2
DCR-x6	262	2	1	2	3	2	4
DCR-x7	304	2	1	2	2	2	2
DCR-x8	135	1	0	1	1	1	1
DCR-x9	223	2	1	2	2	2	2
DCR-x10	226	2	1	2	2	2	2
DCR-x11	243	3	3	3	3	2	3
DCR-x12	228	1	1	1	1	1	1
DCR-x13	310	2	2	2	2	2	2
DCR-x14	163	NR	NR	discarded	1	1	1
DCR-x15	174	1	1	1	1	1	1
DCR-x16	192	2	1	1	1	1	1
DCR-x17	272	4	2	4	3	3	3
DCR-x18	147	1	1	1	1	1	1
DCR-x19	205	2	2	2	2	2	2
DCR-x20	193	1	1	1	1	1	1
DCR-x21	166	1	1	1	1	1	1

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B4. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
DCR-x22	163	1	1	1	1	1	1
DCR-x23	148	2	0	1	1	1	1
DCR-x24	218	1	1	1	1	1	1
DCR-x25	179	1	1	1	1	1	1
DCR-x26	204	2	1	2	2	1	2
DCR-x27	155	1	1	1	1	1	1
DCR-x28	186	1	1	1	1	1	1
DCR-x29	126	1	0	1	1	1	1
DCR-x30	169	1	1	1	1	1	1
DCR-x31	138	1	1	1	1	1	1
DCR-x32	128	1	0	1	1	1	1
DCR-x33	117	2	1	1	1	1	1
DCR-x34	273	2	1	2	2	1	2
DCR-x35	259	2	2	2	2	2	2
DCR-x36	250	3	2	4	3	2	3
DCR-x37	257	3	1	2	2	1	2
DCR-x38	315	5	5	5	5	5	5
DCR-x39	118	1	1	1	0	0	0
DCR-x40	106	1	0	1	1	1	1
DCR-x41	290	2	1	discarded	0	0	0
DCR-x42	289	3	3	3	3	3	3
DCR-x43	261	3	3	3	3	3	3
DCR-x44	124	2	1	2	2	2	2
DCR-x45	120	1	1	1	-	-	not available
DCR-x46	246	1	1	1	1	1	1
DCR-x47	275	3	3	3	3	3	3

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B5. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=75) from Doe River collected on 22 Jul 2004 and 25 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
DRV-1	235	3	3	3	3	3	3
DRV-2	245	3	3	3	2	2	2
DRV-3	265	4	4	4	3	3	3
DRV-4	243	3	3	3	3	3	3
DRV-5	248	3	3	3	3	3	3
DRV-6	231	3	3	3	3	3	3
DRV-7	248	3	3	3	-	-	not available
DRV-8	232	2	2	2	2	2	2
DRV-9	244	3	3	3	3	3	3
DRV-10	214	2	2	2	2	2	2
DRV-11	226	2	2	2	2	2	2
DRV-12	211	2	2	2	2	2	2
DRV-13	233	2	2	2	2	2	2
DRV-14	205	1	1	1	1	1	1
DRV-15	192	1	1	1	1	1	1
DRV-16	179	1	1	1	1	1	1
DRV-17	150	1	1	1	1	1	1
DRV-18	218	2	2	2	1	2	2
DRV-19	84	0	0	0	0	0	0
DRV-20	61	0	0	0	-	-	not available
DRV-21	181	1	1	1	1	1	1
DRV-22	146	1	1	1	1	3	2
DRV-23	160	1	1	1	2	2	2
DRV-24	167	1	1	1	1	2	2
DRV-25	170	1	1	1	1	3	2
DRV-26	77	0	0	0	0	0	0
DRV-27	69	0	0	0	-	-	not available
DRV-28	60	0	0	0	0	0	0
DRV-29	70	0	0	0	0	0	0
DRV-30	62	0	0	0	0	0	0
DRV-31	62	0	0	0	0	0	0

[a] Stream IDs that include 'x' were collected in 2005.

Table B5. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
DRV-32	80	0	0	0	-	-	not available
DRV-33	171	1	2	2	1	2	1
DRV-34	136	1	1	1	1	1	1
DRV-35	133	1	1	1	1	1	1
DRV-36	176	1	1	1	1	1	1
DRV-37	142	1	1	1	1	1	1
DRV-38	187	2	2	2	2	2	2
DRV-39	196	2	2	2	2	2	2
DRV-x1	280	3	3	3	3	2	3
DRV-x2	253	2	2	2	2	2	2
DRV-x3	246	3	3	3	3	2	3
DRV-x4	255	3	3	3	3	2	3
DRV-x5	305	6	6	6	6	5	6
DRV-x6	330	5	5	5	4	4	4
DRV-x7	250	3	3	3	3	3	3
DRV-x8	250	1	2	2	2	2	2
DRV-x9	259	3	3	3	3	2	3
DRV-x10	130	1	1	1	1	1	1
DRV-x11	131	1	1	1	1	1	1
DRV-x12	234	2	2	2	2	2	2
DRV-x13	234	2	2	2	2	2	2
DRV-x14	203	2	2	2	2	2	2
DRV-x15	240	2	2	2	2	2	2
DRV-x16	251	2	2	2	2	2	2
DRV-x17	198	1	1	1	1	1	1
DRV-x18	166	1	1	1	1	1	1
DRV-x19	189	1	1	1	1	1	1
DRV-x20	207	1	1	1	1	1	1
DRV-x21	175	1	1	1	1	1	1
DRV-x22	141	1	1	1	1	1	1
DRV-x23	240	2	2	2	2	2	2

[a] Stream IDs that include ‘x’ were collected in 2005.

Table B5. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
DRV-x24	213	2	2	2	2	2	2
DRV-x25	227	2	2	2	2	2	2
DRV-x26	210	2	2	2	2	2	2
DRV-x27	244	2	2	2	2	2	2
DRV-x28	186	1	1	1	1	1	1
DRV-x29	161	1	1	1	1	1	1
DRV-x30	174	1	1	1	1	1	1
DRV-x31	170	1	1	1	1	1	1
DRV-x32	145	1	1	1	1	1	1
DRV-x33	164	1	1	1	1	1	1
DRV-x34	186	1	1	1	1	1	1
DRV-x35	182	1	1	1	1	1	1
DRV-x36	146	1	1	1	1	1	1

[a] Stream IDs that include ‘x’ were collected in 2005.

Table B6. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=66) from Rocky Fork collected on 05 Oct 2004 and 25 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
RFC-1	225	4	4	4	4	4	4
RFC-2	210	5	4	5	5	4	4
RFC-3	215	4	4	4	4	4	4
RFC-4	144	3	2	2	NR	NR	discarded
RFC-5	227	4	4	4	3	3	3
RFC-6	173	2	2	2	2	2	2
RFC-7	175	3	3	3	3	3	3
RFC-8	205	4	4	4	4	5	4
RFC-9	180	2	2	2	2	2	2
RFC-10	190	5	5	5	5	5	5
RFC-11	149	2	2	2	2	2	2
RFC-12	215	5	5	5	4	4	4
RFC-13	190	3	3	3	3	4	3
RFC-14	205	3	3	3	2	2	2
RFC-15	169	2	2	2	2	2	2
RFC-16	199	5	4	5	4	3	5
RFC-17	162	2	2	2	2	2	2
RFC-18	137	1	1	1	1	1	1
RFC-19	143	2	2	2	2	2	2
RFC-20	155	2	2	2	2	2	2
RFC-21	127	1	1	1	1	1	1
RFC-22	135	-	-	not available	1	1	1
RFC-23	116	1	1	1	1	1	1
RFC-24	118	1	1	1	1	1	1
RFC-25	120	1	1	1	1	1	1
RFC-26	112	1	1	1	1	1	1
RFC-27	109	1	1	1	1	1	1
RFC-28	109	1	1	1	1	1	1
RFC-29	79	0	0	0	0	0	0
RFC-30	68	0	0	0	0	0	0
RFC-31	65	0	0	0	0	0	0

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B6. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
RFC-32	73	0	0	0	0	0	0
RFC-33	73	0	0	0	0	0	0
RFC-34	72	1	1	1	-	-	not available
RFC-35	62	0	0	0	0	0	0
RFC-36	63	0	0	0	0	0	0
RFC-37	64	0	0	0	0	0	0
RFC-38	70	0	0	0	0	0	0
RFC-x1	192	2	2	2	3	2	2
RFC-x2	179	3	3	3	3	2	3
RFC-x3	160	2	2	2	2	2	2
RFC-x4	221	5	5	5	4	3	4
RFC-x5	180	3	2	3	3	3	3
RFC-x6	195	2	1	2	3	2	2
RFC-x7	220	4	3	4	3	3	3
RFC-x8	191	3	3	3	3	2	3
RFC-x9	220	3	2	4	4	3	3
RFC-x10	150	2	2	2	2	2	2
RFC-x11	141	1	1	1	1	1	1
RFC-x12	233	3	2	3	3	2	3
RFC-x13	203	3	2	3	3	3	3
RFC-x14	170	3	2	2	2	2	2
RFC-x15	169	2	2	2	2	2	2
RFC-x16	147	2	2	2	2	2	2
RFC-x17	137	1	1	1	1	1	1
RFC-x18	145	2	1	2	1	2	2
RFC-x19	215	2	2	2	2	2	2
RFC-x20	118	1	1	1	1	1	1
RFC-x21	205	3	3	3	3	2	3
RFC-x22	173	3	2	2	2	2	2
RFC-x23	137	1	1	1	1	1	1
RFC-x24	145	1	1	1	1	1	1

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B6. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
RFC-x25	105	1	0	1	1	1	1
RFC-x26	124	0	0	0	1	1	1
RFC-x27	116	1	1	1	1	1	1
RFC-x28	118	1	1	1	1	1	1

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B7. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=62) from Tellico River collected on 06 Aug 2004 and 12 Aug 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
TEL-1	182	2	2	2	2	2	2
TEL-2	204	2	2	2	2	3	3
TEL-3	200	2	2	2	2	2	2
TEL-4	206	3	3	3	2	3	3
TEL-5	228	3	3	3	3	3	3
TEL-6	153	NR	NR	discarded	2	2	2
TEL-7	172	2	2	2	2	2	2
TEL-8	160	1	1	1	2	2	2
TEL-9	180	2	2	2	2	2	2
TEL-10	195	2	2	2	1	2	2
TEL-11	98	0	1	0	0	0	0
TEL-12	209	2	2	2	2	2	2
TEL-13	221	2	3	3	3	3	3
TEL-14	200	3	3	3	3	3	3
TEL-15	225	2	2	2	2	3	2
TEL-16	237	2	2	2	2	2	2
TEL-17	226	3	3	3	3	3	3
TEL-18	239	3	3	3	2	2	2
TEL-19	217	2	2	2	2	2	2
TEL-20	208	1	2	2	2	2	2
TEL-21	208	2	2	2	2	2	2
TEL-22	220	2	2	2	2	2	2
TEL-23	228	3	3	3	2	2	2
TEL-24	255	2	2	2	2	2	2
TEL-25	79	0	0	0	-	-	not available
TEL-26	68	0	0	0	-	-	not available
TEL-27	67	0	0	0	0	0	0
TEL-28	95	0	0	0	0	0	0
TEL-29	85	0	0	0	0	0	0
TEL-30	74	0	0	0	0	0	0
TEL-31	80	0	0	0	0	0	0

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B7. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
TEL-32	88	0	0	0	0	0	0
TEL-x1	143	1	1	1	1	1	1
TEL-x2	234	3	3	3	3	3	3
TEL-x3	200	1	1	1	1	1	1
TEL-x4	197	1	1	1	1	1	1
TEL-x5	245	3	3	3	3	2	3
TEL-x6	225	2	1	2	2	1	2
TEL-x7	181	1	1	1	1	1	1
TEL-x8	242	4	3	4	4	4	4
TEL-x9	215	3	3	3	3	3	3
TEL-x10	224	3	3	3	3	3	3
TEL-x11	205	3	1	1	1	1	1
TEL-x12	229	1	1	1	1	1	1
TEL-x13	199	1	1	1	1	1	1
TEL-x14	204	1	1	1	1	1	1
TEL-x15	203	1	1	1	1	1	1
TEL-x16	207	1	1	1	1	1	1
TEL-x17	182	1	1	1	1	1	1
TEL-x18	169	1	1	1	1	1	1
TEL-x19	217	2	1	2	2	2	2
TEL-x20	174	1	1	1	1	1	1
TEL-x21	158	1	1	1	1	1	1
TEL-x22	165	1	0	1	1	1	1
TEL-x23	180	1	1	1	1	1	1
TEL-x24	167	1	1	1	1	1	1
TEL-x25	182	1	1	1	1	1	1
TEL-x26	175	1	1	1	1	1	1
TEL-x27	145	1	1	1	1	1	1
TEL-x28	162	1	1	1	2	2	2
TEL-x29	222	4	4	4	4	4	4
TEL-x30	229	3	3	3	3	2	3

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B8. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=86) from Bald River collected on 06 Aug 2004 and 29 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
BLD-1	191	NR	NR	discarded	2	2	2
BLD-2	238	3	3	3	3	3	3
BLD-3	237	5	5	5	3	4	5
BLD-4	198	1	1	1	1	2	2
BLD-5	235	2	2	2	2	2	2
BLD-6	193	2	2	2	2	2	2
BLD-7	181	1	1	1	1	2	2
BLD-8	182	1	1	1	1	1	1
BLD-9	175	1	1	1	1	1	1
BLD-10	249	2	2	2	2	2	2
BLD-11	199	2	2	2	2	1	2
BLD-12	168	1	1	1	1	1	1
BLD-13	215	2	2	2	2	2	2
BLD-14	156	1	1	1	1	1	1
BLD-15	206	2	2	2	2	2	2
BLD-16	178	2	2	2	2	2	2
BLD-17	155	1	1	1	1	1	1
BLD-18	164	1	1	1	1	1	1
BLD-19	220	2	2	2	2	2	2
BLD-20	186	2	2	2	2	2	2
BLD-21	165	1	1	1	2	2	2
BLD-22	220	2	2	2	2	2	2
BLD-23	194	2	2	2	2	2	2
BLD-24	195	1	1	1	1	1	1
BLD-25	187	2	2	2	2	2	2
BLD-26	180	1	1	1	1	2	2
BLD-27	207	2	2	2	2	2	2
BLD-28	253	3	3	3	2	2	2
BLD-29	227	2	2	2	2	2	2
BLD-30	233	2	2	2	2	2	2
BLD-31	175	1	1	1	2	2	2

[a] Stream IDs that include 'x' were collected in 2005. NR denotes non-readable samples.

Table B8. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
BLD-32	156	2	2	2	1	1	1
BLD-33	259	3	3	3	2	2	2
BLD-34	170	1	1	1	2	2	2
BLD-35	209	2	2	2	2	2	2
BLD-36	239	3	3	3	4	4	4
BLD-37	161	1	1	1	1	1	1
BLD-38	105	0	0	0	0	0	0
BLD-39	67	0	0	0	0	0	0
BLD-40	70	0	0	0	0	0	0
BLD-41	90	0	0	0	0	0	0
BLD-42	95	0	0	0	0	0	0
BLD-43	68	0	0	0	0	0	0
BLD-44	77	0	0	0	-	-	not available
BLD-45	67	0	0	0	0	0	0
BLD-46	70	0	0	0	-	-	not available
BLD-47	93	0	0	0	0	0	0
BLD-x1	102	1	0	0	0	0	0
BLD-x2	110	0	0	0	0	0	0
BLD-x3	115	0	0	0	0	0	0
BLD-x4	124	0	0	0	0	0	0
BLD-x5	143	1	1	1	1	1	1
BLD-x6	157	1	1	1	1	1	1
BLD-x7	142	1	1	1	1	1	1
BLD-x8	165	1	1	1	1	1	1
BLD-x9	146	1	1	1	1	1	1
BLD-x10	165	1	1	1	1	1	1
BLD-x11	198	1	1	1	1	1	1
BLD-x12	173	1	1	1	1	1	1
BLD-x13	170	1	1	1	1	1	1
BLD-x14	182	1	1	1	1	1	1
BLD-x15	204	2	2	2	2	2	2

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B8. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
BLD-x16	222	2	2	2	2	2	2
BLD-x17	188	1	1	1	1	1	1
BLD-x18	196	3	3	3	3	3	3
BLD-x19	210	2	2	2	2	2	2
BLD-x20	238	2	2	2	3	3	3
BLD-x21	179	1	0	1	1	1	1
BLD-x22	167	1	1	1	-	-	not available
BLD-x23	132	1	1	1	1	1	1
BLD-x24	202	2	2	2	2	2	2
BLD-x25	180	1	1	1	1	1	1
BLD-x26	208	2	2	2	2	2	2
BLD-x27	232	3	2	3	3	2	3
BLD-x28	204	2	2	2	2	2	2
BLD-x29	226	3	3	3	3	3	3
BLD-x30	102	0	0	0	0	0	0
BLD-x31	248	3	3	3	3	3	3
BLD-x32	265	3	3	3	3	3	3
BLD-x33	248	2	2	2	2	2	2
BLD-x34	235	3	3	3	3	3	3
BLD-x35	285	3	3	3	3	3	3
BLD-x36	250	3	2	3	3	3	3
BLD-x37	250	3	3	3	3	3	3
BLD-x38	202	2	2	2	2	2	2
BLD-x39	254	3	3	3	3	3	3

[a] Stream IDs that include ‘x’ were collected in 2005. NR denotes non-readable samples.

Table B9. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=88) from North River collected on 06 Aug 2004 and 29 Jul 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
NRT-1	207	2	2	2	2	2	2
NRT-2	167	1	1	1	1	1	1
NRT-3	145	1	1	1	2	2	2
NRT-4	147	1	1	1	2	2	2
NRT-5	175	1	1	1	2	2	2
NRT-6	149	2	2	2	2	2	2
NRT-7	164	1	1	1	1	1	1
NRT-8	145	2	1	2	2	2	2
NRT-9	198	2	3	3	3	3	3
NRT-10	152	1	1	1	1	1	1
NRT-11	223	3	3	3	4	4	4
NRT-12	145	1	1	1	1	1	1
NRT-13	152	2	1	1	2	2	2
NRT-14	190	3	3	3	3	3	3
NRT-15	195	2	2	2	2	2	2
NRT-16	155	1	1	1	2	2	2
NRT-17	197	2	2	2	2	2	2
NRT-18	129	1	1	1	1	1	1
NRT-19	159	1	1	1	2	2	2
NRT-20	175	2	2	2	2	2	2
NRT-21	262	5	5	5	5	5	5
NRT-22	254	3	3	3	3	3	3
NRT-23	233	3	2	3	3	3	3
NRT-24	228	3	3	3	3	3	3
NRT-25	197	3	3	3	3	3	3
NRT-26	142	1	1	1	2	2	2
NRT-27	186	3	3	3	3	3	3
NRT-28	193	2	2	2	2	2	2
NRT-29	186	2	2	2	2	2	2
NRT-30	257	4	4	4	4	3	4
NRT-31	240	4	4	4	4	4	4

[a] Stream IDs that include ‘x’ were collected in 2005.

Table B9. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
NRT-32	196	2	2	2	2	2	2
NRT-33	206	2	2	2	2	2	2
NRT-34	175	2	2	2	2	2	2
NRT-35	178	1	1	1	1	1	1
NRT-36	94	0	0	0	0	0	0
NRT-37	84	0	0	0	0	0	0
NRT-38	83	0	0	0	-	-	not available
NRT-39	73	0	0	0	0	0	0
NRT-40	74	0	0	0	0	0	0
NRT-41	68	0	0	0	0	0	0
NRT-42	68	0	0	0	-	-	not available
NRT-43	62	0	0	0	0	0	0
NRT-44	68	0	0	0	0	0	0
NRT-45	66	0	0	0	0	0	0
NRT-46	248	3	3	3	3	3	3
NRT-47	243	2	2	2	2	2	2
NRT-x1	160	1	1	1	1	1	1
NRT-x2	173	1	1	1	1	1	1
NRT-x3	156	1	1	1	1	1	1
NRT-x4	102	0	0	0	0	0	0
NRT-x5	142	1	1	1	1	1	1
NRT-x6	139	1	1	1	1	1	1
NRT-x7	156	1	1	1	1	1	1
NRT-x8	156	1	1	1	1	1	1
NRT-x9	155	1	1	1	1	1	1
NRT-x10	144	1	1	1	1	1	1
NRT-x11	145	1	1	1	1	1	1
NRT-x12	184	1	1	1	1	1	1
NRT-x13	216	2	2	2	2	2	2
NRT-x14	172	1	1	1	1	1	1
NRT-x15	193	2	2	2	2	2	2

[a] Stream IDs that include ‘x’ were collected in 2005.

Table B9. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
NRT-x16	102	0	0	0	0	0	0
NRT-x17	121	1	1	1	1	1	1
NRT-x18	117	1	1	1	1	1	1
NRT-x19	212	2	2	2	2	2	2
NRT-x20	178	2	2	2	1	1	1
NRT-x21	233	3	3	3	3	3	3
NRT-x22	216	4	4	4	4	3	3
NRT-x23	213	2	2	2	3	3	3
NRT-x24	252	6	6	6	5	5	5
NRT-x25	229	5	5	5	5	5	5
NRT-x26	238	4	4	4	4	4	4
NRT-x27	259	6	6	6	6	5	5
NRT-x28	249	3	2	3	3	3	3
NRT-x29	177	1	1	1	1	1	1
NRT-x30	185	1	1	1	1	1	1
NRT-x31	229	2	2	2	2	2	2
NRT-x32	227	2	2	2	2	2	2
NRT-x33	237	3	3	3	3	3	3
NRT-x34	279	5	5	5	5	4	5
NRT-x35	245	4	3	4	4	4	4
NRT-x36	222	2	2	2	2	2	2
NRT-x37	243	2	2	2	2	2	2
NRT-x38	244	4	4	4	4	4	4
NRT-x39	235	4	4	4	4	4	4
NRT-x40	226	2	2	2	2	2	2
NRT-x41	224	2	2	2	2	2	2

[a] Stream IDs that include ‘x’ were collected in 2005.

Table B10. Transverse and sagittal ages obtained by two readers (ES, JL) for *O. mykiss* (N=70) from S. Fork Citico Creek collected on 30 Sep 2004 and 16 Aug 2005.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
CIT-1	196	2	2	2	2	2	2
CIT-2	167	2	2	2	2	2	2
CIT-3	183	2	2	2	2	2	2
CIT-4	181	2	2	2	2	2	2
CIT-5	170	2	2	2	2	2	2
CIT-6	152	2	2	2	2	2	2
CIT-7	169	2	2	2	2	2	2
CIT-8	229	3	3	3	2	3	3
CIT-9	158	2	2	2	2	2	2
CIT-10	93	0	0	0	0	0	0
CIT-11	225	3	3	3	3	3	3
CIT-12	214	3	3	3	2	3	3
CIT-13	213	2	2	2	2	2	2
CIT-14	229	3	3	3	3	3	3
CIT-15	199	3	3	3	2	3	3
CIT-16	229	3	3	3	3	3	3
CIT-17	189	2	2	2	2	2	2
CIT-18	197	2	2	2	2	2	2
CIT-19	185	2	2	2	2	2	2
CIT-20	203	2	2	2	-	-	not available
CIT-21	74	0	0	0	0	0	0
CIT-22	76	0	0	0	0	0	0
CIT-23	103	0	0	0	0	0	0
CIT-24	98	0	0	0	-	-	not available
CIT-25	92	0	0	0	0	0	0
CIT-26	106	0	0	0	0	0	0
CIT-27	103	0	0	0	0	0	0
CIT-28	104	0	0	0	0	0	0
CIT-29	106	0	0	0	0	0	0
CIT-30	71	0	0	0	0	0	0
CIT-31	70	0	0	0	0	0	0

[a] Stream IDs that include 'x' were collected in 2005.

Table B10. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
CIT-32	71	0	0	0	0	0	0
CIT-33	66	0	0	0	0	0	0
CIT-34	78	0	0	0	0	0	0
CIT-35	90	0	1	0	0	0	0
CIT-x1	113	1	1	1	1	1	1
CIT-x2	110	1	1	1	1	1	1
CIT-x3	118	1	1	1	1	1	1
CIT-x4	116	1	1	1	1	1	1
CIT-x5	141	1	1	1	1	1	1
CIT-x6	112	1	2	2	2	2	2
CIT-x7	143	2	2	2	2	2	2
CIT-x8	155	1	1	1	1	1	1
CIT-x9	166	1	1	1	-	-	not available
CIT-x10	150	1	1	1	2	1	1
CIT-x11	200	3	2	3	3	2	3
CIT-x12	136	1	1	1	1	1	1
CIT-x13	144	1	1	1	1	1	1
CIT-x14	193	2	2	2	2	2	2
CIT-x15	191	3	3	3	1	3	3
CIT-x16	234	3	3	3	2	2	2
CIT-x17	130	1	1	1	1	1	1
CIT-x18	151	1	1	1	1	1	1
CIT-x19	130	1	1	1	1	1	1
CIT-x20	154	1	1	1	1	1	1
CIT-x21	124	1	0	1	1	1	1
CIT-x22	174	3	3	3	3	2	3
CIT-x23	204	3	3	3	3	3	3
CIT-x24	173	3	3	3	3	2	2
CIT-x25	205	3	3	3	3	2	3
CIT-x26	150	1	1	1	1	1	1
CIT-x27	147	1	0	1	1	1	1

[a] Stream IDs that include ‘x’ were collected in 2005.

Table B10. Continued.

Sample ID[a]	Length (mm)	Transverse otolith age			Sagittal otolith age		
		ES	JL	Agreed age	ES	JL	Agreed age
CIT-x28	212	3	3	3	3	3	3
CIT-x29	212	2	2	2	2	2	2
CIT-x30	225	4	4	4	3	4	4
CIT-x31	206	3	3	3	3	3	3
CIT-x32	181	2	2	2	2	2	2
CIT-x33	188	3	3	3	3	3	3
CIT-x34	230	4	4	4	4	4	4
CIT-x35	198	3	3	3	3	3	3

[a] Stream IDs that include ‘x’ were collected in 2005.

APPENDIX C

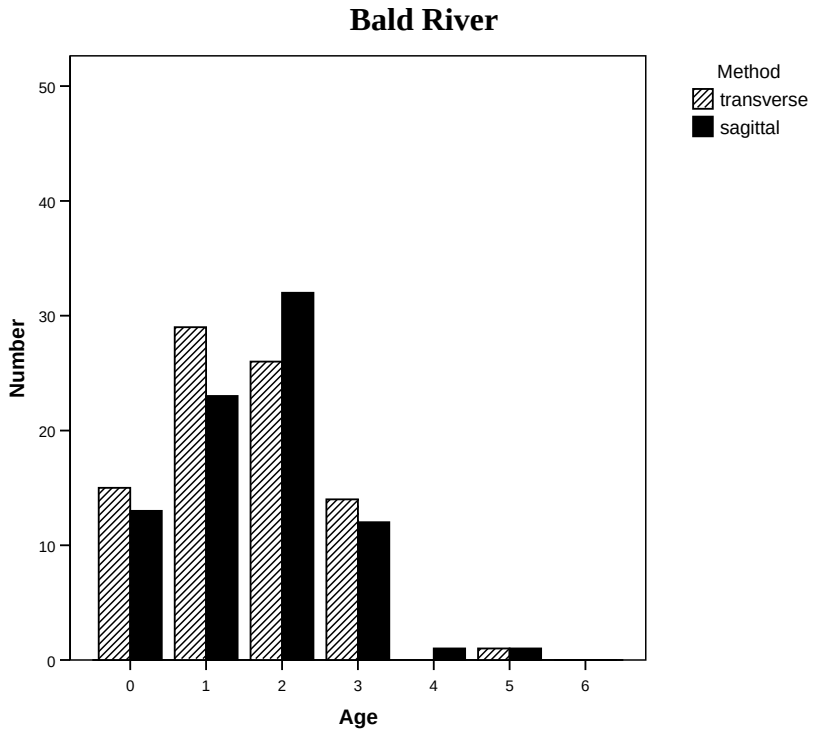


Figure C1. Age frequencies from transverse and sagittal otolith sections for Bald River *O. mykiss.*

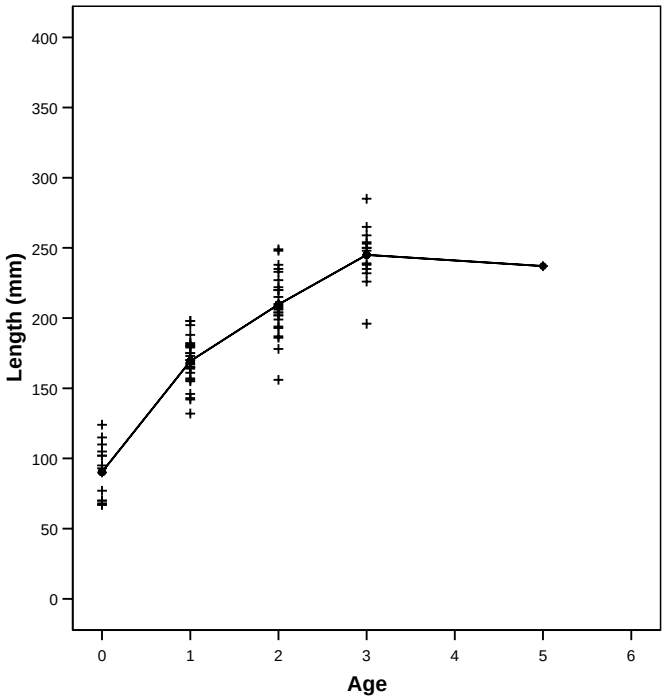


Figure C2. Mean lengths at capture for Bald River *O. mykiss*.

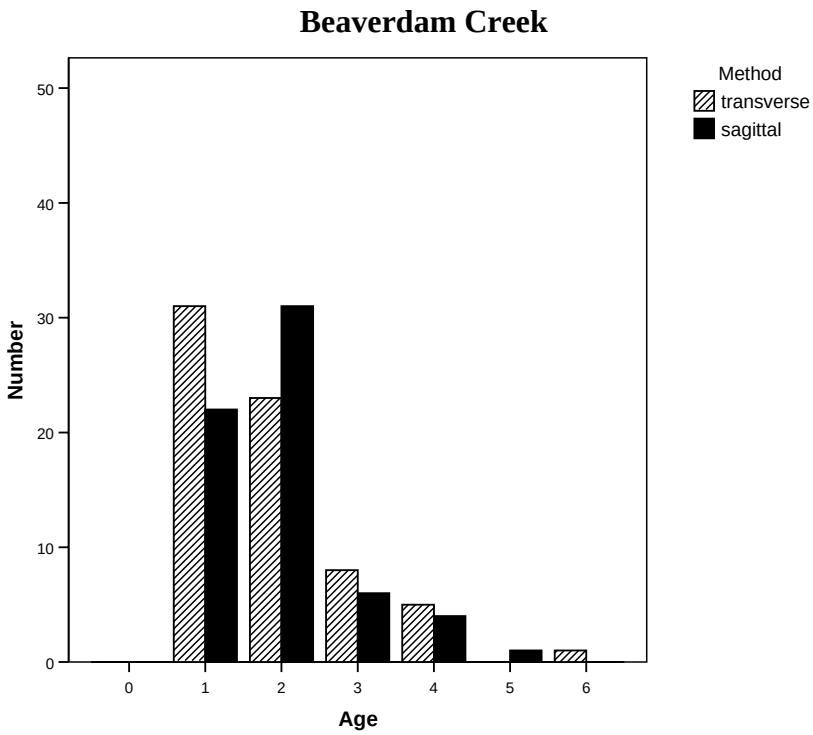


Figure C3. Age frequencies from transverse and sagittal otolith sections for Beaverdam Creek *O. mykiss.*

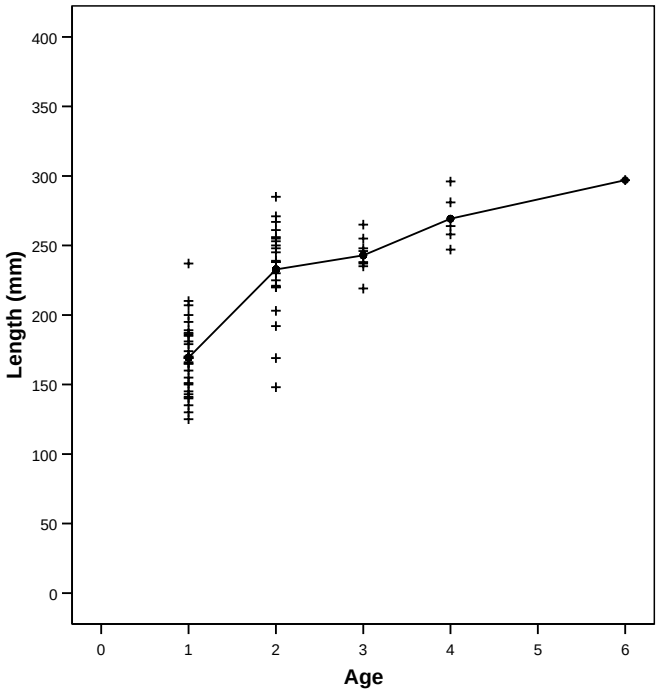


Figure C4. Mean lengths at capture for Beaverdam Creek *O. mykiss*.

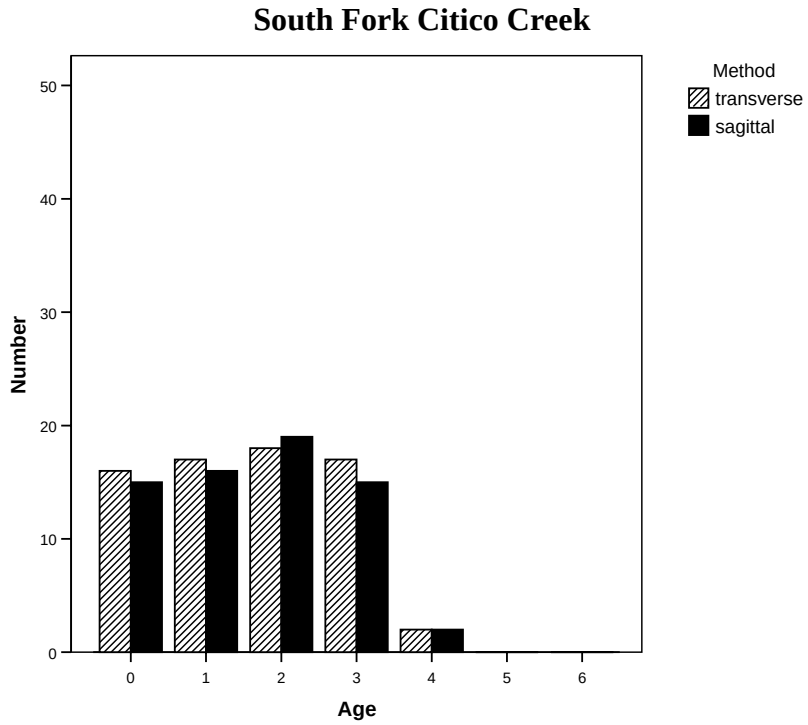


Figure C5. Age frequencies from transverse and sagittal otolith sections for South Fork Citico Creek *O. mykiss.*

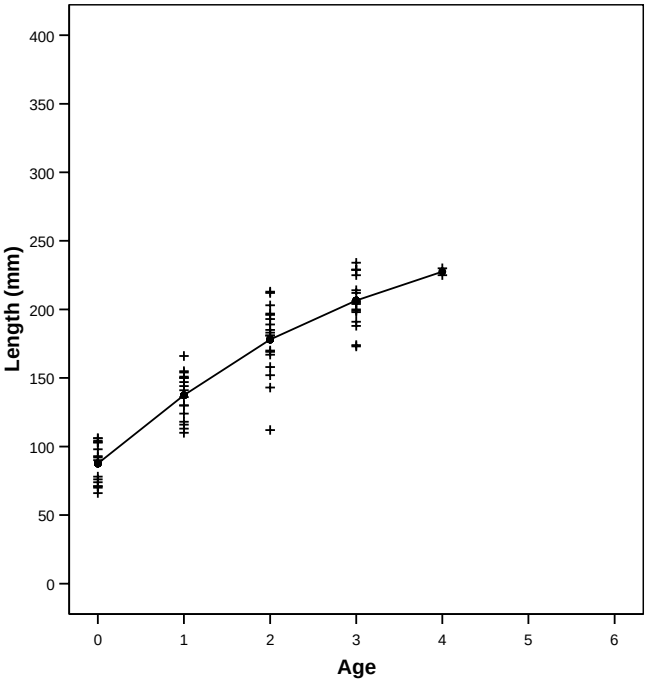


Figure C6. Mean lengths at capture for South Fork Citico Creek *O. mykiss*.

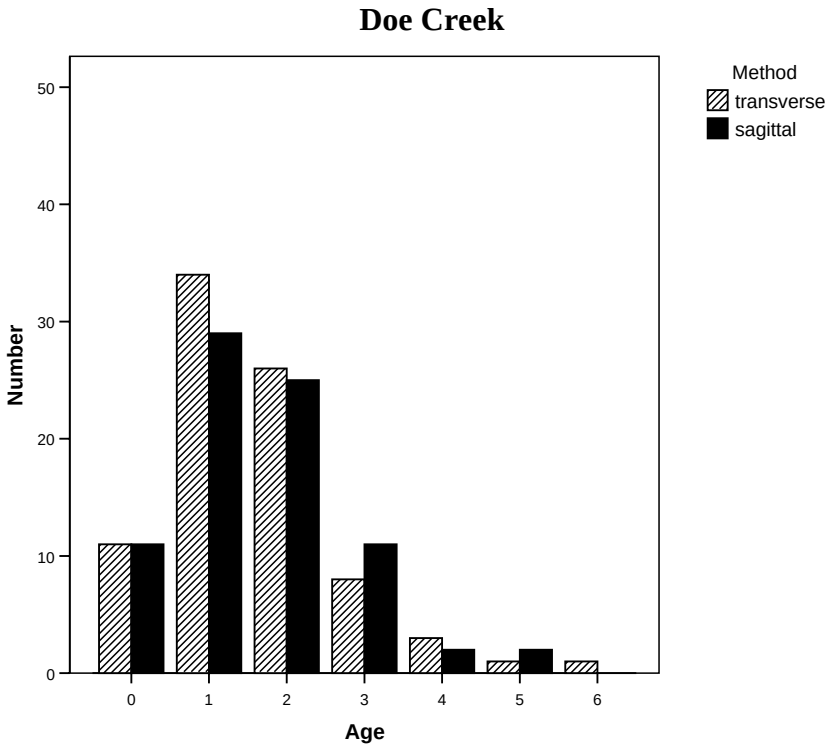


Figure C7. Age frequencies from transverse and sagittal otolith sections for Doe Creek *O. mykiss.*

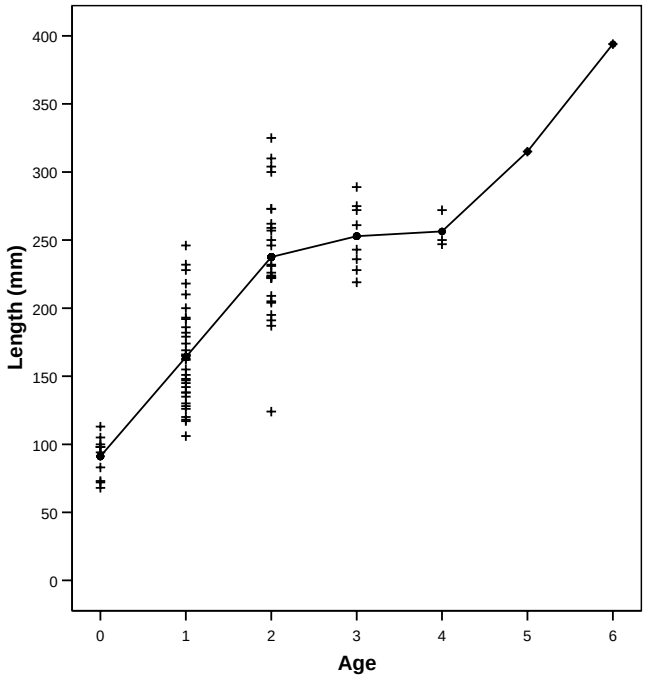


Figure C8. Mean lengths at capture for Doe Creek *O. mykiss*.

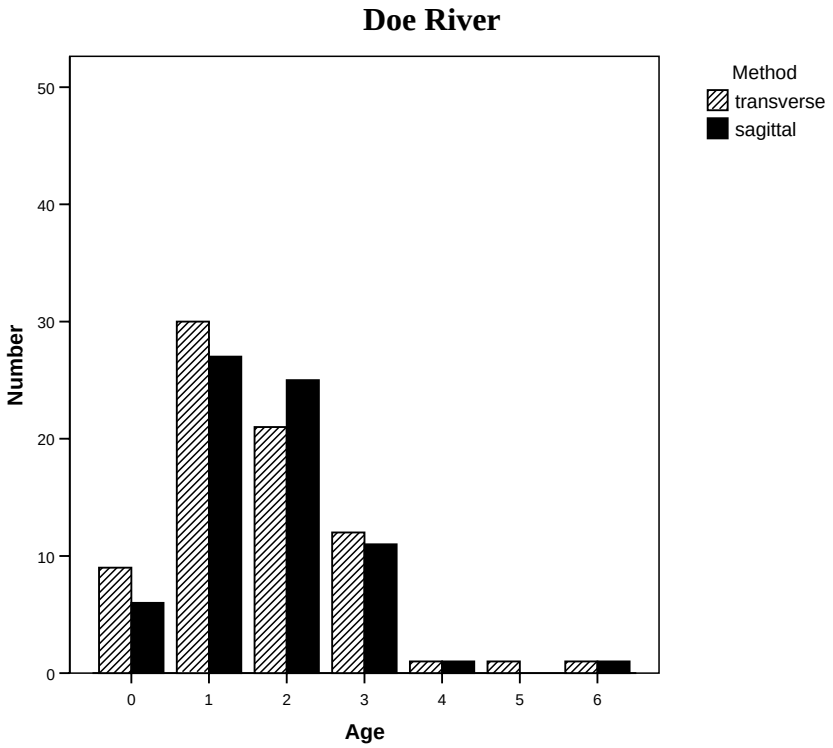


Figure C9. Age frequencies from transverse and sagittal otolith sections for Doe River *O. mykiss.*

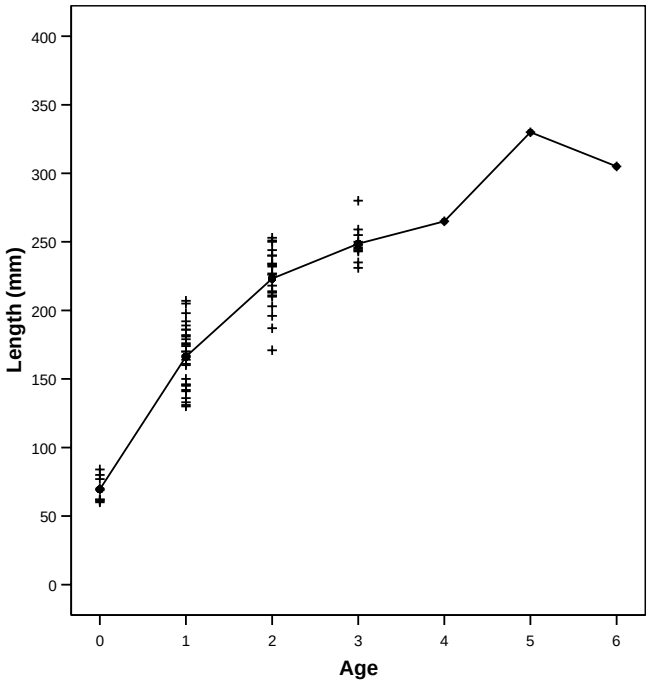


Figure C10. Mean lengths at capture for Doe River *O. mykiss*.

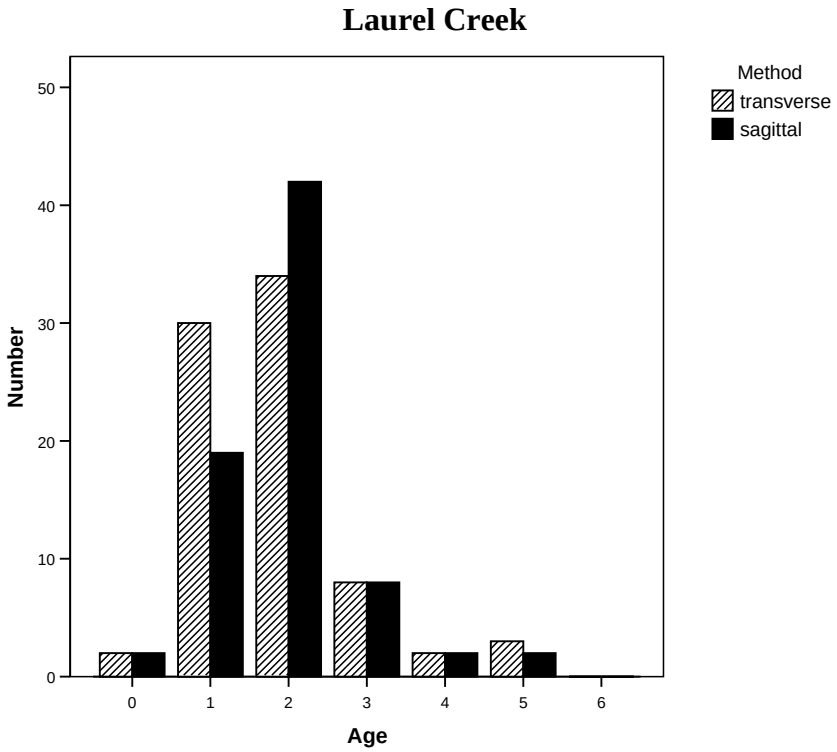


Figure C11. Age frequencies from transverse and sagittal otolith sections for Laurel Creek *O. mykiss.*

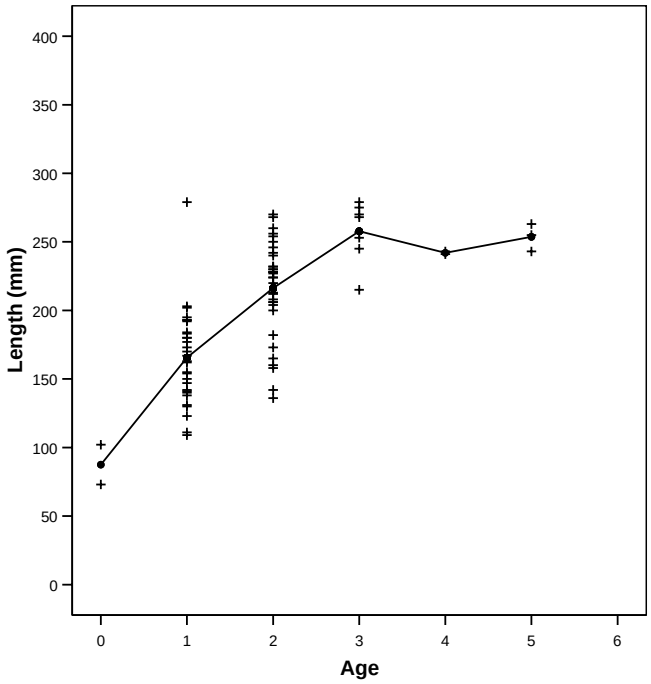


Figure C12. Mean lengths at capture for Laurel Creek *O. mykiss*.

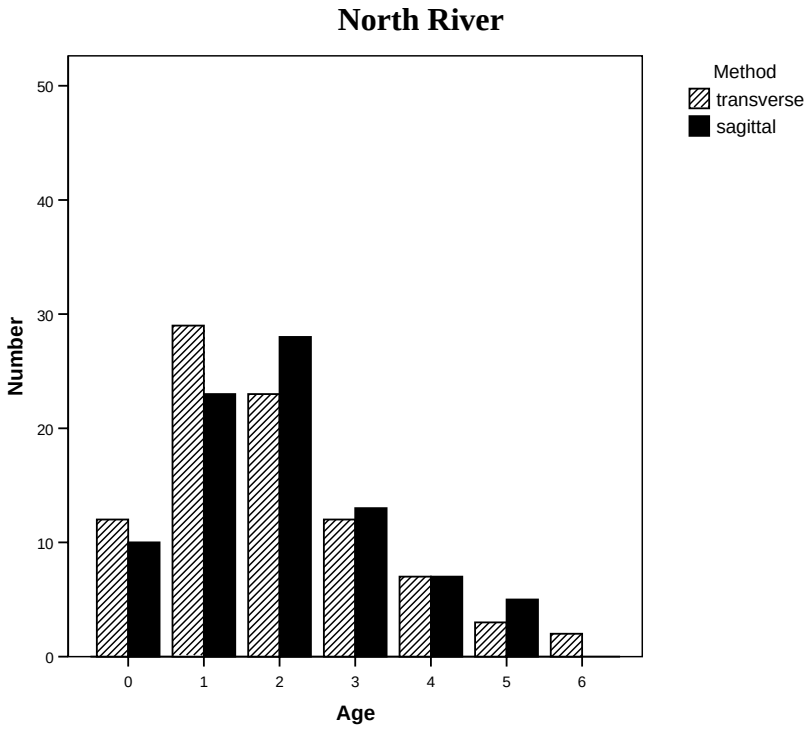


Figure C13. Age frequencies from transverse and sagittal otolith sections for North River *O. mykiss.*

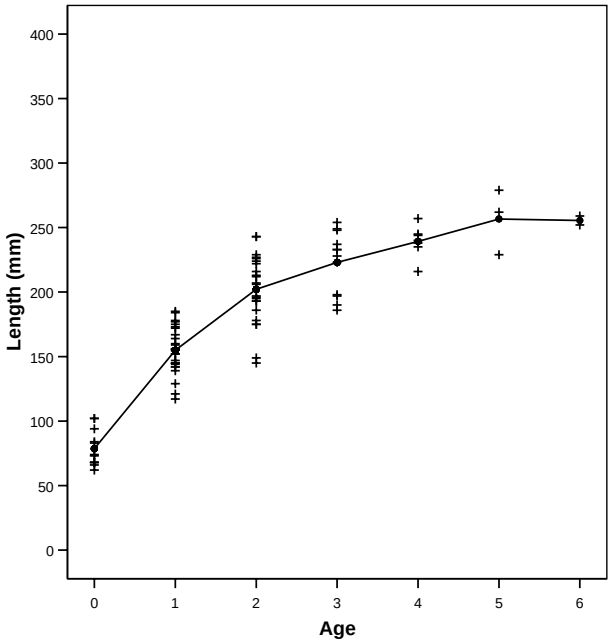


Figure C14. Mean lengths at capture for North River *O. mykiss*.

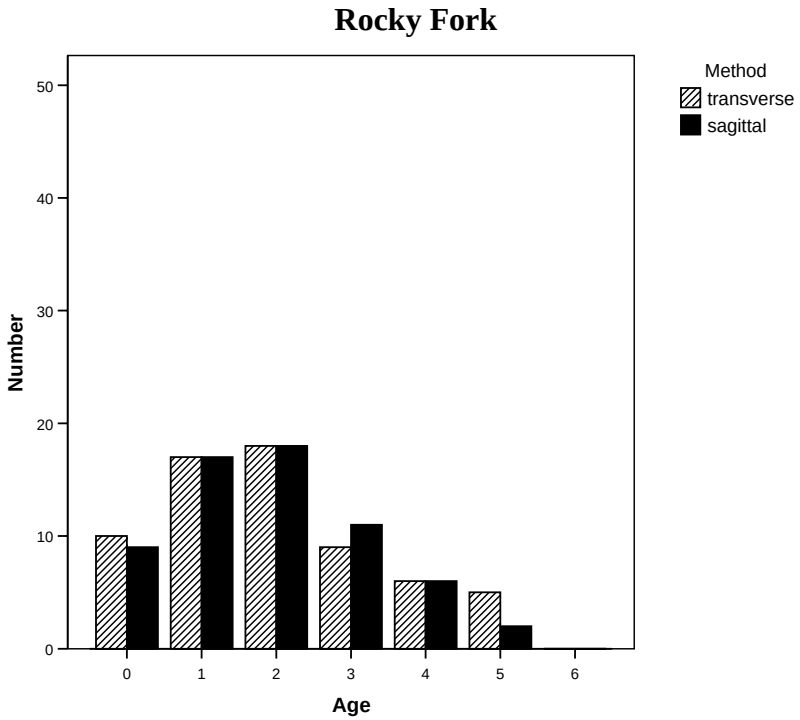


Figure C15. Age frequencies from transverse and sagittal otolith sections for Rocky Fork *O. mykiss.*

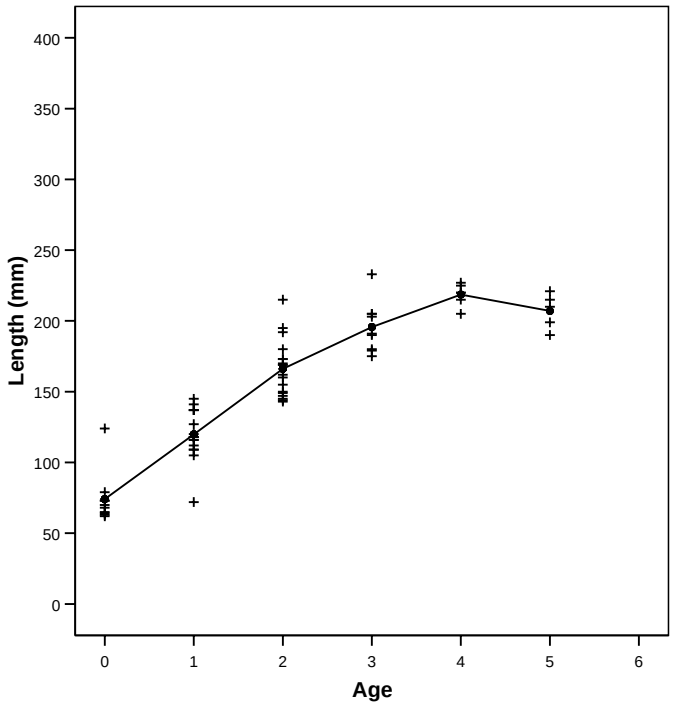


Figure C16. Mean lengths at capture for Rocky Fork *O. mykiss*.

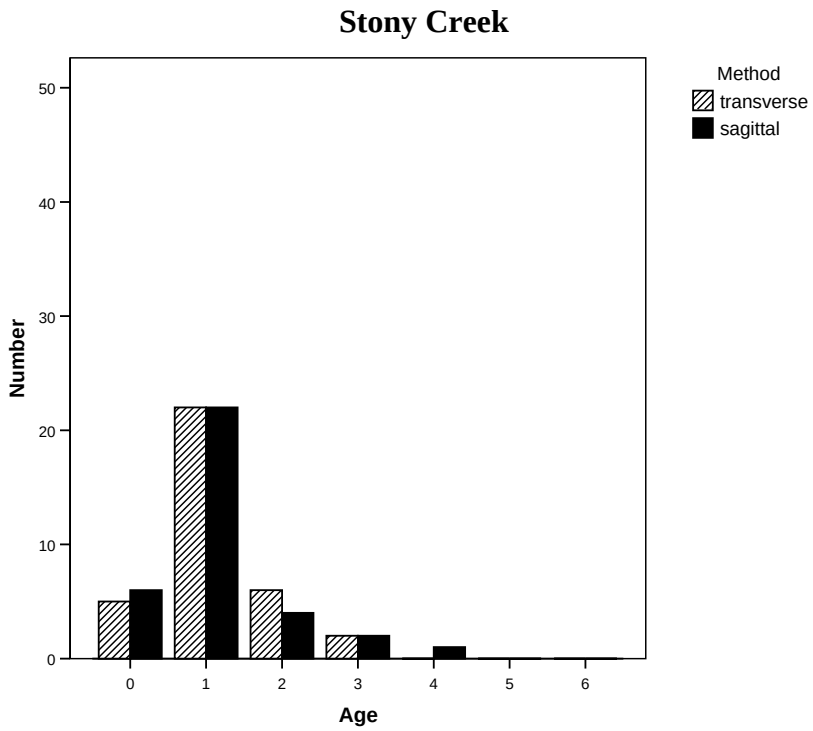


Figure C17. Age frequencies from transverse and sagittal otolith sections for Stony Creek *O. mykiss.*

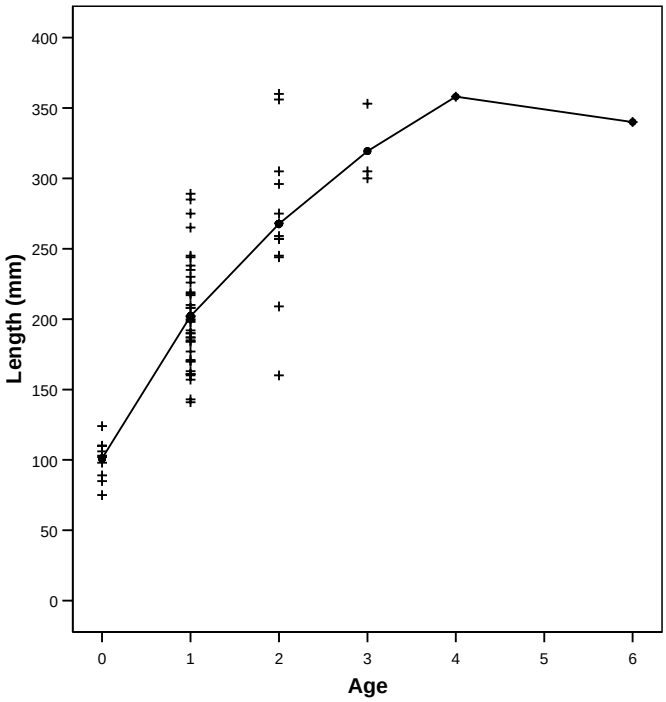


Figure C18. Mean lengths at capture for Stony Creek *O. mykiss*..

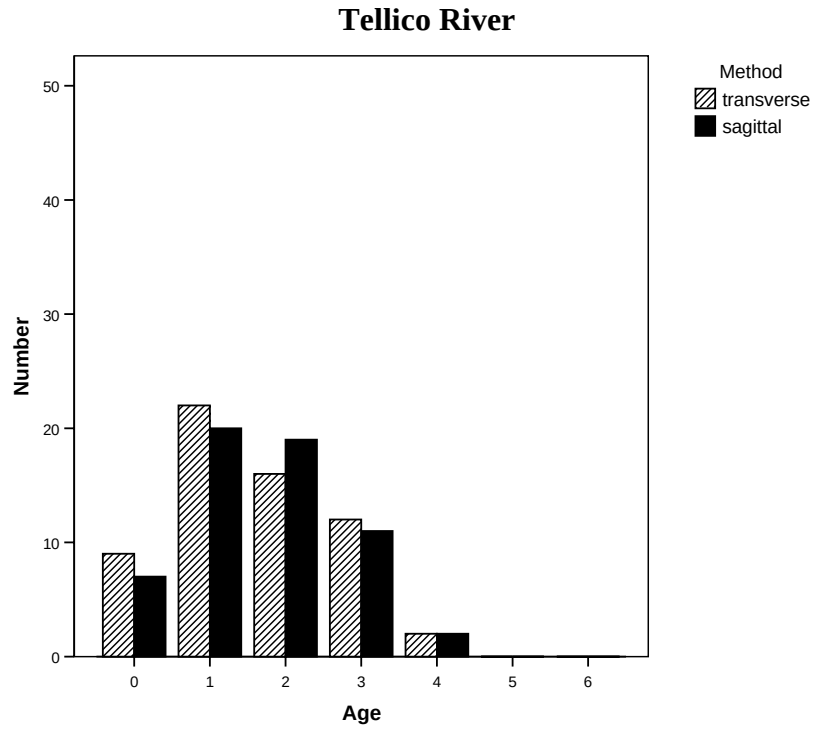


Figure C19. Age frequencies from transverse and sagittal otolith sections for Tellico River *O. mykiss.*

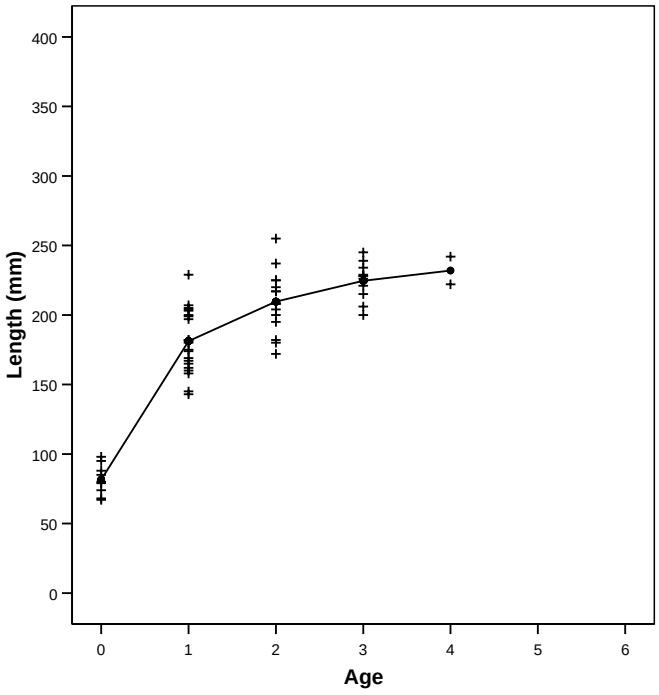


Figure C20. Mean lengths at capture for Tellico River *O. mykiss*.

VITA

Reggie Eric Sawyers was born in Richlands, VA on 21 April 1974. He was raised in Bluefield, VA and attended Graham High School, where he graduated in 1992. After graduation, he studied Criminal Justice at Bluefield College before entering the United States Air Force in 1995 as a Communications-Computer Operator. After an honorable discharge, he came to the University of Tennessee, Knoxville, where he received a B.S. in Wildlife and Fisheries Science with a minor in Forestry in 2003 and a M.S. in Wildlife and Fisheries Science in 2006.