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ESTIMATING THE AGES OF MOUNTAIN SUCKER *CATOSTOMUS PLATYRHYNCHUS* FROM THE BLACK HILLS: PRECISION, MATURATION, AND GROWTH

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ABSTRACT.—Although mountain sucker *Catostomus platyrhynchus* is considered secure across its range, it has declined in parts of its range and is listed in South Dakota as a species of greatest conservation need. To our knowledge, no research has identified which calcified structure provides the most precise age estimates for mountain sucker, and little is known about mountain sucker population dynamics. To identify which structure provided the most precise age estimates, we compared age estimates from scales, sectioned pectoral fin rays, whole asteriscus otoliths, and polished asteriscus otoliths collected from 110 mountain sucker from 2 creeks in the Black Hills of South Dakota. Additionally, we quantified growth, age, and size at maturation for one population of mountain sucker in the Black Hills. Polished otoliths had the greatest precision of the 4 structures used, followed by sectioned pectoral fin rays. Mountain sucker reached an average size of 100 mm total length (TL) during their fourth growing season and reached an average maximum attainable size of 219 mm TL. Mountain sucker began to mature at age 3, with nearly all being mature by age 5. In the Black Hills, the shortest mature male was 95 mm TL and the shortest mature female was 101 mm TL. We recommend using polished otoliths to estimate the ages of mountain sucker. If a nonlethal structure is desired to estimate the ages of mountain sucker, we recommend using sectioned pectoral fin rays. Future research should be directed to fill the many knowledge gaps in the biology and ecology of mountain sucker (e.g., juvenile habitat use in the Black Hills). As these knowledge gaps are addressed, management actions could be taken to conserve this species in the parts of its range where it is declining.

RESUMEN.—Aunque se considera que *Catostomus platyrhynchus* no está en peligro, está en declive en algunas partes de su distribución, y por ello se ha incluido en el catálogo de especies con mayor necesidad de conservación en Dakota del Sur. Hasta nuestro conocimiento, ninguna investigación ha identificado qué estructura calcificada garantiza la mejor estimación de edad de estos peces, y poco se sabe sobre la dinámica de sus poblaciones. Comparamos las estimaciones de edad basándonos en las escamas, radiografías de aletas pectorales segmentadas, los otolitos astericus enteros y otolitos astericus pulidos colectados de 110 ejemplares que habitan en dos arroyos en Black Hills, Dakota del Sur, con el fin de identificar qué estructura ofrece la estimación de edad más precisa. Además, calculamos el crecimiento, edad y tamaño al llegar a la madurez de una de las poblaciones en Black Hills. Los otolitos pulidos mostraban el mayor nivel de precisión de las cuatro estructuras utilizadas, seguidos de las radiografías de las aletas pectorales. Los ejemplares alcanzaron un tamaño medio de 100 mm de longitud total (LT) durante su cuarta estación de crecimiento y un posible tamaño medio máximo de 219 mm LT. *Catostomus platyrhynchus* comienza a madurar a la edad de 3 y prácticamente todos los individuos alcanzaban la edad adulta a los 5. En Black Hills, el macho adulto más corto medía 95 mm y la hembra adulta más pequeña medía 101 mm LT. Recomendamos utilizar otolitos pulidos para estimar las edades de esta especie. Si se desea utilizar una estructura que no requiera sacrificar a los peces para estimar la edad, recomendamos utilizar las radiografías de las aletas pectorales. Se necesitan más investigaciones en el futuro con el fin de llenar las numerosas brechas de conocimiento sobre la biología y ecología de *Catostomus platyrhynchus* (por ejemplo, uso del hábitat de los juveniles en Black Hills). A medida que se aborden estas brechas de conocimiento, podrían llevarse a cabo acciones administrativas para conservar esta especie en las partes de su distribución que muestran declive.

Accurate and precise estimates of fish ages are critical for proper management and conservation of populations. Age estimates can be used to identify age-related life history patterns by assessing recruitment patterns and providing estimates of mortality (Devries and Frie 1996). Additionally, age estimates can be combined with size data to estimate growth rates (Devries and Frie 1996). Knowledge of these 3 dynamic rate functions (i.e., recruitment, growth, and mortality) can provide fisheries managers with insight into a species'

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ecology and allow them to evaluate the response of populations to environmental stressors (Adams et al. 1992) or conservation actions (Quist et al. 2007). Information about population stressors and responses to conservation actions may be of particular interest for endangered or threatened species or species of local conservation need and may aid in the conservation or restoration of these populations (e.g., Scoppettone and Vinyard 1991).

Although mountain sucker *Catostomus platyrhynchus* is considered secure across its range (G5; NatureServe 2012), it has declined in parts of its range, particularly in eastern California (Erman 1973, 1986, Gard and Flittner 1974, Moyle and Vondracek 1985, Decker 1989) and the Missouri River drainage of Wyoming (Patton et al. 1998). In South Dakota, the mountain sucker is listed as a species of greatest conservation need (SDGFP 2013). A long-term analysis of stream fish sampling data from the Black Hills of South Dakota indicated that mountain sucker declined significantly in density and spatial distribution between the 1960s and 2010 (Schultz and Bertrand 2012). Additionally, reviews of mountain sucker biology and status in Canada (Campbell 1992) and across its range (Belica and Nibbelink 2006) indicated that a paucity of basic mountain sucker ecological information exists.

Previous studies have used scales to estimate the ages of mountain sucker (Hauser 1969, Wydoski and Wydoski 2002). However, many previous studies with species other than mountain sucker have shown that scales provide both inaccurate (Heidinger and Clodfelter 1987, Ross et al. 2005) and imprecise (Robillard and Marsden 1996, Kocovsky and Carline 2000, Isermann et al. 2010) age estimates. Additionally, scales provide imprecise age estimates for other catostomid species (Beamish 1973, Sylvester and Berry 2006, Quist et al. 2007). Several other calcified structures have been used to estimate the ages of catostomids, including cleithra (Quist et al. 2007), opercula (Scoppettone 1988, Quist et al. 2007), pectoral fin rays (Chen and Harvey 1995, Sylvester and Berry 2006, Quist et al. 2007, Sweet et al. 2009), and otoliths (Sylvester and Berry 2006, Quist et al. 2007). Otoliths provide the most precise age estimates for catostomids (Sylvester and Berry 2006, Quist et al. 2007), and otoliths are accurate for white sucker *Catostomus commersonii* (evidence from known-age fish; Thompson and Beckman 1995). However, no studies have examined the precision of calcified structures used to estimate the ages of mountain sucker.

Ideally, a calcified structure that can be obtained nonlethally should be used when estimating the ages of individuals of a rare, threatened, or endangered species, if accurate and precise age estimates can be obtained from that structure. Inaccurate and imprecise age estimates can lead to biased estimates of recruitment, growth, and mortality for a given population. Underestimating ages of fish can lead to overestimates of growth, mortality, and exploitation. Vandergoot et al. (2008) found that total annual mortality rates from scale and anal fin spine age estimates were 20% and 4% higher, respectively, than mortality estimates from otoliths for yellow perch *Perca flavescens* from Lake Erie as a result of underestimation. Quist et al. (2007) recommended pectoral fin rays as a nonlethal structure to estimate the ages of 3 native species of concern, including multiple catostomid species (i.e., bluehead sucker *Catostomus discobolus,* flannelmouth sucker *Catostomus latipinnis*, and roundtail chub *Gila robusta*). However, Sylvester and Berry (2006) found that compared to otoliths, fin rays may underestimate the ages of white sucker older than 5 years old. Fin rays underestimate the ages of other fish species as well, especially for older individuals (e.g., Johnson 1971, Rien and Beamesderfer 1994, Quist et al. 2007). Therefore, researchers must verify they are using the most accurate and precise structure for a given species before quantifying dynamic rate functions of populations of those species.

The objectives of this study were to (1) evaluate the precision of scales, sectioned pectoral fin rays, whole asteriscus otoliths, and polished asteriscus otoliths for estimating ages of mountain sucker in the Black Hills of South Dakota, and (2) use the most precise structure to quantify the percentage of mature mountain sucker at different ages, the shortest length at maturation for males and females, and growth rates for a population of mountain sucker in the Black Hills.

METHODS

Study Area

The Black Hills are a ponderosa pine *Pinus ponderosa*–forested, dome-shaped uplift

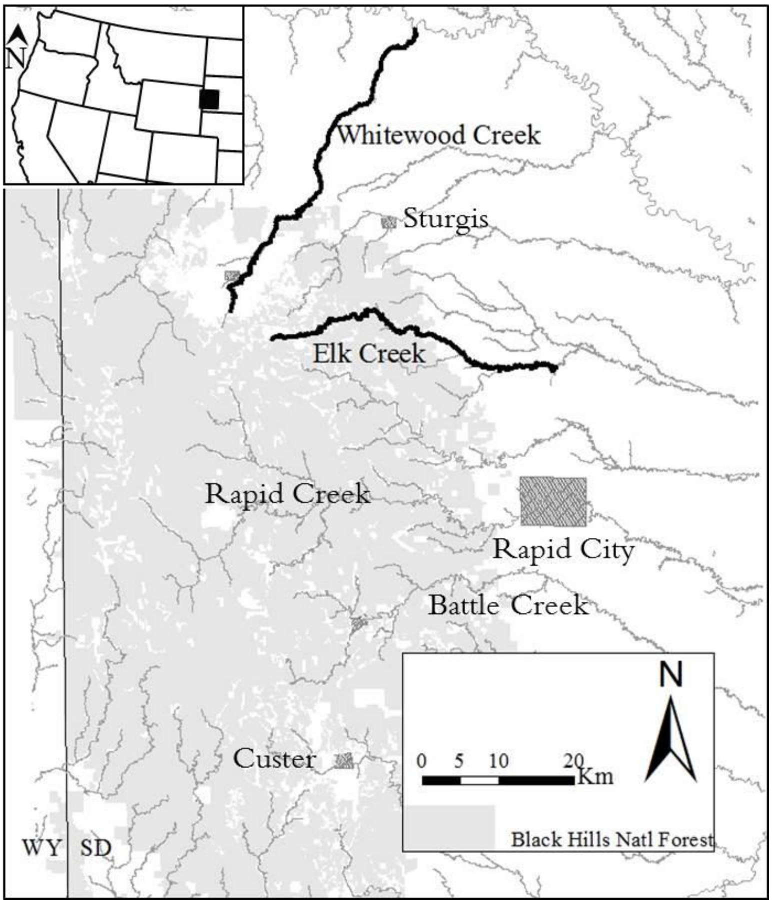

Fig. 1. Mountain sucker *Catostomus platyrhynchus* were collected from various locations in Whitewood and Elk creeks (bold). These 2 creeks eventually flow into the Belle Fourche River, northeast of the Black Hills, South Dakota.

surrounded by mid- and short-grass prairie, and these hills represent an island of suitable habitat for montane and forest-dwelling species, both aquatic and terrestrial. Geologically, the center of the dome is characterized by Precambrian metamorphic and intrusive rocks and is surrounded by a ring of Cretaceous sedimentary formations that completely encircle the core (DeWitt et al. 1989). These sedimentary formations have substantial effects on the stream hydrology of the region (Fig. 1). Streams that arise in the center of the Black Hills lose much of their surface discharge to the porosity of the formations as they flow north or east off the core of uplift (Williamson and Carter 2001). These zones of stream intermittency are known as the Loss Zone and can limit the distribution and dispersal of fishes between watersheds, especially in dry years. Riparian areas are typically a mix of open riparian meadows, willow-dominated stream banks, or forested ecosystems.

Historically, the Black Hills contained a relatively depauperate native fish fauna consisting of mountain sucker and longnose dace *Rhinichthys cataractae* throughout the area. Scattered populations of white sucker, creek chub *Semotilus atromaculatus,* and fathead minnow *Pimephales promelas* are considered to be native to the lower portions of drainages (Bailey and Allum 1962, Koth 2007). Other species (e.g., lake chub *Couesius plumbeus,* finescale dace *Chrosomus neogaeus,* and longnose sucker *Catostomus catostomus*) were present in isolated populations but many populations of all 3 species appear to have been extirpated (Isaak et al. 2003). Three species of salmonids (i.e., brook trout *Salvelinus fontinalis,* brown trout *Salmo* *trutta,* and rainbow trout *Oncorhynchus mykiss*) were introduced to the Black Hills in the late 1800s (Bailey and Allum 1962) and now constitute the majority of the fish biomass in many stream reaches (Schultz et al. 2012).

Structure Collection and Processing

We collected mountain sucker during late August 2010 from Whitewood and Elk creeks in the Black Hills, South Dakota, by using a backpack electrofisher adjusted to output settings that allowed fish capture with dip nets (Fig. 1). We selected these 2 streams because they had high densities of mountain sucker relative to other Black Hills streams (Schultz and Bertrand 2012). The fish were originally collected to estimate the thermal tolerance of mountain sucker (Schultz and Bertrand 2011) and were initially combined into multiple intermixed test groups, which made it impossible to subsequently separate fish from individual creeks. Structures for estimating ages were obtained from individual fish that either perished during these laboratory tests or died in captivity prior to the tests. For each fish, we measured the total length (mm) and determined sex (i.e., male, female, or immature) by dissecting and visually examining for testes or oocytes. The entire pectoral fin was removed from both sides of the body as close to the body wall as possible by using surgical scissors. Scales were collected from an area directly behind the depressed left pectoral fin ventral to the lateral line. Asteriscus otoliths were removed from each mountain sucker according to methods described by Schneidervin and Hubert (1986). For some fish we were not able to successfully collect all structures because of deterioration of the structures (e.g., fungus) or difficulty in finding otoliths. All structures were allowed to dry for a period of at least 3 weeks prior to processing.

Scales were pressed between 2 glass microscope slides and viewed through a dissecting microscope (Olympus© SZX7 with a 1X-4 objective) using transmitted light. At least 10 scales per fish were viewed by each reader before a final age was estimated. One entire pectoral fin (i.e., the one that had the smoothest base after removal) was embedded in epoxy and three 0.5-mm thin sections were cut out of each fin as close to the base as possible using the methods described by Koch and Quist (2007). All 3 fin ray thin sections for an individual fish were glued to the same microscope slide and polished with wetted 1000-grit sandpaper. Fin ray sections were viewed through a dissecting scope using transmitted light, and immersion oil was placed on each section to enhance clarity. Whole otoliths were submerged underwater in a black dish and viewed through a dissecting scope using reflected light. One otolith from each fish was then glued to a microscope slide and polished using wetted 1000-grit sandpaper until a flat plane was produced. Polished otoliths were viewed through a dissecting scope using transmitted light, and immersion oil was placed on the polished surface to enhance clarity. Although Quist et al. (2007) showed 100% agreement between sectioned and whole otoliths for other catostomid species, the precision of whole and polished otoliths was evaluated from each individual fish because for other fish species, whole otoliths underestimate ages compared to sectioned otoliths (e.g., Hoyer et al. 1985).

Ages were estimated from scales, sectioned fin rays, whole otoliths, and polished otoliths as the number of visible annuli present on each structure. Annuli on each structure were counted by 3 independent readers with differing levels of experience in estimating ages of fish (i.e., one experienced, one intermediate, and one novice). Readers with differing levels of experience were used to determine if readers with very little experience could produce age estimates similar to those produced by an experienced reader. Such information would provide insight into the amount of training new readers might need when estimating ages of mountain sucker. The experienced reader had estimated the ages of thousands of fish by using calcified structures and had experience estimating ages from scales, fin rays, whole otoliths, and polished/sectioned otoliths. The intermediate reader had estimated the ages of hundreds of fish by using calcified structures and had experience estimating ages from fin spines, whole otoliths, polished/sectioned otoliths, and scales. The novice reader had no experience estimating the ages of fish. No readers had any knowledge of fish length while estimating ages.

Structure Analysis

Mean coefficients of variation (CV = [SD/mean number of annuli] * 100) for each structure, complete reader agreement (i.e., all

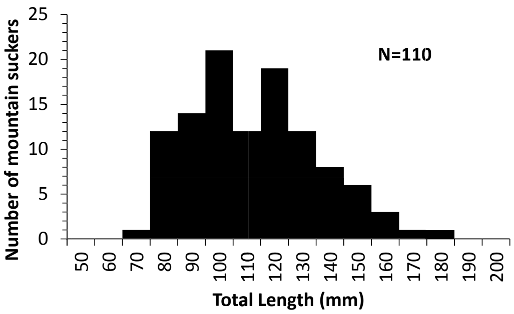

Fig. 2. Length frequency histogram for mountain sucker *Catostomus platyrhynchus* collected from Whitewood and Elk creeks in the Black Hills, South Dakota, during August 2010.

3 readers agreed on the age for a given structure), and partial reader agreement (i.e., at least 2 of the 3 readers agreed on the age for a given structure) were used to assess the precision of age estimates derived from scales, pectoral fin rays, whole otoliths, and polished otoliths. Age-bias plots similar to those suggested by Campana et al. (1995) were used to assess age estimation biases among the readers and the 4 different structures. To assess bias among readers, mean ages estimated by the novice and intermediate readers were plotted against ages estimated by the experienced reader for a given structure. To assess bias among structures, the mean scale, sectioned fin ray, and whole otolith age estimates were plotted against polished otolith age estimates for each reader. Although otoliths have not been validated for mountain sucker by using known-age fish, sectioned otoliths have been validated for white sucker (Thompson and Beckman 1995), and sectioned or cracked otoliths have been validated for a variety of other species (Taubert and Tranquilli 1982, Erickson 1983). Therefore, polished otoliths were assumed to be the most accurate structure in this analysis and were used as the standard against which age estimates from other structures were compared. Linear regression was used to evaluate whether the slopes and intercepts for each relationship on individual age-bias plots were significantly different than 1 and 0, respectively ($\alpha = 0.05$). Additionally, bias among relationships was assessed by comparing 95% confidence intervals of mean ages to an equivalence line represented by a 1:1 relationship (i.e., a bias exists if the 95% confidence interval does not overlap the 1:1 line). All analyses were completed using the statistical program SAS 9.2 (SAS Institute, Inc., Cary, NC).

Upon completion of independent age estimates by each reader, a consensus polished otolith age for each fish was reached. As noted earlier, the consensus polished otolith age was assumed to represent the most accurate age for each fish. If the age estimate from 2 of the 3 readers agreed on the polished otolith for a given fish, that estimate was considered the consensus age. If all 3 readers disagreed on their initial age estimates, all 3 readers viewed the polished otolith on a computer monitor connected to a dissecting microscope to reach agreement between at least 2 of the 3 readers. The consensus age for each fish was assumed to be the true age of that fish.

Maturation and Growth

Consensus polished otolith ages were used to estimate the percentage of mountain suckers that were mature at each age along with the smallest size at maturation for both males and females. To estimate growth, a von Bertalanffy growth model (von Bertalanffy 1938) was fit to mean lengths at age for all fish combined regardless of sex or maturation. The solver tool in Microsoft Excel was used to fit the von Bertalanffy growth model to the age-structured data (Haddon 2001).

RESULTS

Precision of Age Estimates

Calcified structures were collected from 110 mountain suckers ranging in size from 75 to 180 mm TL (Fig. 2). Approximately 85% ($n \cong 94$) of individuals used in this study were collected from Elk Creek, and the remainder ($n \cong 16$) were collected from Whitewood Creek. We do not have any reason to believe that population characteristics varied greatly for these 2 populations; both contain some of the highest densities of mountain sucker observed in the Black Hills (Schultz and Bertrand 2012). Not all calcified structures were collected from every fish. Therefore, ages were estimated from 107 whole otoliths, 107 polished otoliths, 104 sectioned pectoral fin rays, and 102 scales. Polished otoliths had the highest precision, with a mean CV of 13.1%, and 30% and 83% complete and partial reader

TABLE 1. Mean percent coefficients of variation (standard error in parentheses), and percent complete and partial agreement for fin rays, whole otoliths, scales, and sectioned otoliths from mountain sucker *Catostomus platyrhynchus* collected from Whitewood and Elk creeks in South Dakota, August 2010.

Structure	N	Mean CV (%)	Complete agreement (%)	Partial agreement (%)
Fin rays	104	13.6 (0.93)	25	93
Scales	102	15.1 (1.05)	27	93
Whole otoliths	107	15.9 (0.97)	19	77
Polished otoliths	107	13.1 (1.01)	30	83

agreement, respectively (Table 1). Sectioned pectoral fin rays and scales were slightly less precise than polished otoliths, with a mean CV of 13.6%, and 25% and 93% complete and partial reader agreement, respectively. Scales had a mean CV of 15.1%, and 27% and 93% complete and partial reader agreement, respectively (Table 1). Whole otoliths were the least precise calcified structure, with a mean CV of 15.9%, and 19% and 77% complete and partial reader agreement, respectively (Table 1).

The next 2 paragraphs describe only instances in which a bias was shown in the comparison of readers or structures (i.e., the slope and intercept were significantly different than 1 and 0, respectively). See Figs. 3 and 4 for trends that did not show bias.

We observed different patterns of age estimates between readers. When examining sectioned fin rays, the intermediate reader tended to underestimate ages of older fish compared to the experienced reader; the slope from this relationship was significantly <1, but the intercept was not significantly different from 0 (Fig. 3). When examining scales, the novice reader tended to overestimate ages of younger mountain sucker relative to the experienced reader, as the 95% confidence intervals did not overlap the 1:1 line for age-2 and age-3, and the intercept from this relationship was significantly >0, and the slope was significantly <1 (Fig. 3). When examining whole otoliths, both the intermediate and novice readers tended to underestimate ages of older mountain sucker compared to the experienced reader, as the slopes of both of these relationships were significantly <1 and the intercept from the relationship comparing the intermediate and experienced reader's age estimates was significantly >0 (Fig. 3). When examining polished otoliths, both the intermediate and novice readers tended to underestimate ages of older mountain sucker compared to the experienced reader, as the slopes and intercepts from both of these relationships were significantly <1 and significantly >0, respectively (Fig. 3).

At least 2 of the 3 readers showed a bias in the comparison of mean age estimates from scales, sectioned fin rays, and whole otoliths with polished otolith age estimates for an individual reader (Fig. 4). Relative to polished otoliths, all 3 readers examining sectioned fin rays tended to underestimate ages of age-5 and older mountain suckers. All 3 readers examining scales underestimated nearly all age classes. And when examining whole otoliths, the experienced and novice readers tended to underestimate ages of older mountain sucker. Slopes and intercepts from all 3 relationships were significantly <1 and significantly >0, respectively (Fig. 4). However, for whole otoliths, the 95% confidence intervals overlapped the 1:1 line for the experienced readers, indicating no difference between mean whole otolith age estimates and polished otolith age estimates (Fig. 4).

Maturation and Growth

Consensus polished otolith age estimates ranged from 3 to 6 years. No age-0 through age-2 fish were sampled from Whitewood or Elk creeks. Of the 107 mountain suckers from which polished otoliths were sampled, 15 were estimated to be age-3, 56 were estimated to be age-4, 29 were estimated to be age-5, and 7 were estimated to be age-6. Nearly half (47%) of the mountain suckers collected were mature at age-3, 74% were mature at age-4, and almost all were mature by age-5 and older, with 93% being mature at age-5 and 100% at age-6. In the Black Hills, the shortest observed mature male was 95 mm TL, and the shortest observed mature female was 101 mm TL. Growth of mountain sucker collected from Elk and Whitewood creeks was fairly consistent across ages; mean lengths at each age were approximately 20 mm longer than the previous age (Fig. 5). Mountain sucker within these creeks

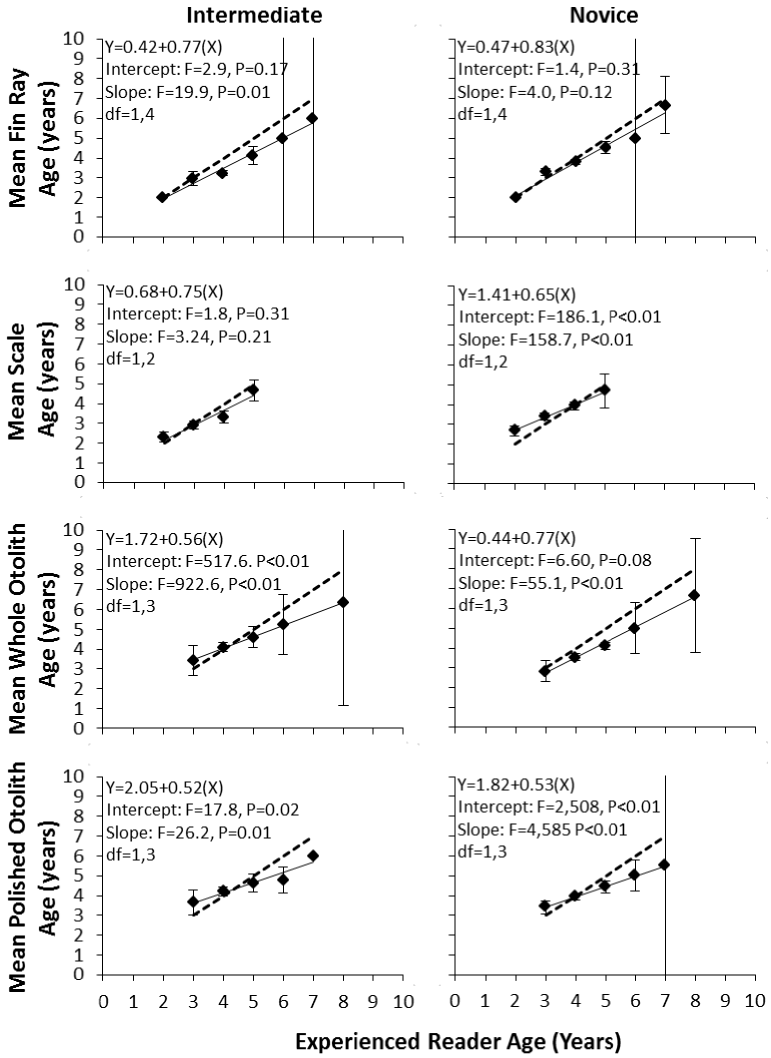

FIG. 3. Age-bias plots comparing mean polished otolith, whole otolith, sectioned fin ray, and scale age estimates from the intermediate and novice reader to age estimates for the same structure from the experienced reader for mountain sucker *Catostomus platyrhynchus* collected from Whitewood and Elk creeks in the Black Hills, South Dakota, during August 2010. Dashed lines represent 1:1 lines and error bars represent 95% confidence intervals.

reached an average size of 100 mm total length (TL) during their fourth growing season and reached an average maximum attainable size (L_∞) of approximately 220 mm (Fig. 5).

DISCUSSION

In this study, we evaluated the precision of 4 calcified structures used to estimate ages of mountain sucker and then used the most precise structure (i.e., polished otoliths, which were also assumed to be most accurate) to derive growth, as well as age and size at maturation, for mountain sucker, a species of conservation interest in the Black Hills of South Dakota. The results of this study may be used by fisheries managers to aid conservation efforts for the species. The presence of several consistent year classes and the rapid maturation of mountain sucker indicate that the species may respond quickly to management actions. Despite being listed as a species of greatest conservation need in South Dakota (SDGFP 2013), mountain sucker have stable populations in some streams in the Black Hills (Schultz and Bertrand 2012).

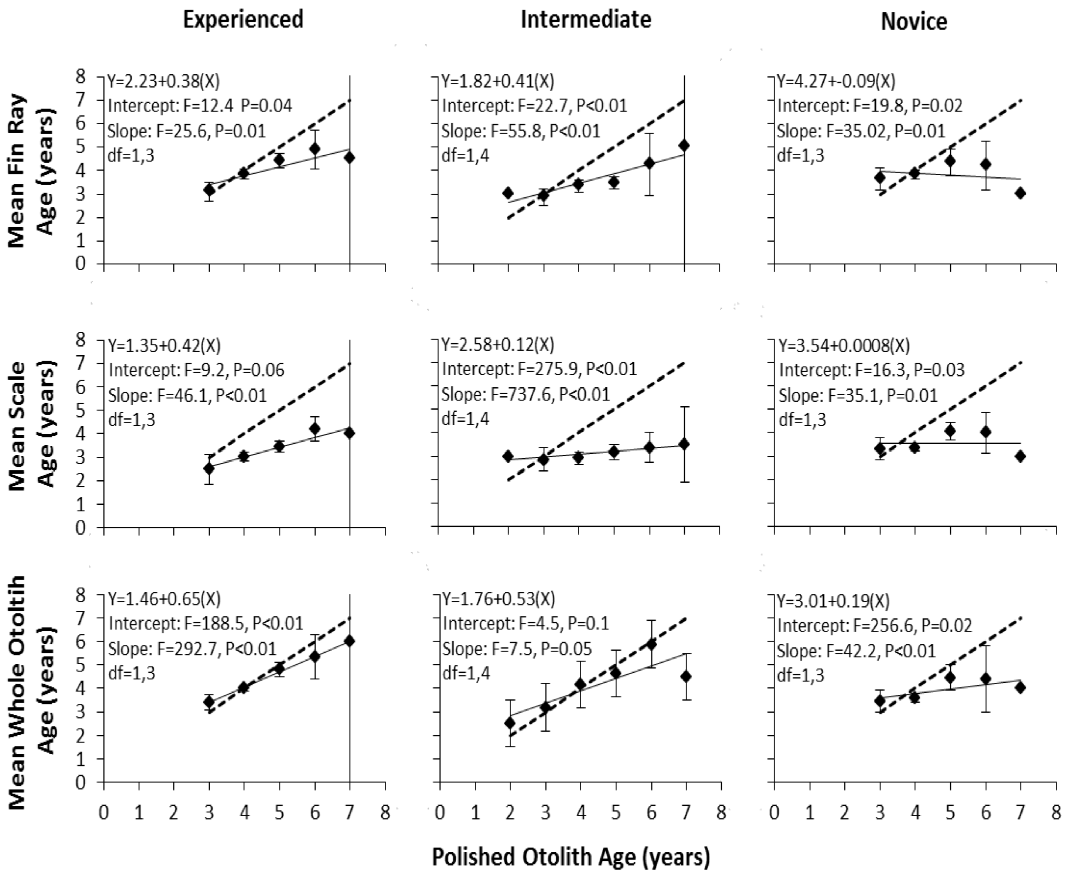

Fig. 4. Age-bias plots comparing mean sectioned fin ray, scale, and whole otolith age estimates to polished otolith age estimates for the experienced, intermediate, and novice readers individually for mountain sucker *Catostomus platyrhynchus* collected from Whitewood and Elk creeks in the Black Hills, South Dakota during August 2010. Dashed lines represent 1:1 lines and error bars represent 95% confidence intervals.

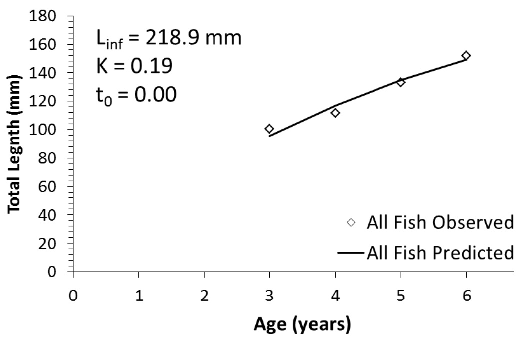

Fig. 5. Observed (points) and predicted (line) mean lengths at age from a von Bertalanffy growth curve for mountain suckers *Catostomus platyrhynchus* collected from Whitewood and Elk creeks in the Black Hills, South Dakota, during August 2010. The parameters for the von Bertalanffy model (i.e., L_∞, K, and t_0) are included on the graph.

Precision of Age Estimates

Polished otoliths were the most precise structure (i.e., had the lowest mean CV and highest complete reader agreement) of those examined for estimating ages of mountain sucker, although differences in CV and in complete and partial reader agreement were small among all 4 structures. Otoliths were also reported to be the most precise structure for estimating the ages of other catostomid species (e.g., Sylvester and Berry 2006, Quist et al. 2007) and noncatostomid species (e.g., Vandergoot et al. 2008, Isermann et al. 2010). Interestingly, whole otoliths were the least precise structure (i.e., had the highest mean CV the and the lowest complete and partial percent reader agreement) that was evaluated. This was surprising because whole otoliths have high precision for other catostomid species. For example, mean CVs and complete reader agreement for whole otolith age estimates from 3 other sucker species and their hybrids ranged from 2.5% to 6.5% and 66.2% to 79.3%, respectively (Quist et al. 2007). These results indicate that the specific structure or even the method of preparation (i.e., whole versus polished otoliths) that results in the most precise age estimates is likely species specific. For example, whole otoliths may produce precise age estimates for some sucker species (e.g., Quist et al. 2007), whereas polished or sectioned otoliths may produce more precise age estimates for another species (our study).

Scales and sectioned fin rays both tended to underestimate ages relative to polished otoliths. Several other studies have shown that scales and fin rays both underestimate ages in catostomid species (e.g., Sylvester and Berry 2006, Quist et al. 2007) and other fishes (e.g., Johnson 1971, Rien and Beamesderfer 1994). Additionally, when examining whole otoliths, experienced and novice readers underestimated ages of older mountain sucker compared to polished otoliths. Whole otoliths underestimate ages compared to sectioned otoliths for some sport fish species (e.g., Hoyer et al. 1985); however, Quist et al. (2007) found 100% agreement between sectioned and whole otoliths for other catostomid species. If scales or fin rays are used to estimate ages of mountain sucker, estimates of growth and mortality should be interpreted with caution because age underestimates might inflate these population parameters (Vandergoot el al. 2008, Yule et al. 2008). Future studies using otoliths to estimate the ages of mountain sucker should validate that age estimates from whole otoliths and polished otoliths are the same, because the potential for underestimating ages from whole otoliths exists for some readers. Additionally, future research should use known-age fish to validate the accuracy of mountain sucker age estimates.

Reader experience and training is important in assuring precise age estimates from mountain sucker. For example, we observed no relationship between mean sectioned fin ray, scale, and whole otolith age estimates compared to polished otolith age estimates for our novice reader. As the novice reader's polished otolith age estimates increased, age estimates did not increase from any other structure, including whole otoliths, indicating difficulty in discerning annuli on other structures. Additionally, both the intermediate and novice readers tended to underestimate ages of the oldest mountain sucker (i.e., ages 6 and older) from whole and polished otoliths compared to the experienced reader. This could be the result of the less experienced readers having difficulty discerning annuli near the outer edges of the otoliths. These trends illustrate the need to properly train all readers when estimating fish ages using an unfamiliar structure (Campana 2001, Maceina et al. 2007).

Maturation and Growth

Mountain sucker in the Black Hills matured at similar ages but at slightly smaller sizes relative to other populations across the species' range. In the Black Hills, the shortest mature male was 95 mm TL and the shortest mature female was 101 mm TL. The shortest mature male and female observed in Lost Creek Reservoir, Utah, were 115 mm TL and 143 mm TL, respectively (Wydoski and Wydoski 2002). Most mountain sucker in the Black Hills were mature by age-4 or age-5, which is similar to observations in southwestern Montana streams where most males matured by age-4 and females matured by age-5 (Hauser 1969).

Several observations from our sampling indicate that mountain sucker in the Black Hills may utilize protracted spawning. In Whitewood Creek, males were first observed in breeding colors (i.e., bright red lateral stripes and anal fin tubercles) in early June and persisted in breeding colors through late August (K. Bertrand, personal observation). Also, the first annulus on polished otoliths for some mountain sucker was very close to the focus, whereas it was far from the focus on others, indicating either both fast and slow growth among individuals during their first year of life or different hatching dates for the same cohort throughout the summer. Other studies have indicated that most spawning for mountain sucker occurs from late May to early July (Hauser 1969, Wydoski and Wydoski 2002).

Growth of mountain sucker in the Black Hills of South Dakota was slower than what has been observed in other parts of its range. Mountain sucker in this study reached lengths at age-3 similar to those in Flathead Creek and East Gallatin River, Montana (Table 2; Hauser 1969), but mean lengths from age-4 and older fish were shorter than those reported

TABLE 2. Mean length (mm) at age (number of fish in each age class) and structure used to estimate ages for mountain sucker *Catostomus platyrhynchus* collected from Elk and Whitewood creeks, South Dakota; Lost Creek Reservoir, Utah; Flathead Creek, Montana; and East Gallatin River, Montana.

Location (reference)	Number of fish	Estimated age (years)									Structure
		1	2	3	4	5	6	7	8	9	
Elk and Whitewood creeks, SD (this study)	107			100 (15)	111 (56)	133 (29)	151 (7)				Polished otoliths
Lost Creek Reservior, UT (Wydoski and Wydoski 2002)	433	64	108	139	160	175	193				Scales
Flathead Creek, MT (Hauser 1969)	185	28	58	92	128	156	177	196	209	223	Scales
East Gallatin River, MT (Hauser 1969)	273	31	63	96	127	150	169	189	205	221	Scales

from 2 Montana streams (Table 2; Hauser 1969). Mountain sucker in this study also had shorter mean lengths than those observed in Lost Creek Reservoir, Utah, for all age classes (Table 2; Wydoski and Wydoski 2002). However, growth rates of mountain sucker in Lost Creek Reservoir, a newly created lentic habitat, were some of the highest observed for the species, so it is not surprising that mountain sucker in the Black Hills grow more slowly.

Management Implications

We recommend using polished otoliths to estimate the ages of mountain sucker because they provided the most precise age estimates; scales, sectioned fin rays, and whole otoliths underestimated ages relative to polished otoliths. If use of a nonlethal structure is desired in order to conserve mountain sucker as a species of greatest conservation need in South Dakota, we recommend using sectioned pectoral fin rays to estimate ages. Sectioned pectoral fin rays provided age estimates closer to polished otoliths than did scales. The fin rays also had a mean CV that was similar to polished otoliths, and were recommended by other researchers as a nonlethal alternative to otoliths (e.g., Quist et al. 2007). Additionally, accuracy of polished otoliths should be validated using known-age mountain sucker.

Because the mountain sucker has declined in parts of its range (Erman 1973, 1986, Gard and Flittner 1974, Moyle and Vondracek 1985, Decker 1989, Patton et al. 1998, Schultz and Bertrand 2012) and is listed as a species of greatest conservation need in South Dakota (SDGFP 2013), efforts should be made to fill in knowledge gaps in its biology and ecology. We discovered several potential future research questions from our age estimation and growth study. First, it would be important to know what habitats juvenile mountain sucker use in the Black Hills. We did not sample juveniles in this study and assumed their absence was due to the presence of trout in these streams. Mountain sucker in other streams in which trout are also present go through an ontogenetic shift in habitat use, as juvenile mountain sucker use different habitat than adults to escape predation (Olsen and Belk 2005). Second, information regarding the factors affecting mountain sucker recruitment and mortality is lacking. Knowledge regarding habitat use of all age classes, with more information regarding population dynamics, could aid with the management of this species in the Black Hills. As knowledge gaps such as these are filled, informed management actions could be taken to conserve this species in other parts of its range where it is declining.

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