Age Structure and Reproductive Activity of the Blue Sucker in the Milk River, Missouri River Drainage, Montana

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ABSTRACT -- The life history and ecology of the blue sucker (*Cycleptus elongatus*) in the lower Milk River, Montana were investigated in 2002 and 2003. A total of 253 blue sucker was captured; 248 adult fish, three larval fish, and two age-0 juveniles. The ages (n = 102) of the adult blue sucker ranged from 10 to 37 years; maximum age greatly exceeded ages reported in other studies. Blue sucker in the Milk River population grew slower, matured later, and lived longer than fish at lower latitudes. Adult females of the blue sucker were longer and weighed more than adult males at a given age. The Von Bertalanffy growth equations for length were expressed as $L = 752.9(1\text{-}e^{-0.1457t})$ for females and $L = 695.1(1\text{-}e^{-0.1743t})$ for males. The Von Bertalanffy growth equations for weight were expressed as $W = 3844.3[(1\text{-}e^{(-0.1412t)})^{2.8171}]$ for females and $W = 2754.9[(1\text{-}e^{(-0.1604t)})^{2.8883}]$ for males. In 2002, 189 out of 222 adult fish were determined to be reproductively active: 93 females and 96 males. In 2003, one female fish out of 26 fish caught was determined to be reproductively active. Catches of adult blue sucker were highest during periods of high spring discharge as adults likely migrated into the Milk River from the Missouri River to spawn during May and June.

Key words: age, blue sucker, *Cycleptus elongatus*, growth, larval fish, Milk River, Missouri River, reproduction, von Bertalanffy.

The blue sucker (*Cycleptus elongatus*) is a large cypriniform fish (family Catostomidae) of large river habitats in the Mississippi, Missouri, Pearl, and Rio Grande River drainages (Becker 1983, Pflieger 1997). Although the species is

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widespread from Montana east to Wisconsin and Pennsylvania and south to Alabama and Mexico it is uncommon or rare in many locations. Many aspects of blue sucker life history are poorly known. Information has been elusive because the species typically occupies deep swift water in the main channel (Pflieger 1997) where many conventional sampling methods are ineffective (Moss et al. 1983). Most available information has been on adult fish; juveniles have seldom been captured (Hand and Jackson 2003, Morey and Berry 2003).

Supposedly, prior to spawning the blue sucker migrates to riffles in large turbid tributaries such as the Milk River in the upper Missouri River basin, Montana. The blue sucker has been documented in the lower Milk River as sexually mature adults (Stash et al. 2001, Fuller 2002) and as larval fish (Gardner and Stewart 1987) during the spring and early summer. Age-0 juveniles have been captured in the Missouri River just below the confluence of the Milk and Missouri rivers (Fuller 2000). Additional information on blue sucker life history and ecology is needed for the management of the species in the Milk River as well as in other locations throughout its range.

The goal of our study was to investigate the life history and ecology of the blue sucker in the lower Milk River, Montana. The specific objectives of our study were to: 1) assess age and growth of blue sucker, 2) assess the relationship between spring flows and blue sucker year class strength, and 3) characterize the spawning run of blue sucker in relation to river discharge.

STUDY AREA

The Milk River, named by Lewis and Clark for its milky-colored, turbid waters, is one of the largest tributaries of the upper Missouri River. It is 1,126 km in length and drains an area of approximately 57,839 km^2. From its headwaters in Glacier National Park, Montana, it flows northeastward, crossing into Canada for 348 km. It re-enters the United States in Hill County, Montana, and flows through northeastern Montana to its confluence with the Missouri River immediately downstream of Fort Peck Dam (Fig. 1).

Sampling was conducted on the lower 188 river kilometer (rkm) of the Milk River, below Vandalia Dam and in the first 4.8 rkm of the Missouri River downstream of the Milk River. Riffle and run habitats within the study area were sampled. Riffles were classified as areas with shallow, turbulent water passing through or over stones or gravel of a fairly uniform area. Runs were classified as areas with a depth of at least 0.9-m with slow to moderate current. Areas of slower moving water, pool-like in nature, were classified as runs. Four sampling locations were established on the Milk River and one sampling location was established on the Missouri River. At each location, three random sampling sites were established. Sampling occurred at each of these sites over the period May to August, 2002 and 2003.

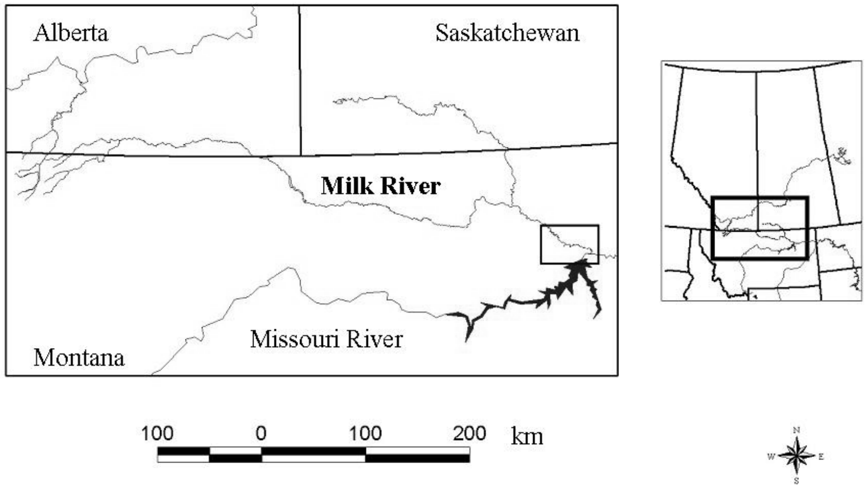

Figure 1. Lower Milk River study area, Montana.

METHODS

The blue sucker was sampled with five gears: stationary gill nets, floating gill nets, trammel nets, hoop nets, and bag seines in an attempt to effectively sample the range of sizes and habitats present. Each gear was deployed at least three times per sampling site from mid-May to mid-August 2002 and 2003. Stationary gill nets and hoop nets were set overnight. Stationary gill nets were 30 by 1.8 m and were divided into four 7.5 m panels of 1.9, 3.8, 5.0, and 7.6 cm mesh (bar measure) sizes. Floating gill nets were 150 by 1.8 m high, with 7.6 cm bar measure mesh. Trammel nets were 22.9 m long with a 2.5 cm inner mesh and a 15.2 cm outer mesh. Hoop nets were 1 m in diameter with a mesh size 2.5 cm. Bag seines were of two sizes: 10.7 by 1.8 m and 7.6 by 1.8 m. Both seines had 5 mm ace mesh and a "many ends" mud lead line attached.

Collected individuals of the blue sucker were measured to the nearest mm for total length (TL) and weighed to the nearest g. The condition factor was expressed as $K = W(10^5)/L^3$, where W = weight and L = length (Lagler 1956). Analysis of variance (ANOVA) was used to test for differences in lengths, weights, and condition factors among females, males, and fish of unknown sex (Ott and Longnecker 2001). When significant differences were detected, Tukey's multiple comparisons test was used to separate means.

The presence of mature fish with milt or roe was sought as evidence of spawning activity. Collected individuals were checked externally for maturation. If roe or milt was detectable after gentle pressure was applied to the abdomen, the fish was recorded as reproductively active.

For age analysis, diagonal pliers were used to cut the first pectoral fin ray as close to the point of articulation as possible (Sappington et al. 1998). Pectoral fin rays were chosen for age analysis because scales are known to underestimate the age of catostomids (Beamish and McFarland 1987). Methods for determining the age from pectoral fin rays followed DeVries and Frie (1996) and as modified by Dingman (2001). Fins were soaked in distilled water for at least 2 hr to moisten the attached flesh facilitating its removal from the fins. The first lead fin ray was glued parallel to a labeled, wooden craft stick, by using clear epoxy with the end nearest the point of articulation closest to the end of the stick. Glued fins were allowed to dry for 24 hr before cutting.

Thin sections of fin rays were cut with a Buehler Isomet Speed Sectioning saw equipped with a 10 cm diameter by 0.3 mm thick diamond-edged wafer blade. The first cut was made as close to the proximal end of the fin as possible to create a smooth edge. Four fin ray sections were mounted on a glass slide by using clear fingernail polish. Fin ray sections were viewed under a microscope attached to a Biosonics Optical Pattern Recognition System (OPRS). Annual rings were counted to determine age; one clear ring was assumed to be developed each year. No validation of age was possible. If the fin sections were not readable a second series of cuts was attempted. Two people (a primary and secondary reader) independently aged sections from each fish. If the disagreement for fish aged between 5 and 10 years was within one year, fish aged from 11 to 15 years were within +/- 2 years, and fish aged 16 years and greater were within +/- 3 years, the age determined by the primary reader was assigned. All other disagreements on the age were determined by a second pair of independent readings. If there was still disagreement after two paired readings, a third reading was made with both people present.

Lengths and weights by age were used to estimate Von Bertalanffy growth curves (Moreau 1987). Separate growth curves were estimated for females and males. Von Bertalanffy growth equations were expressed as $TL = L_{\infty}(1\text{-}e^{-kt})$ for total length (mm) and $W = W_{\infty}[(1\text{-}e^{-kt})^{b}]$ for weight, where TL is the total length (mm) of the blue sucker at age t, W is the weight (g) of a fish at age t, L_{∞} and W_{∞} are the theoretical limiting size, k is the curvature parameter, and b is the exponent of the length-weight relationship. Because of a shortage of small, young fish, the initial condition parameter was set at zero and a two-parameter model was fit. Estimates for Von Bertalanffy growth parameters were calculated in SAS (1999). A log-likelihood ratio test was used to test for differences between female and male growth rates (Kimura 1980).

To evaluate if river discharge in spring and year class strength were correlated, estimated ages of fish (n = 152; 53 females, 49 males, and 50 unknown sex) were assigned to a brood year. Catches of blue sucker by age were assumed to be indicative of brood year strengths. Catches were ranked by brood year. The estimated number of fish by brood year from the age determination was plotted against the frequency of days above the May and June mean discharge rate (27 m^3/s) separately for May and June 1972 to 1992. Daily discharge measurements were obtained from the United States Geological Service gauging station on the Milk River near Nashua, Montana. The relationship between catches and flows was evaluated with Spearman's Rank Correlation (Higgins 2004). For these analyses, only the years 1972 to 1992 were used, based on the assumption that fish from brood years 1972 to 1992 were recruited fully, and that in the absence of a fishery, their lifespan would commonly reach 30 years.

The second type of evidence sought for assessing the Milk River for spawning was the potential presence of larval blue sucker. Larval fish samples were taken weekly from mid-May to mid-August 2002 and 2003, during daylight hours. Weather related problems prevented the sampling of certain locations in some weeks in 2002. Larval sampling began two weeks earlier in 2003 than in 2002, but ended at the same time. Larval fish were sampled with 0.5 by 1.8 m conical nets (750 um Nitex mesh) with attached buckets and weighted with two 4.5 kg lead weights (Kelso and Rutherford 1996). A flow meter (General Oceanics 230 OR) was suspended in the mouth of the net to estimate total water volume sampled (Kelso and Rutherford 1996). Two nets were placed on either side of the bow of the boat and released simultaneously into the water for 10 minutes with the boat idling upstream. After each tow, the cod-end cups were removed and the water drained out. The contents were placed in whirl-pak bags containing 10% formalin. Phloxene-B, a chemical dye, was added to stain larval fish to improve their visibility and to expedite sorting. In the laboratory, each sample was rinsed and sorted. Larval fish were identified to the species level by using a larval fish key developed by Kay et al. (1994).

RESULTS

A total of 253 individuals of blue sucker was caught, 225 fish in 2002 and 28 in 2003. Of that total, 124 adult fish were caught in hoop nets, 84 adult fish in stationary gill nets, 22 adult fish in floating gill nets, and 18 adult fish in trammel nets. One juvenile (age-0) blue sucker was caught in a bag seine and one juvenile (age-0) and three larval fish were caught in larval nets. In 2002, 84% (189) of collected individuals were determined to be reproductively active, 93 females and 96 males. In 2003, only one female blue sucker was determined to be reproductively active.

Females ranged in total length from 634 to 806 mm (mean TL = 722 mm, SE = 42) and weighed between 2,100 and 4,700 g (mean weight = 3,302 g, SE = 603). The length-weight relationship for females was expressed as $\log_{10}W = -3.66 + 2.51 \log_{10}L$ ($r^2 = 0.62$). Males ranged in total length from 532 to 754 mm (mean TL = 661 mm, SE = 49) and weighed between 800 and 3,600 g (mean weight = 2,267 g, SE = 583 g). The length-weight relationship for males was expressed as $\log_{10}W = -4.81 + 2.89 \log_{10}L$ ($r^2 = 0.70$). Individuals of the blue sucker of unknown sex ranged in total length from 531 to 805 mm (mean TL = 681 mm, SE = 103) with weight between 1,200 and 4,200 g (mean weight = 2,618 g, SE = 811). The length-weight relationship for those of unknown sex was expressed as $\log_{10}W = -5.3 + 3.07 \log_{10}L$ ($r^2 = 0.87$). Lengths and weights were significantly different among females, males, and those of unknown sex ($F = 1.33$, df = 82, $P < 0.05$). Mean condition factors were 0.87 (SE = 0.10) for females, 0.79 (SE = 0.10) for males, and 0.80 (SE = 0.08) for unknown sex. Female condition factor was significantly different from that of males and unknown sex ($P < 0.05$), but male condition factor was not significantly different than individuals of unknown sex ($F = 1.54$, df = 82, $P > 0.05$).

Ages were assigned to 152 fish; 53 females, 49 males, and 50 unknown sex. Fin sections typically had the same general pattern of putative annual marks. Females ranged in age from 14 to 37 years, males ranged in age from 10 to 33 years, and those of unknown sex ranged in age from 11 to 33 years. The first eight to 10 annuli were spaced widely, but subsequent annuli were packed tightly (Figs. 2-4).

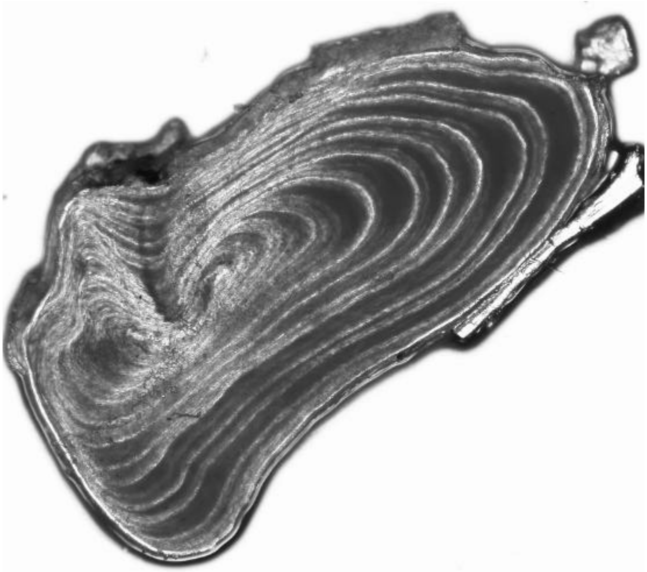

Figure 2. The lead pectoral fin ray section of an unknown sex blue sucker (603 mm TL; 1,750 g) collected from the Milk River, Montana in 2002. Estimated age was 13 years.

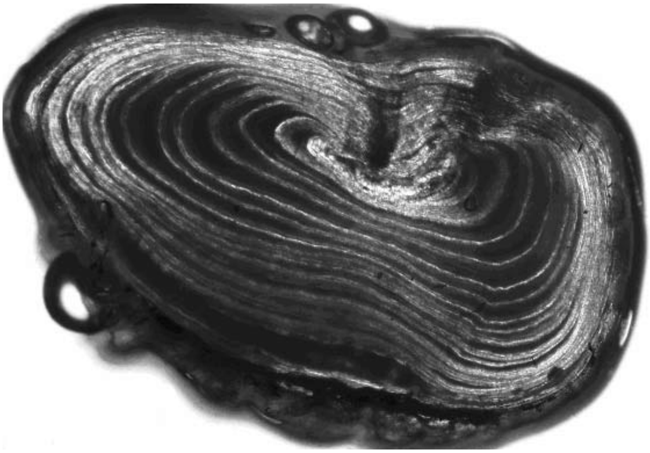

Figure 3. The lead pectoral fin ray section of a female blue sucker (690 mm TL; 3,050 g) collected from the Milk River, Montana in 2002. Estimated age was 17 years.

Figure 4. The lead pectoral fin ray section of a male blue sucker (750 mm TL; 3,000 g) collected from the Milk River, Montana. Estimated age was 33 years.

Females were longer than males at a given age (Fig. 5). The Von Bertalanffy growth equations for length were expressed as $L = 752.9(1-e^{-0.1457t})$ for females and $L = 695.1(1-e^{-0.1743t})$ for males.

The curvature parameter, k, was not significantly different between females and males ($\chi^2 = 1.77$, df = 2, P > 0.05). Asymptotic length, L_∞, for females and males was significantly different ($\chi^2 = 26.35$, df = 2, P < 0.05). The Von Bertalanffy growth equations for length, with the same fitted k, were expressed as $L = 743.1\ (1-e^{-0.1608t})$ for females and $L = 702.8\ (1-e^{-0.1608t})$ for males.

Females weighed more than the males at a given age (Fig. 6). The Von Bertalanffy growth equations for weight were expressed as $W = 3844.3[(1-e^{(-0.1412t)})^{2.8171}]$ for females and $W = 2754.9[(1-e^{(-0.1604t)})^{2.8883}]$ for males.

The weight growth curvature parameter, k, was not significantly different between females and males ($\chi^2 = 1.77$, df = 2, P > 0.05). Asymptotic weight, W_∞, for females and males was significantly different ($\chi^2 = 31.30$, df = 2, P < 0.05). The Von Bertalanffy growth equations for weight, with the same fitted k, were expressed as $W = 3844.3[(1-e^{(-0.1604t)})^{3.2587}]$ for females and $W = 2819.2[(1-e^{(-0.1551t)})^{3.2587}]$ for males. The Von Bertalanffy growth equations indicated that an age-22 female was 721 mm and 3489 g and that an age-22 male was 682 mm and 2527 g.

The timing and duration of the spring seasonal discharge patterns near Nashua,

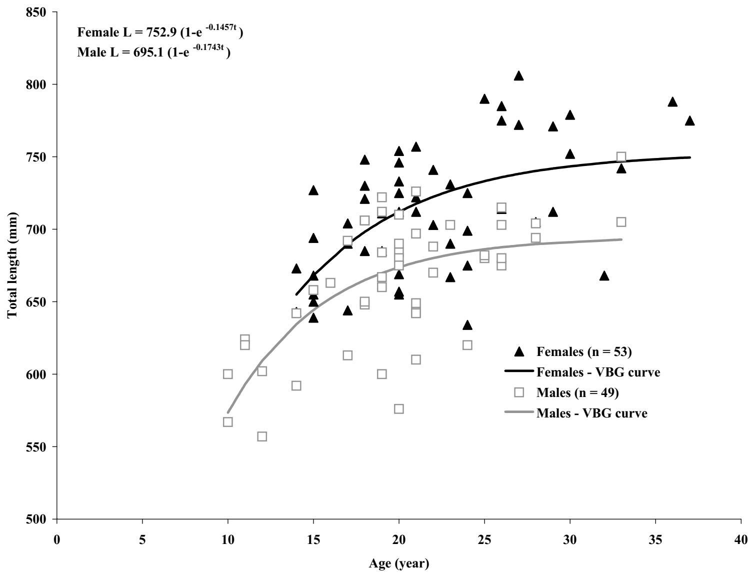

Figure 5. Length at age and the Von Bertalanffy growth curve for blue sucker collected in 2002 and 2003 from the Milk River, Montana.

Montana differed greatly between 2002 and 2003 for the period May to mid-August. Increased spring discharge lasted for 41 days in 2002, increased on 9 June, peaked at 62 m^3/s on 15 June, then dropped and peaked again at 78 m^3/s on 28 June and returned to base flows on 18 July. Increased spring discharge lasted for 17 days in 2003, increased on 6 May, peaked at 70 m^3/s on 12 May, and returned to base flows on 28 May. The later peak in spring discharge in 2002 resulted from seasonal precipitation whereas the peak in 2003 resulted from snowmelt.

Higher catches of adult blue sucker occurred in 2002, the year with higher spring discharge than in 2003, the year with lower spring discharge (Fig. 7). On the rising limb of the hydrograph on 10 June 2002, 120 adult fish were caught in two hoop nets. In 2003, in contrast only 26 adult fish were captured, also in mid-June. The three larval blue sucker captured in 2002 were caught on the descending limb of the hydrograph. One larval fish was caught on 21 June and two were caught on 28 June. The two juveniles captured in 2003 were caught two months after the peak in discharge. One juvenile was caught on 15 July and the other on 16 July.

Assuming that the age analysis represented the true brood year, no relationship was evident between year class strength and seasonal discharge (Fig. 8). There was little correlation between brood years and May discharge (r = 0.10, P = 0.6431, df = 21) nor June discharge (r = 0.13, P = 0.6431, df = 21).

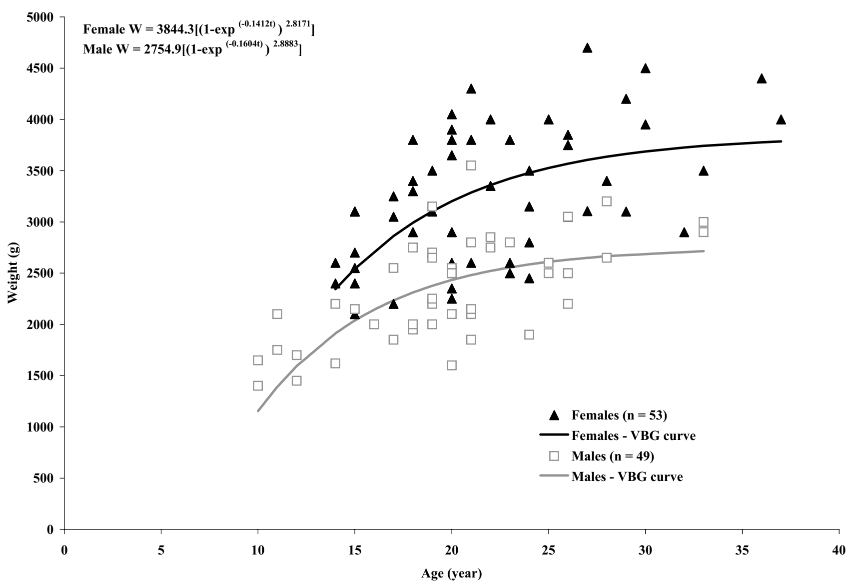

Figure 6. Weight at age and the Von Bertalanffy growth curve for blue sucker collected in 2002 and 2003 from the Milk River, Montana.

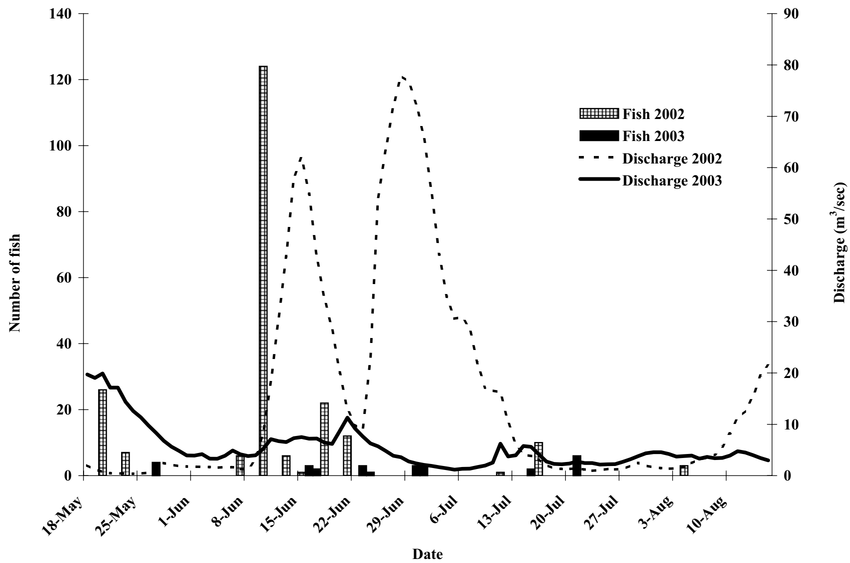

Figure 7. The distribution of blue sucker caught in the lower Milk River study and the mean daily discharge from the United States Geological Survey gauging station near Nashua, Montana, 2002 and 2003.

DISCUSSION

The estimated ages of the blue sucker in the Milk River (females 14-37, males 10-33) were much greater than ages for fish reported from other locations. Maximum ages determined from scales were 10 in the Neosho River, Kansas (Moss et al. 1983), 13 in the Yazoo River, Mississippi (Hand and Jackson 2003), 22 in the Grand River, Missouri (Vokoun et al. 2003), and 17 in the Missouri River, Montana (Berg 1981). The differences in maximum age between our study and others might result in part from the use of pectoral fin rays rather than scales for aging. Although previous aging studies on blue sucker have used scales to determine age, Rupprecht and Jahn (1980) compared scales and pectoral fins rays and found age discrepancies of up to three years greater in pectoral fin rays after the age of seven. The age determination method of blue sucker for our study has not been validated, but photographs from fin ray sections showed the apparent longevity of these fish (Figs. 2-4), especially the differences between the smaller, presumably younger fish (Figs. 2 and 3) and the larger, presumably older fish (Fig. 4).

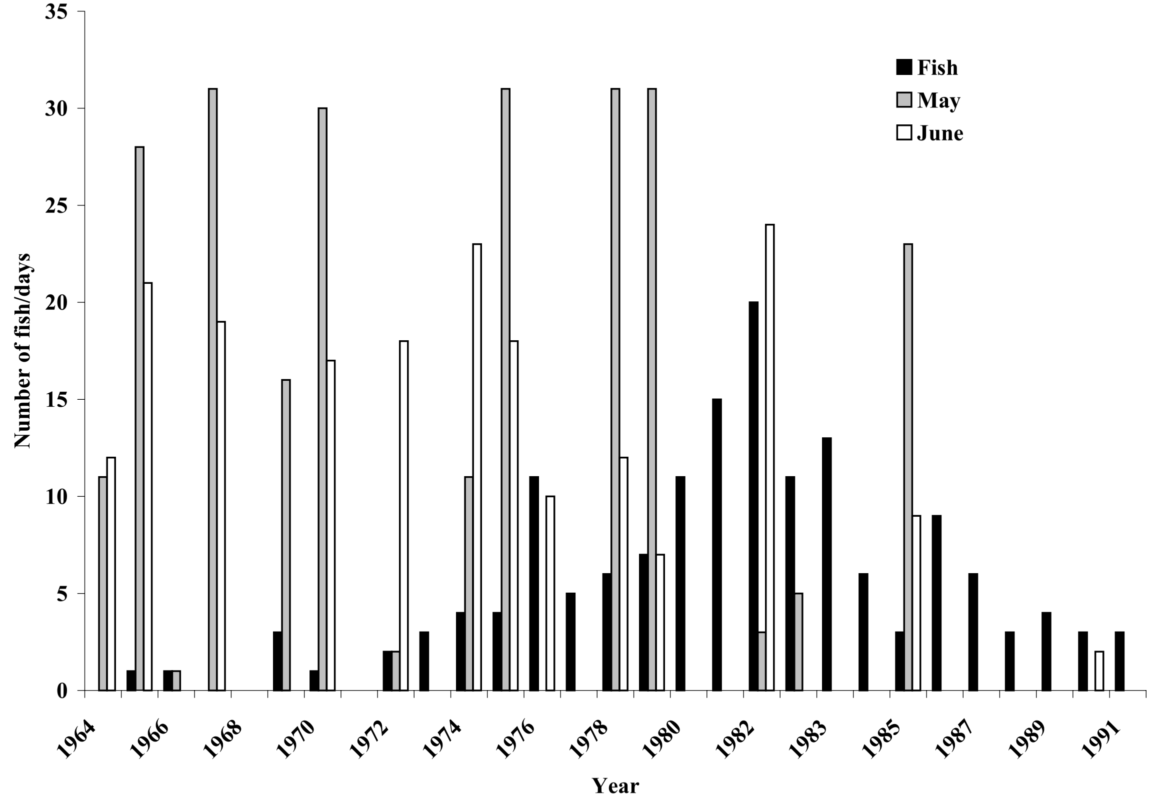

Figure 8. The estimated number of blue sucker by brood year and the number days above the mean discharge rate (27-m^3/s), May and June 1964-1992 for the Milk River from the United States Geological Survey gauging station near Nashua, Montana.

The general pattern of early growth in the first decade followed by slow growth afterward for many years is similar to that observed in paddlefish (*Polyodon spathula*) (Scarnecchia et al. 1996) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) (Everett et al. 2003) in the upper Missouri River system. The older ages of mature females (minimum age 14) to the younger ages of mature males (minimum age 10) also was consistent with paddlefish and shovelnose sturgeon. Females likely matured later than males and might have reached larger sizes than males. This pattern also has been well documented for both the paddlefish and sturgeon (Scarnecchia et al. 1996, Everett et al. 2003).

A second possible cause of the older fish in our study than elsewhere might be the tendency for fish at higher latitudes to grow slower, mature later, and live longer than fish at lower latitudes (Nikolsky 1963). This pattern has been observed in growth and maximum age of channel catfish (*Ictalurus punctatus*) in the Yellowstone River when compared to stocks further south (Starkey and Scarnecchia 1999).

If ages of blue sucker in all of the studies are accurate, individuals of blue sucker in the Milk River are taking longer to reach a given length and weight, and also delaying maturation and living longer than fish in other populations. In the Neosho River, Kansas, reproductively ready mature males (507 mm TL) are as young as age-3 (Moss et al. 1983) and in the Mississippi River, Iowa, reproductively ready males (503 mm TL) are as young as age-4 (Rupprecht and Jahn 1980); whereas, fish at similar lengths in the Milk River were age-10. The blue sucker in the lower Milk River appeared to be slower growing, longer-lived and later maturing than in lower latitudes. Because of the observed slower growth and later maturation, blue sucker in the Milk River might be less resilient; once depleted, they would take longer to recover.

The long life span also might explain why so few young blue sucker have been found in the upper Missouri River over the past three decades (Gardner and Stewart 1987, Fuller 2000, Fuller 2002). Reproduction might be scarce and irregular and the stock might persist because of the long life span and low annual mortality. If reproduction occurs at low levels over several years each decade, strong year class peaks would not be present (Fig. 8). Conversely, if highly successful reproduction and recruitment occurs only rarely each decade, strong year class peaks might exist, but might not be exactly detectable in an analysis of brood years if age determination is not sufficiently accurate.

The timing and size distribution of the blue sucker caught were indicative of a migratory run of adult fish associated with high spring discharge. Several types of evidence support this interpretation. First, in 2002, more than half of the fish were captured on the increasing limb of the hydrograph (Fig. 7). Of the 189 known reproductively active fish caught in 2002, 174 were caught between 20 May 2002 and 18 June 2002, which coincided with the period of high discharge. In contrast, few fish were captured when there was a low, stable hydrograph in 2002 and 2003. Secondly, the size distribution for 248 adult fish caught (531 mm and 806 mm) was consistent with sizes of fish caught in previous sampling conducted on the Milk River (Gardner and Stewart 1987, Fuller 2000, Stash et al. 2001, Fuller 2002). Thirdly, a high fraction of fish was caught in two hoop nets, which indicated that they were traveling together. Evidence of group movements also came from telemetry. In 2003, the Montana Department of Fish Wildlife and Parks tracked the movements of fifteen radio-tagged blue sucker in the Missouri River into the Milk River on and around 7 May 2003 on the rising limb of the hydrograph. All the fish exited on the descending limb of the hydrograph about 15 May 2003, and within a week of exiting the Milk River, 12 of the fish traveled more than 350 km, two traveled more than 414 km, and one traveled 545 km up the Yellowstone River (Dave Fuller, Montana Department of Fish, Wildlife, and Parks, personal communication). The absence of small blue sucker (i.e., 100 to 500 mm TL), the seasonal trends in catches of adults, and the movements of radio-tagged fish suggested that adult blue sucker migrated in groups into the Milk River during the spring. The presence of milt and roe in our study indicated that the migratory fish were ready to spawn.

This pattern of migratory spawning behavior associated with high spring discharge is common in many riverine species. In the James River, South Dakota, spawning blue sucker is found associated with average to above average flow and no individuals are found in a year with below average flow (Morey and Berry 2003). Modde and Irving (1998) found that the spawning migration of the razorback sucker (*Xyrauchen texanus*) in the middle Green River, Utah was influenced similarly by increases in discharge and temperature. This pattern also has been noted for other sucker species including the quillback (*Carpiodes cyprinus*) (Parker and Franzin 1991) and white sucker (*Catostomus commersoni*) (Barton 1980).

Movement of reproductively active adults into the Milk River during the increased hydrograph was followed by evidence of successful spawning. Larval fish were captured on the descending limb of the hydrograph (2002) in mid to late June and the age-0 juvenile fish were captured two months after the peak in the hydrograph (2003). Brown (1989) found 41 yolk-sac larvae three days after a peak in the hydrograph in the Lamine River, Missouri and Moss et al. (1983) found age-0 juvenile fish that were 100 mm long by midsummer in the Neosho River, Kansas.

Despite the indication that more individuals of the blue sucker were present for spawning in 2002, when flows were higher for longer periods, than 2003, when flows were lower, no correlation was found between brood year strengths (as indicated by catches) and either May or June flows. Several reasons might account for the lack of positive relationships. First, catches actually might not represent brood year strength. Secondly, age determination is only approximate and mis-aged fish might make the detection of a relationship difficult. Thirdly, the relationship between brood year strength and flows might not be expressed adequately by the flow index used (i.e., the rank of the number of days with flows above 27 m^3/s). For a more reliable brood year analysis to be calculated, validated brood year strength data should be used, age determination also should be validated, and more information should be obtained on how migration and spawning of blue sucker are influenced by flows. Until then it is not possible to either conclude or dismiss the hypothesis that flows and brood year strengths are correlated.

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