Shenandoah River Fish Population Assessment Following Fish Kills 2004-2007

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Background

Unexplained episodes of fish mortality (fish kills) and fish exhibiting signs of stress have occurred throughout the Shenandoah River over the past four years (2004-2007). These fish kills have been restricted to the larger rivers in the watershed with no substantial problems in the tributaries being documented. The kills occurred in the North Fork Shenandoah in 2004; South Fork 2005; South River, North Fork, Main stem 2006; and North Fork, South Fork, and Main stem in 2007. Similar kills occurred in the Cowpasture and upper James River in spring 2007 (Figure 1).

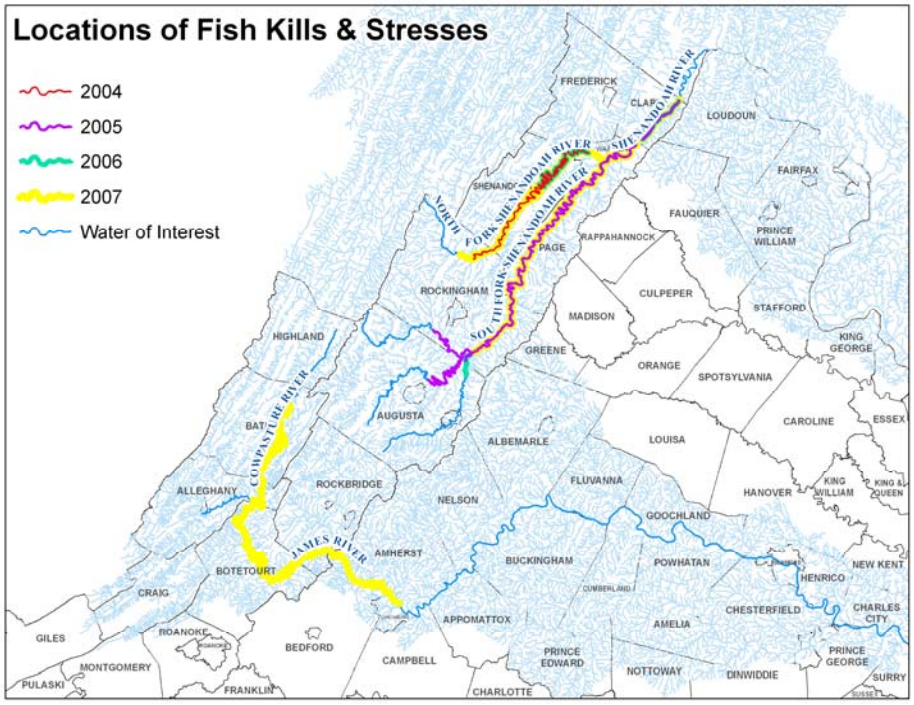

Figure 1. Location of fish kills in Shenandoah River System and upper James River System 2004-2007.

The majority of the kills have taken place in the spring (March-May), but some events have also been documented in the late fall and early winter. The spring episodes have involved primarily adult smallmouth bass and redbreast sunfish. While mortality and morbidity has also been observed with other species in these spring episodes, population effects are thought to be negligible. Kills occurring in the fall and early winter (2006) involved primarily one species, the northern hogsucker. The spatial extent and severity of these fish kill episodes has not been uniform or consistent from year to year.

All but one fish kill episode has occurred shortly after a precipitation event. Water temperature has also sharply increased preceding the spring kill episodes. In the majority of the spring fish kills fish started dying when water temperatures reached and maintained 15 degrees Celsius or 60 degrees Fahrenheit. (Figure 2).

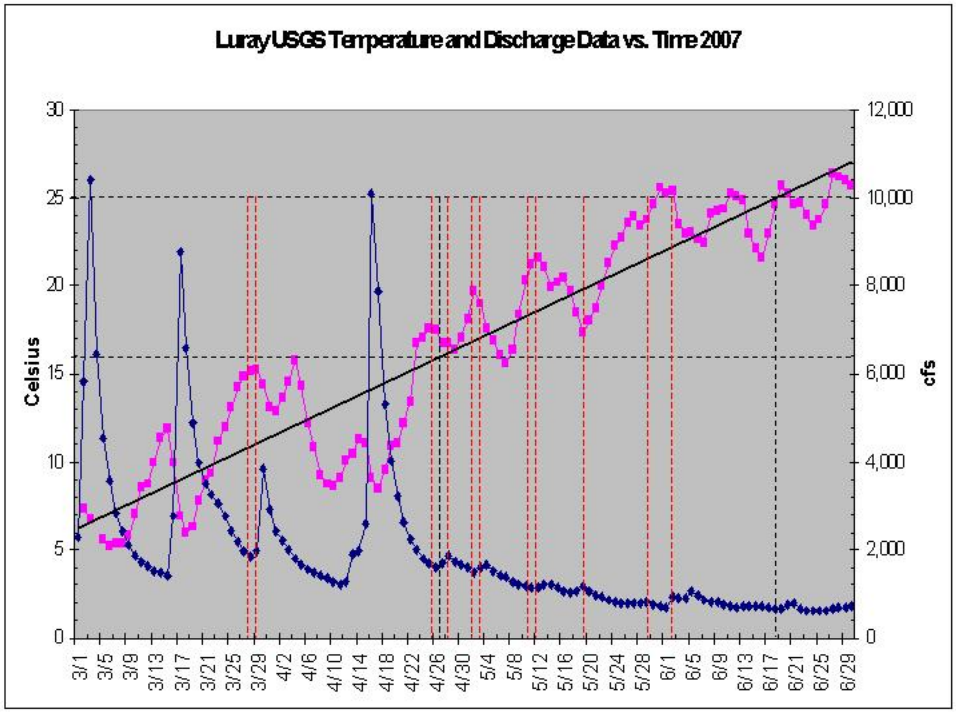

Figure 2. Real-time data from USGS gage at Luray on South Fork Shenandoah River. Flow is in blue; Temperature in pink; Fish kills in red vertical lines.

While the investigation of what caused these fish kills continues, anglers and river enthusiasts are wondering: What is the status of the fish population in the Shenandoah River? This assessment of the current status of the smallmouth bass and redbreast sunfish population is based on interpretation of electrofishing data collected by the Virginia Department of Game and Inland Fisheries (VDGIF) over the last decade. The dataset for additional species is not as comprehensive, and therefore inferences to changes in these populations cannot be made with any confidence. However, reviewing the available data, it appears that other species have not been significantly impacted by the recent fish kills.

South Fork Shenandoah

The most significant fish kill and episode of fish morbidity occurred in the South Fork in spring 2005. At that time biologists estimated that up to 80% of the adult smallmouth bass and redbreast sunfish were lost. That estimate was generated in late summer of 2005 primarily from a depletion population survey conducted by VDGIF at one location in Rockingham County. An identical population survey was completed at that site in 2003 prior to the fish kill. The 2005 kill on the South Fork was also the most noticeable to date by the public as high numbers of dead fish were observed throughout the river.

Small numbers of dead fish and fish with lesions were documented in the lower reaches of the South River from Grottoes to Port Republic in April 2006. The remainder of the South Fork Shenandoah River was free of fish kills in 2006. In April of 2007 fish kills and fish exhibiting signs of stress were observed throughout the entire length of the South Fork Shenandoah River.

The most noticeable change in the smallmouth bass population since the beginning of the fish kills in 2005 has been in the size structure. The population has shifted toward smaller and younger fish. There has been a measurable decrease of smallmouth bass between 9 and 16 inches in the population (Figure 3).

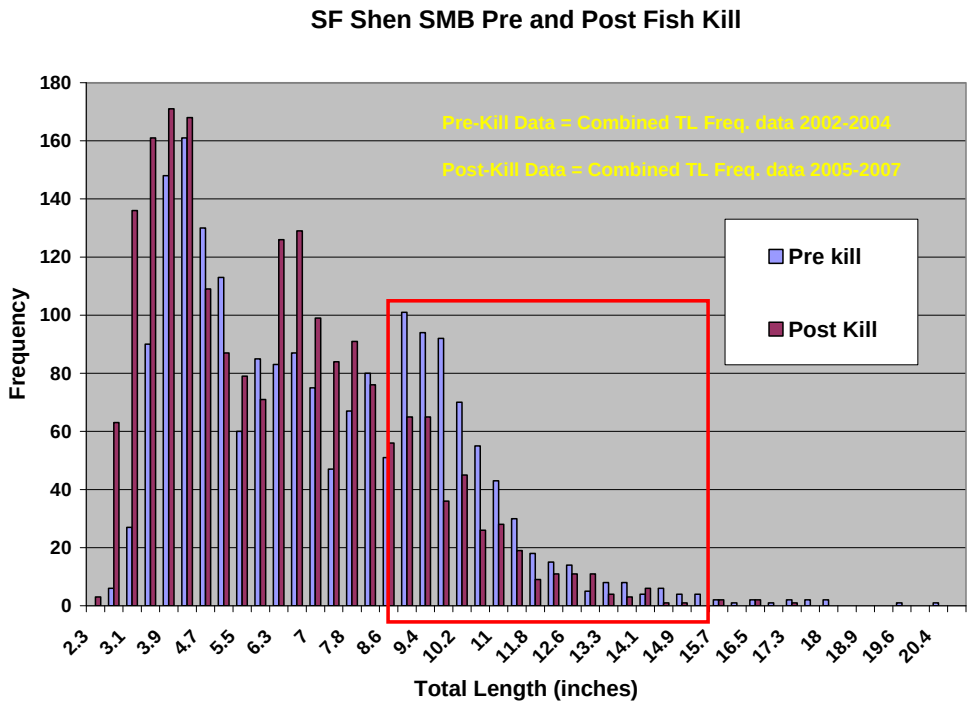

Figure 3. Lumped smallmouth length distribution data from pre and post fish kill time periods. Graph represents all smallmouth bass collected during those years from fall electrofishing.

There has also been a decline in the electrofishing catch rate of smallmouth greater than 14 inches since the start of the kills (Figure 4). However, electrofishing catch rates for all smallmouth bass > 11 inches has remained near the average for the past decade.

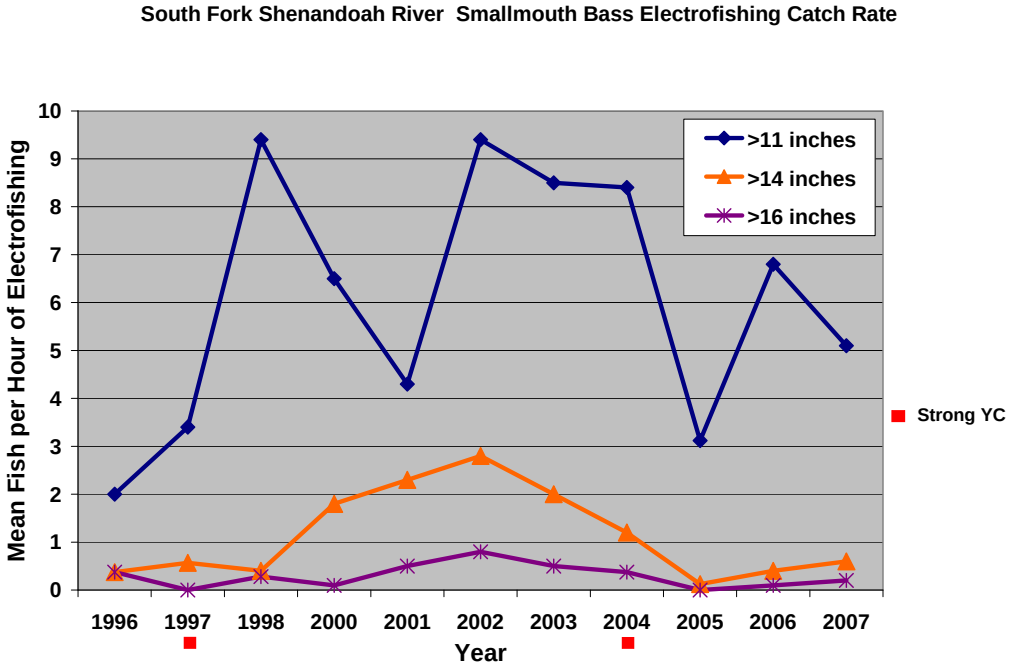

Figure 4. Mean catch rate of smallmouth bass broken-down by size group. SF Shenandoah River.

The most significant factor that has minimized the impact on overall numbers of smallmouth bass from the recent kill episodes has been spawning success. Smallmouth bass spawning success the past four years (2004-2007) has been above average, with 2004 being the best spawning year in the past decade (Figure 5).

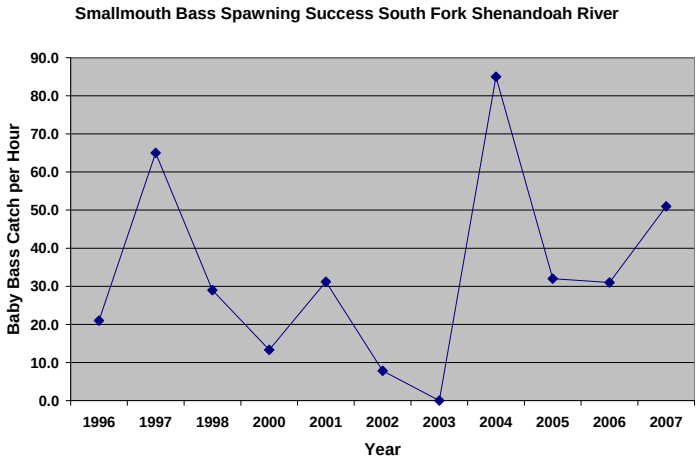

Figure 5. Smallmouth bass spawning success in the South Fork Shenandoah River.

Growth rate of juvenile smallmouth bass increased dramatically in 2006-2007 as compared to previous data collected up to a decade ago. Age 1 and 2 smallmouth bass in the South Fork are growing almost twice as fast as before the kills began (Figure 6). This same phenomenon was observed in the North Fork and Main stem Shenandoah. Biologists have not aged adequate numbers of bass older than age 2 in the past three years; therefore changes in growth rates of adult bass have not been thoroughly evaluated. The cause for the increased growth rate of juvenile bass since the beginning of the fish kills is not well understood.

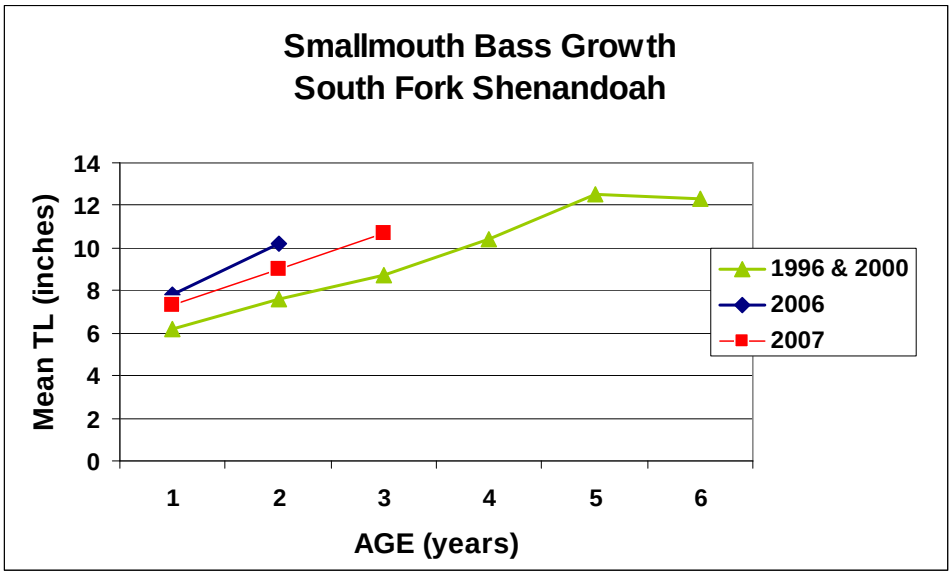

Figure 6. Smallmouth bass growth rates pre and post fish kill years in the South Fork Shenandoah.

The annual mortality estimate for smallmouth bass was calculated for the fish kill period and compared to estimates from pre-kill years. Annual mortality only increased by 10-15% since the start of the kills. This is a relatively small change and probably represents what impact harvest would have on the overall smallmouth bass population. An angler creel survey conducted in 1997 indicated that 98% of all smallmouth bass caught were released. While the smallmouth bass fishery is currently a “catch and release” fishery based on the 1997 creel survey data, creel survey data from the 1980’s indicated that catch and release rates for smallmouth bass ranged from 57-85%. Catch and release rates were even lower in the 1970’s. The loss of smallmouth due to the fish kills may only represent what would have been removed historically by anglers if anglers were harvesting smallmouth bass.

The redbreast sunfish population has exhibited similar trends to the smallmouth bass in recent years. Detecting changes in abundance and/or size distributions due to the fish kills has been difficult. There is high variability in single-boat electrofishing catch rates for sunfish from year to year, and overall numbers remain near the long-term average (Figure 7). Unfortunately biologists do not have sufficient length data for sunfish to

evaluate any changes in size structure due to the fish kills. Sunfish length data was recorded during the same recent electrofishing sampling and the average length of redbreast sunfish only decreased by 1 inch after the fish kills at both sites.

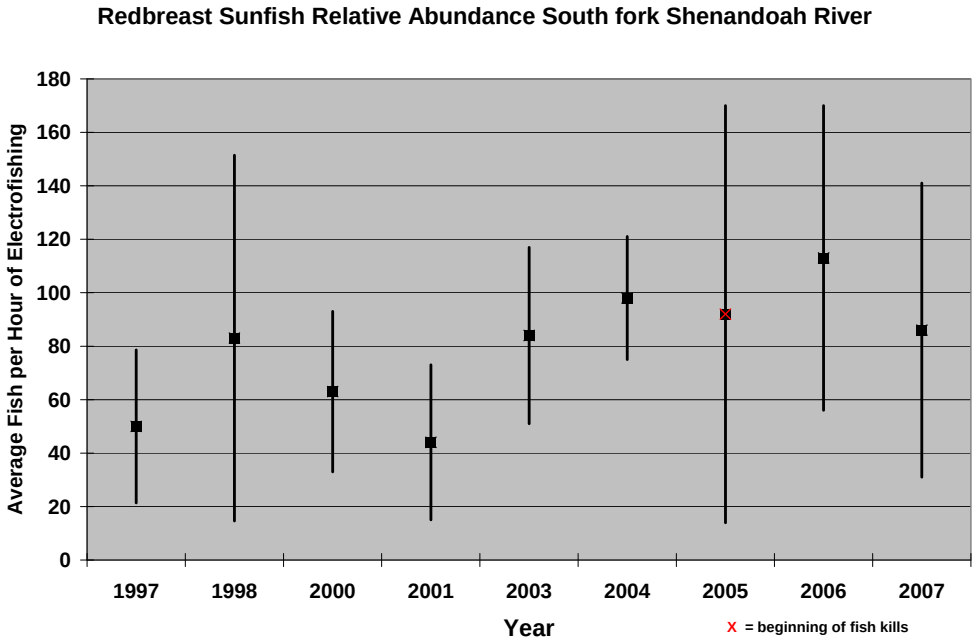

Figure 7. Redbreast sunfish relative abundance South Fork Shenandoah River. Vertical bars represent 90% confidence intervals.

North Fork Shenandoah

The first major fish kill episode in the Shenandoah River Basin occurred in the North Fork in spring 2004. Fish kills and episodes of fish morbidity continued over the next three years. Unfortunately, VDGIF does not have as extensive information on the fish population of the North Fork as it does for the South Fork Shenandoah. Difficulty in locating suitable access and consistent low flow patterns over the past decade are two of the main reasons for this. Extreme low flow conditions in fall 2007 inhibited biologists from collecting any electrofishing data from the North Fork.

However, similar changes in the smallmouth bass population to those seen in the South Fork were observed. Relative abundance of adult smallmouth bass was above average in the fall of 2006 (Figure 8). Prior to the kills, 2003 was a "banner" year for electrofishing catch rate for adult smallmouth. This was probably due to the increased flows in the river at the time of sampling. Biologists were granted access to areas of the North Fork that they could not normally sample under normal flow conditions.

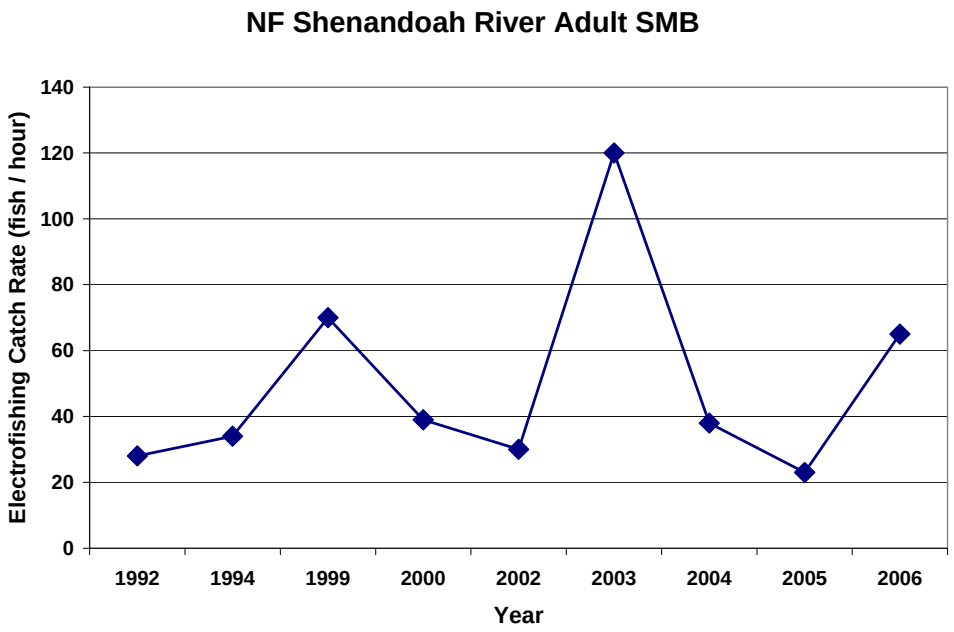

Figure 8. Adult smallmouth bass relative abundance for North Fork Shenandoah River.

As is the case in the South Fork, spawning success is what controls the densities of adult smallmouth available to anglers (Figure 9). 1999 through 2003 were terrible years for smallmouth recruitment due to drought (1999-2002) and high water (2003). Excellent spawning success from 2004-2006 has increased the proportion of smallmouth bass >11 in the population (Figure 10). Biologists also "pooled" data from pre and post fish kill years to see if there has been a measurable change in the size structure of the smallmouth bass population. While there were no "statistical" changes documented, there is a noticeable loss of bass > 15 inches in the post kill years (Figure 11).

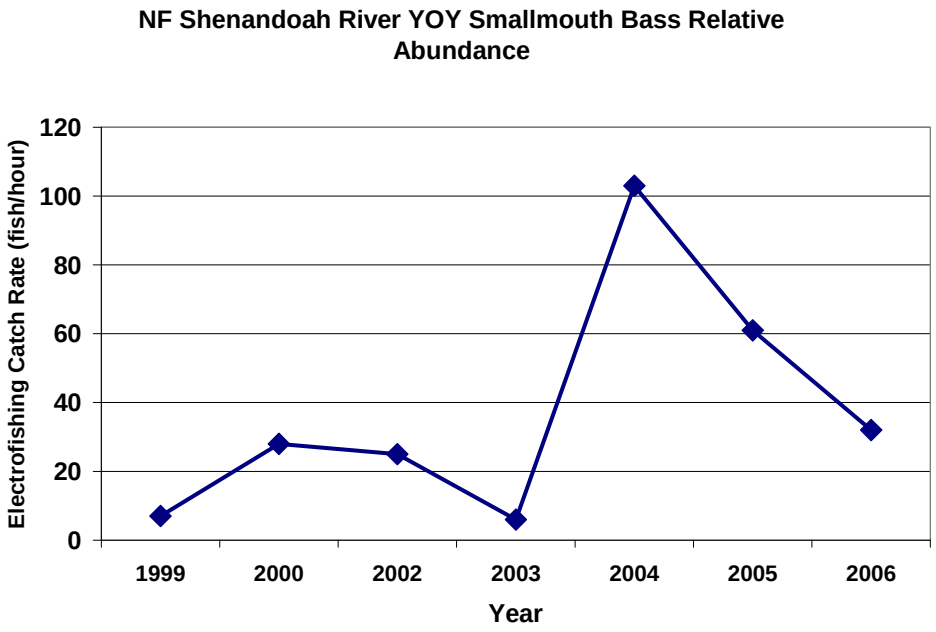

Figure 9. Smallmouth bass spawning success, North Fork Shenandoah River.

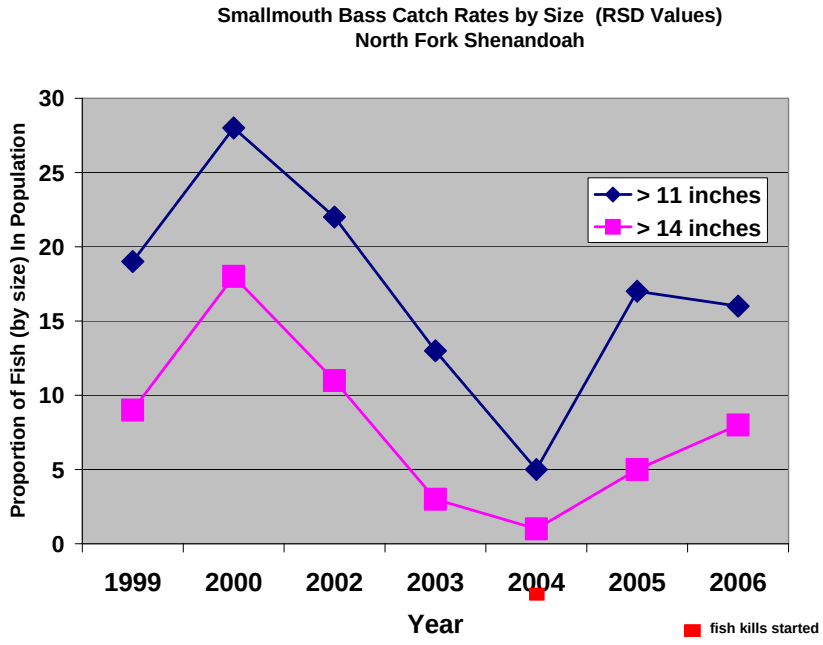

Figure 10. Smallmouth bass relative abundance, broken-down by size classes, North Fork Shenandoah River

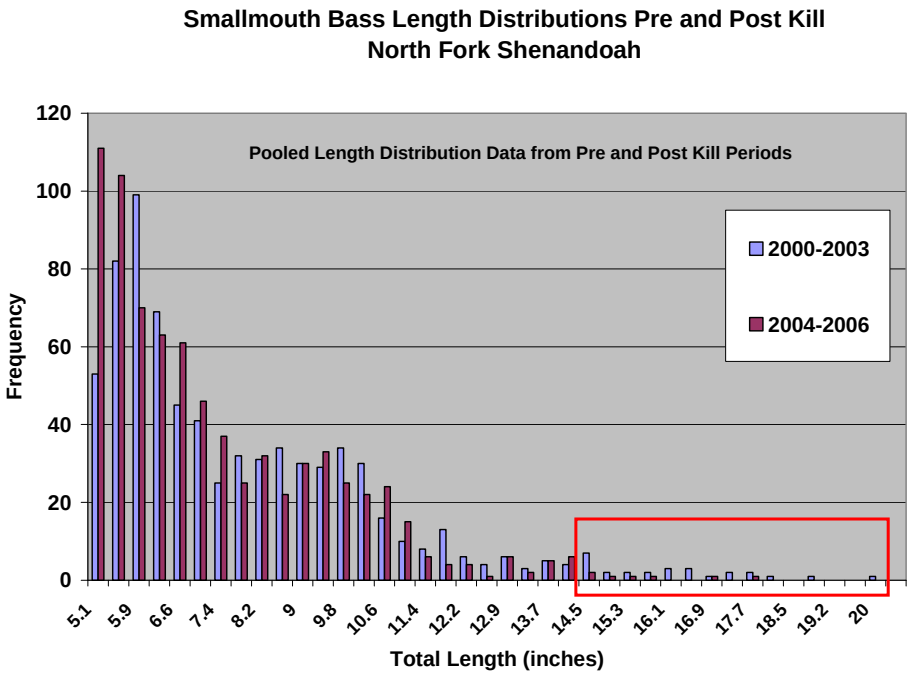

Figure 11. Pooled length data for smallmouth bass collected pre and post fish kill.

Just as was observed in the South Fork, an increase of 10-15% in annual mortality has resulted in no real changes in the total population except a slight reduction in the number of older/larger smallmouth. Juvenile smallmouth bass growth rate has increased since the kills began in 2004. While this increase is not as dramatic as observed in the South Fork or Main stem Shenandoah, it is helping fish recruit into the fishery at an earlier age.

The redbreast sunfish population exhibits a pattern of decline that started several years before the start of the fish kills in 2004. This decline can also be seen when looking at electrofishing catch rates broken out by location (Figure 12). Drought and high-water conditions leading up to the beginning of the kills in 2004 may explain this downward trend. However, without additional data from the 1990's, biologist can only speculate as to the mechanisms that manipulate the redbreast sunfish population in the North Fork. While densities of redbreast sunfish have continued to be suppressed from pre-kill levels, the population is maintaining itself. While it is speculated that the average size of redbreast sunfish has decreased in the North Fork, there is not enough historic fish length data to test that hypothesis.

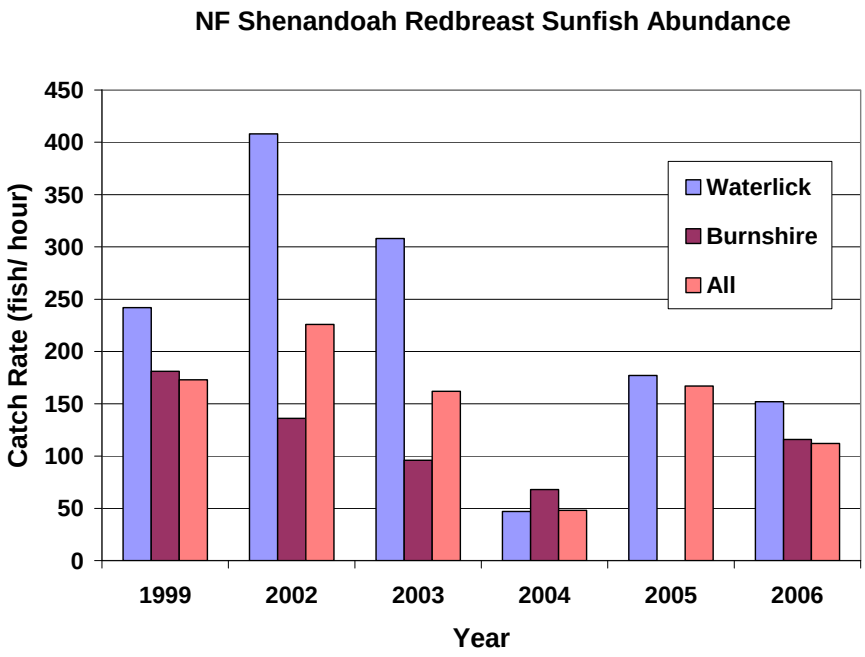

Figure 12. Redbreast sunfish relative abundance on the North Fork Shenandoah River.

Main stem Shenandoah

There is a high degree of natural variability in electrofishing catch rates of adult smallmouth bass in the Main stem Shenandoah River. There is probably more variability in this data due to the lower number of sites sampled and inconsistency in number of sites sampled from year to year. For some years only one or two sites were sampled and these data were omitted from the analysis to reduce bias. Similar to the South Fork and North Fork, low water levels and aquatic vegetation greatly influence the capture success of smallmouth bass in the Main stem. Electrofishing catch rate of adult smallmouth bass is influenced by spawning success, and spawning success is highly variable (Figure 13).

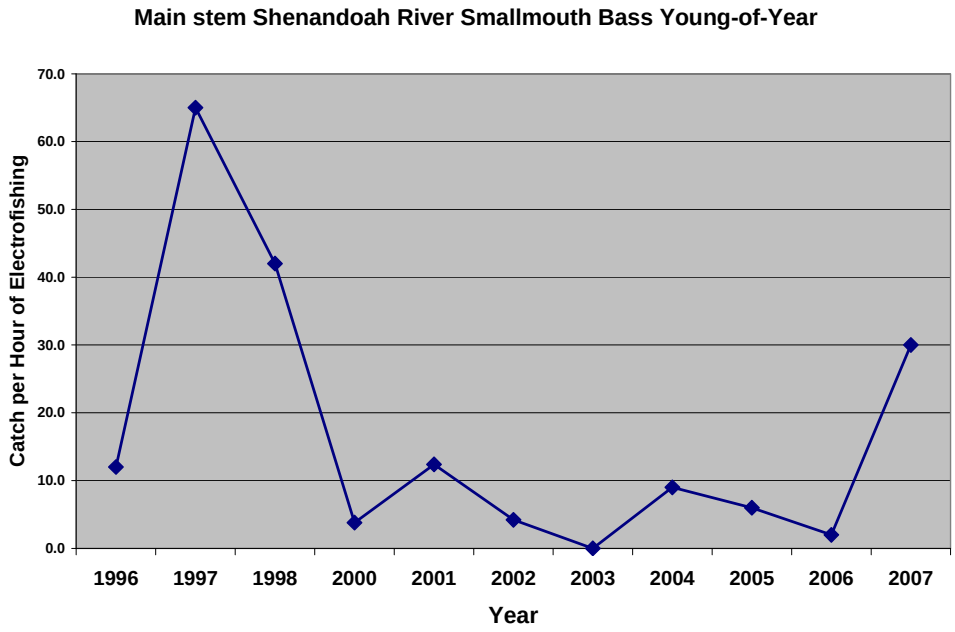

Figure 13. Smallmouth bass spawning success Main stem Shenandoah River.

Catch rate increased steadily for several years following a very successful spawning year (Figure 14). The decrease in catch rate from 2002 through 2004 can be attributed to the poor spawning years due to drought and high water. Catch rates went even lower in 2005 due to the fish kill that year. However, the excellent spawn in 2004 has helped increase the numbers of adult fish the past two years even with more fish kills occurring in 2007.

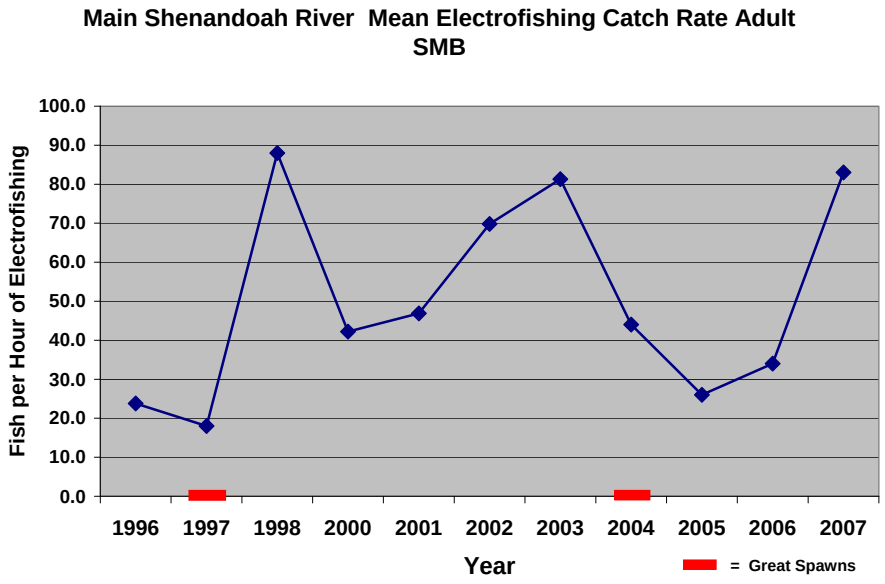

Figure 14. Relative abundance of adult smallmouth bass in the Main stem Shenandoah River.

Both catch rate of adult bass and the proportion of fish > 11 inches in the population were similar when comparing 2003 (pre-kill) and 2007 (post-kill) data. While there has not been a significant change in the length distribution of the bass population since the start of the fish kills, there has been a decrease in the numbers of 8-15 inch fish and most fish over 18 inches have all but disappeared (Figure 15).

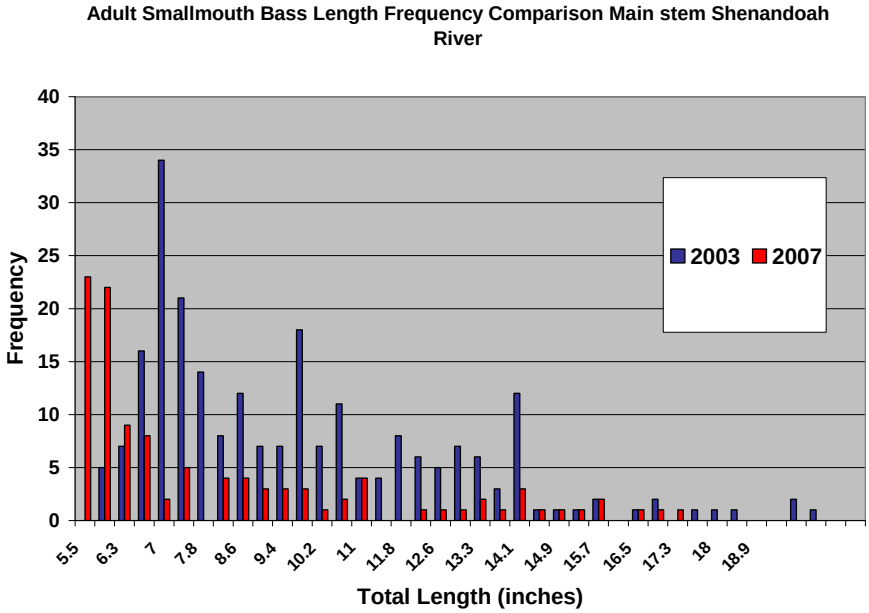

Figure 15. Comparison of size and number of smallmouth bass pre and post fish kill.

The growth rate of 0-2 year-old smallmouth bass has doubled since the first fish kills in 2005. Fish are reaching 12 inches in length in about ½ the time as before the inception of the fish kills. There are many biotic and abiotic factors that influence fish growth. Biologists cannot fully explain this phenomenon.

Redbreast sunfish numbers in the Main stem Shenandoah River are quite variable from year to year. Redbreast numbers started to decline in 2003 before the first fish kills in 2003. Part of this could be due to drought conditions that lasted between 1999 and 2002. Adding to this decline could have also been the higher than average river levels in 2003. Both drought and high water can negatively affect spawning success of sunfish. The effects of these "unfavorable" spawning conditions would have lasted through 2006. The fish kill in 2005 would have added to this decline in sunfish numbers. However, river conditions that were favorable for smallmouth bass spawning from 2004 through 2007 also helped redbreast sunfish rebuild their population. While some sunfish morbidity and

mortality was reported in the Main stem Shenandoah in 2007, the loss of sunfish in 2007 cannot be detected at the population level (Figure 16).

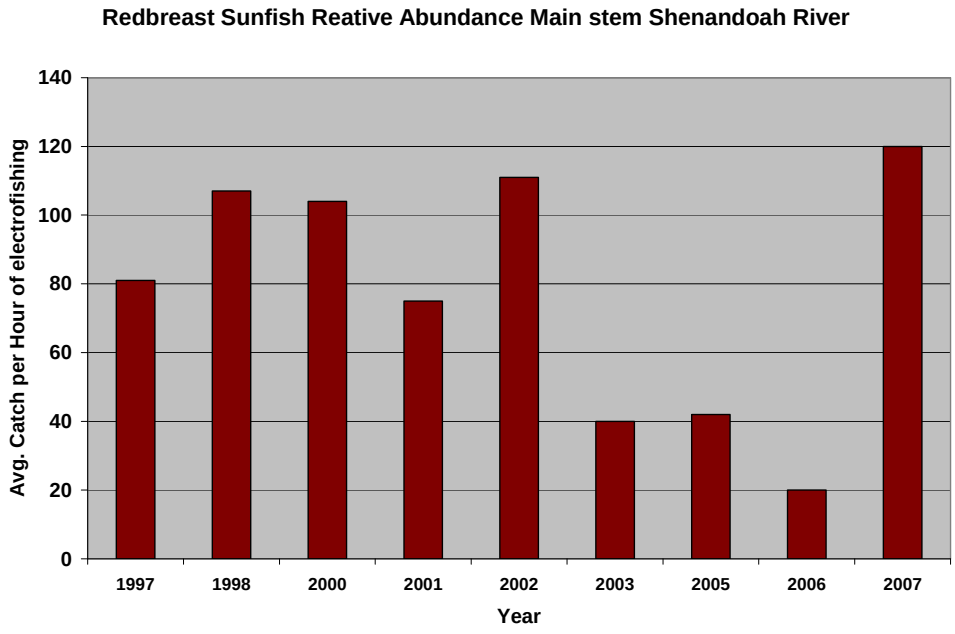

Figure 16. Redbreast sunfish relative abundance Main stem Shenandoah River.

As was mentioned earlier in this report, significant numbers of adult northern hogsuckers died in three different fish kills in 2006. These fish kills involving just this species occurred in late May, late November and early December. All three kill episodes erupted a few days following a rain event in which the river received runoff. Biologists are unsure if the hogsucker kills are related to the other kills that have affected mostly bass and sunfish. The cause of these sucker kills is still remains a mystery. Biologists have not documented any impacts at the population level for northern hogsuckers in the Main stem Shenandoah River.

Conclusions

- Fish kills in the Shenandoah River system have not been uniform in spatial extent (location) or severity from year to year. For this reason impacts to the fish population vary by location.
- Mortality has been observed primarily in older smallmouth bass and redbreast sunfish.
- There has been some indication of stress in other fish species, but mortalities in other species have been light.
- The most noticeable impact to the fish population has been the loss of larger/older smallmouth bass and redbreast sunfish.
- Across the entire river, overall numbers of smallmouth bass and redbreast sunfish have not changed significantly since before the fish kills. This is primarily due to excellent spawning success of these two species over the past four years.
- The annual mortality rate for smallmouth bass increased by 10-15% since the start of the fish kills. This is most noticeable as reduced numbers of larger bass.
- Growth rates of juvenile smallmouth bass have increased since the start of the fish kills.
- Continued monitoring of the fish population will be needed to determine the long-term effects of these fish kills on the Shenandoah River fishery.