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Natural Resource Stewardship and Science

Fish Community Monitoring at Pipestone National Monument

2001 – 2014 Trend Report

Natural Resource Report NPS/HTLN/NRR—2015/1066

ON THE COVER

Dr. Katie Bertrand from South Dakota State University (SDSU) teaching a student how to identify a fish (upper left), two SDSU students learning how to measure fish (upper right), Hope Dodd (HTLN) teaching students how to seine (lower left), and Tyler Cribbs (HTLN) teaching students how to measure flow rates (lower right).

Photograph courtesy of Scott T. Sabo, SDSU

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This report received informal peer review. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

Pipestone National Monument (PIPE), located in southwestern Minnesota, was established to protect and interpret the cultural resources surrounding the pipestone quarries and to provide American Indian tribes access to these quarries. A goal at PIPE is to maintain and restore the historic prairie ecosystem that surrounds these pipestone quarries, and an important component of tallgrass prairie systems is water quality/quantity and biotic integrity of prairie streams. Changes in land use have resulted in habitat loss and degradation, and poor water quality in many prairie streams. This has partially led to the decline of many native prairie fishes within their ranges, including the federally endangered Topeka Shiner (*Notropis topeka)*. Although human disturbances within a watershed can alter a lotic system, PIPE may offer important habitat for conserving native and endangered species.

In 2001, an annual fish monitoring program was initiated at PIPE to determine the status and long-term trends in fish community composition, and to correlate this community data to water quality and habitat conditions. Fish community data were collected at two reaches from 2001 to 2010 by Heartland I&M Network (HTLN) and 2013-2014 by HTLN and South Dakota State University (SDSU). One reach was sampled above the Winnewissa Falls, a 2.5 m waterfall, and a downstream reach was sampled near the western border of the park. In 2011 and 2012, Topeka Shiner status was assessed only at the downstream reach where this species has historically been found. Physical habitat and water quality were collected in conjunction with fish community sampling.

The fish community in Pipestone Creek differed between the upstream reach on the east side of the park and the downstream reach near the west boundary. The fish community above the falls consisted primarily of species tolerant to poor stream conditions with no Topeka Shiners collected at this reach during the 12 years sampled. Richness, diversity, stream integrity and abundance were generally low, potentially due to daily fluctuations in dissolved oxygen (DO). Levels of DO fell below 5 mg/L at night, a lethal level for many fish species (USEPA 1988). In comparison, the downstream reach had higher richness and diversity and showed fair to good stream integrity. Typical of prairie streams, the downstream reach consisted primarily of species moderately tolerant to poor water quality (Pflieger 1997, Bramblett *et al*. 2005, Fischer and Paukert 2008). The Lower reach contained 87% of the Topeka Shiner abundance within sites sampled at PIPE from 2001-2014. The remaining 13% of Topeka Shiners were collected at reaches located between the Lower and Above Falls reach that were no longer sampled after 2006. The presence of Topeka Shiners downstream of the falls indicates a higher quality fish community than that found above the falls.

Fish community monitoring indicates the downstream reach of Pipestone Creek is more favorable for prairie fishes, including the Topeka Shiner. Although a small portion (~1 km) of Pipestone Creek flows through the park, PIPE may serve as a refuge for the endangered species. Continuation of the fish community monitoring program coordinated and directed by HTLN and implemented with assistance of SDSU will not only allow for professional development of SDSU students, but will provide an opportunity to research fish community interactions, environmental factors affecting these interactions, and Topeka Shiner population dynamics and movement, with implications for land use management throughout the Pipestone Creek watershed.

Acknowledgments

We would like to thank Dr. Katie Bertrand from SDSU for organizing this educational opportunity for students to work with HTLN and PIPE staff. Thanks to Seth Hendriks and Glen Livermont, for their assistance in establishing a data collection partnership between PIPE, HTLN, and SDSU. We also thank the many park staff, interns, and volunteers who assisted with data collection throughout this long-term monitoring program. We would also like to acknowledge the assistance of Lloyd Morrison with data analysis and Sarah Hinman for assisting with formatting of the report.

Introduction

Pipestone National Monument (PIPE), located in southwestern Minnesota, is approximately 1.2 km^2 in size, of which 80% is native or restored tallgrass prairie. A goal at PIPE is to maintain and restore the historic prairie ecosystem surrounding the pipestone quarries. An integral part of tallgrass systems is water quality/quantity and biotic integrity of prairie streams. A severe threat to prairie systems has been the conversion of large portions of grasslands to cropland or livestock pasture (Knopf and Samson 1997) during the last century. These disturbances have increased sedimentation, nutrient loading, and other chemical pollution, potentially altering the water quality and habitat of prairie streams. In addition, other anthropogenic factors, such as dams, have also caused direct habitat loss and fragmentation (Mammoliti 2002). Many native fish populations have been adversely impacted throughout their ranges by factors associated with land use changes. As a result of habitat changes and a decline of water quality conditions in Midwestern streams, the Topeka Shiner (*Notropis topeka*), a native prairie stream fish found at PIPE, was listed as federally endangered in 1998 under the Endangered Species Act of 1973 (63 FR 69008). At the time of listing, the Topeka Shiner inhabited less than 10% of its historic range (Tabor 1998). In addition to this federally protected species, several other Midwestern stream fishes are imperiled, making it necessary to protect prairie streams on publicly owned lands in order to offer refuge for native species.

Native fish communities are an important component of prairie stream systems. Changes or shifts in stream habitat complexity and water quality often determine biotic communities, including fish (Lazorchak *et al*. 1998). Therefore, monitoring trends in fish community composition and associated habitat conditions serves as a surrogate for measuring water quality and overall stream integrity. Many fish species are considered intolerant of habitat alterations and monitoring their assemblages can serve as a useful tool for assessing changes in water and habitat quality (Karr 1981; Robison and Buchanan 1988; Pflieger 1997; Barbour *et al*. 1999; Peitz 2005). Accordingly, trends in the composition and abundance of fish populations have been historically used to assess changes in the biological integrity of streams (Karr 1981; Barbour *et al*. 1999; Moulton *et al.* 2002). Moreover, the intrinsic value of fish to the public as environmental indicators and for recreational opportunities makes the status of fish diversity a valuable interpretive topic for park visitors, as well as a tool for preserving/conserving aquatic resources and supporting management decisions at PIPE.

Objectives

The specific objectives for fish community monitoring at PIPE are: (1) to determine the status of and long term trends in fish richness, diversity, abundance, and community composition and, (2) to correlate the long-term community data to overall water quality and habitat conditions.

Methods

Details on methods of site selection, fish sampling, and habitat and water quality data collection not listed in this report can be found in the Protocol for Monitoring Fish Communities in Small Streams in the Heartland Inventory and Monitoring Network (Dodd *et al.* 2008).

Study Area and Reach Selection

Approximately 1 km of Pipestone Creek flows through PIPE. The stream was stratified into four sections based on natural breaks in the stream (such as large pools or a waterfall). During 2001-2010 and 2013-2014, two reaches were sampled for fish community assessment at Pipestone Creek: a reach above the Winnewissa Falls (Above Falls) where the creek flows into the park and one on the western border of the park (Lower) where the creek flows out of PIPE (Figure 1). A sample reach is a section of stream encompassing all channel units (riffles, runs, pools, glides) within the stream, resulting in a representative fish sample. Reach length was based on the ability to find areas of the stream with adequate water to collect fish from five sample sites (channel units) within the reach or the ability to find areas where seining would be effective (large, deep pools were excluded). In 2011 and 2012, Topeka Shiner status was assessed at the Lower reach only.

Fish Collection

Fish communities were sampled in August/September from 2001-2010, and 2013-2014. Fish were collected using a common sense seine (also referred to as a minnow seine) of 1.8 m depth and a mesh size of 6.44 mm. In each year fish were collected from three to five sites (channel units) within the reach. In pool or run channel units, a two-person crew dragged the seine across the bottom, trapping fish against a bank or shallow water area until the seine could be raised out of the water. Block seines were deployed if flow between pools was present, in an attempt to isolate fish in the selected pool. In riffle channel units, kick seining was used with one or two people disturbing the substrate in a downstream direction, dislodging fish into the seine. In 2011 and 2012, only Topeka Shiners were targeted for collection at the Lower reach. Additionally, backpack electrofishing (pulsed DC) was employed at two pools within the Lower reach in 2011, specifically for collection of Topeka Shiners. Once collected, fish were retained in the net in water or in an aerated bucket of water until they could be examined. All fish were identified to species, if possible, and counted. From 2001-2005, all Topeka Shiners were measured, weighed, sexed, and aged (juvenile vs. adult). Beginning in 2006, a subsample of 30 individuals per species (including Topeka Shiners) at each reach were measured and weighed, and any diseases or anomalies were recorded. Fish difficult to identify in the field were preserved for laboratory identification. All other fish (including all Topeka Shiners) were released back into the sample reach.

Habitat and Water Quality

Physical habitat and water quality were collected in conjunction with fish sampling during 2001-2010 and 2013. In-stream habitat (width, depth, length, substrate, etc.), streambank erosion, and riparian vegetation were collected at each site within the reach (see Dodd *et al*. 2008 for a list of all habitat parameters collected). Prior to fish collection, discrete water quality measurements (temperature, dissolved oxygen, pH, and conductivity) were collected at each site within the reach during 2001-2006 using hand-held meters. In 2007-2010 and 2013, continuous sampling replaced discrete water quality sampling. Data loggers were deployed at reaches to obtain hourly temperature, dissolved oxygen, pH, specific conductance, and turbidity data for a minimum of 24 hours. Only physical habitat data related to site size (width, depth, length) and water temperature were collected in 2014.

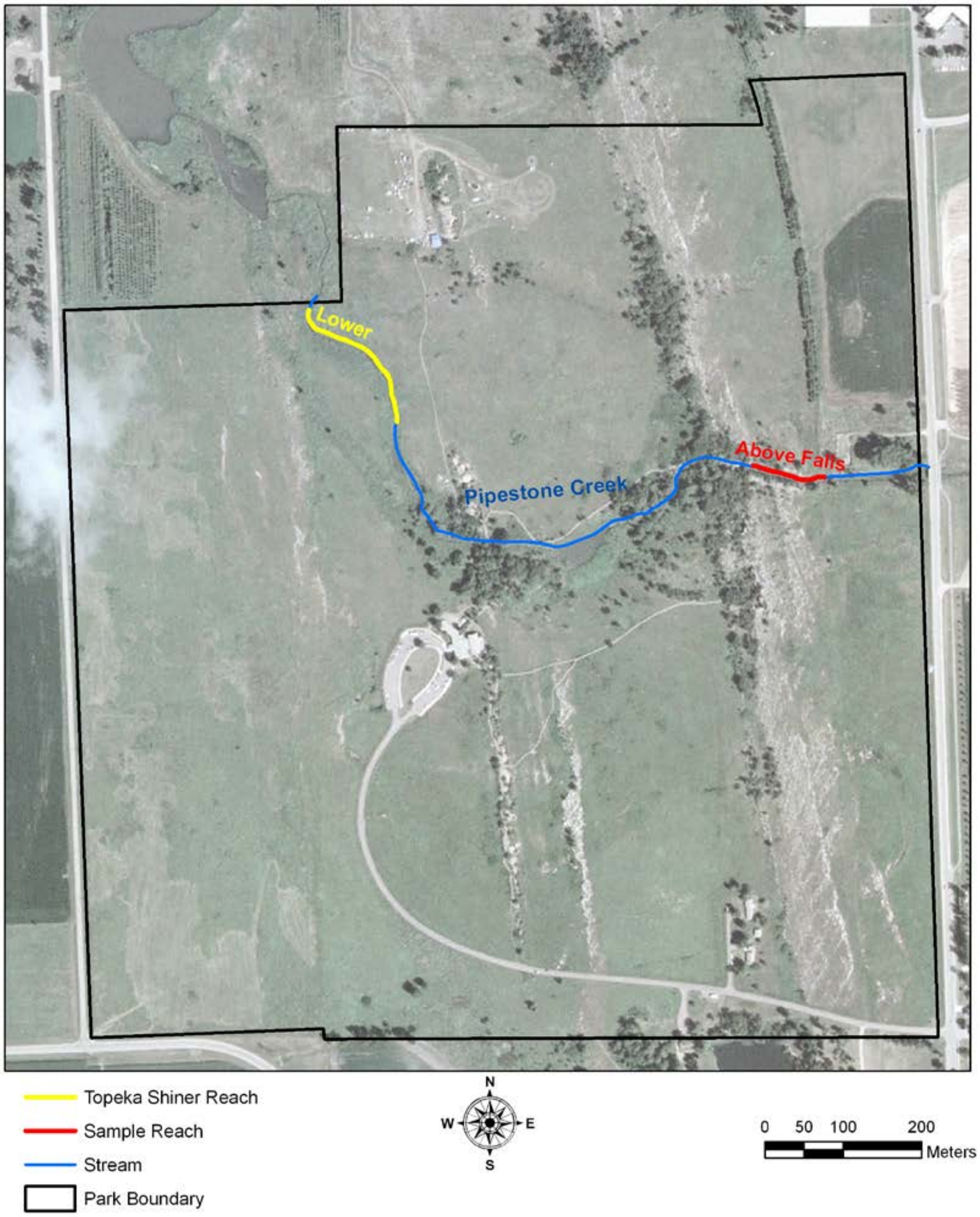

Figure 1. Location of the two reaches sampled in 2001-2010 and 2013-2014 for fish community assessment. The Lower reach (yellow) was sampled in 2011 and 2012 to assess status of Topeka Shiner.

Data Analysis

Fish Metrics

Six biological metrics were calculated for both reaches (Above Falls and Lower reach) sampled during 2001-2010 and 2013-2014. These metrics reflect fish community diversity (species richness, community diversity and evenness), abundance (catch and catch per area), and overall stream integrity (Index of Biotic Integrity). Community diversity was assessed using Simpson's Diversity Index (see Dodd *et al*. 2008), which indicates the probability that two individuals picked at random from the reach are the same species. This index has an inverse relationship with diversity; the index decreases as diversity increases. Because it is more intuitive that an increasing index score correspond to increasing diversity, the inverse of the Simpson's Index (1-SI) was used in analyses. Therefore, a diversity value (1-SI) of 1 corresponds to a completely diverse community while a value of 0 indicates no diversity. Pielou's evenness index was used to assess community evenness within and among years (see Attrill 2002 for equation). In this report, catch refers to the total number of fish caught, and catch per area (CPA) is this catch divided by the surface area of the reach that was sampled (mean width * total length of stream sampled in reach).

The index of biotic integrity (IBI) developed by Karr (1981) and used regionally in Midwest steams by Fausch *et al.* (1984) was calculated to assess stream integrity and health. The IBI includes 12 metrics: 1) total number of fish species; 2) number and identity of darter species; 3) number and identity of sunfish species; 4) number and identity of sucker species; 5) number and identity of species intolerant to poor water quality and habitat conditions; 6) proportion of individuals as green sunfish; 7) proportion of individuals as omnivores; 8) proportion of individuals as insectivorous cyprinids; 9) proportion of individuals as top carnivores; 10) number of individuals in sample; 11) proportion of individuals as hybrids; 12) proportion with an anomaly (disease, eroded fins, lesions, or tumors). Each of the 12 raw metric values was scored as 1 (worst), 3, or 5 (best). The metric scores were added to calculate an IBI score that ranges from 12 to 60. Based on this IBI score, the overall integrity of the stream is classified from very poor to excellent: very poor = 0-20; poor = 21-30; fair = 31-40; good = 41-50; excellent (reference condition) = 51-60. More detailed methods on calculating biological metrics used in this report can be found in Karr (1981), Fausch *et al*. (1984), and Dodd *et al.* (2008).

Because the Above Falls reach is different in water quality (dissolved oxygen) and in-stream habitat composition (substrate type and site dimensions; see Table 5 in Peitz 2005) than the Lower reach, reaches were analyzed separately. Regression analyses were used to evaluate trends in fish metrics across time using $\alpha = 0.05$ as the level of significance. Any metrics that demonstrated a significant temporal trend would be used in analyses with habitat and water quality parameters to determine if changes in abiotic factors account for the trends in fish communities. Prior to regression analysis, a natural logarithm transformation was used to correct for non-normality of catch and CPA data. In addition, a Durbin-Watson test for serial autocorrelation was performed on all fish metrics using $\alpha =$ 0.05 as the level of significance. Two metrics, evenness at the Lower reach and Topeka Shiner abundance, were found to be inconclusive for autocorrelation. All other fish metrics were not significantly autocorrelated. Therefore, we conducted linear regression analysis without data transformation.

Control charts were used in addition to regression analyses to indicate deviation of the community from baseline conditions. This is accomplished by plotting measurements through time with reference to a baseline that represents the averages of empirical measurements and serves as a reference point for establishment of control limits. Control limits specify thresholds beyond which variability in the measurement of interest indicates a process is going out of control (Morrison 2008). Univariate control charts were used to assess richness, diversity, and evenness with control limits based on the average and standard deviation of the first ten years of baseline data. To determine the appropriate baseline, sample variance for N = 3, N = 4, N=5, etc. years of data up to the entire 12 year data set was plotted and graphically analyzed. At ten years of data, the sample variance showed an asymptote or decline for each of the fish metrics; therefore, the first ten years of data were selected as the baseline.

Using catch and catch per area of all species in the community, trends in overall fish assemblages were evaluated by multivariate control charts with both reaches analyzed separately. Multivariate control charts are a distance-based ordination that considers the relative abundance relationships of all species in a community and computes the distance of the community at any point in time from a centroid. This distance is then plotted over time, and a bootstrapping technique is used to generate percentiles that serve as control limits (Anderson and Thompson 2004). We used the program *control chart.exe* to construct the multivariate control charts (Anderson 2008), inputting catch or catch per area for each species in each year at a reach. We used the first three years for calculating the centroid and evaluated the divergence from this period in future years. CY dissimilarity, which modifies zero values by adding a constant before logarithmic transformations, was used as the distance measure. The first ten years were used in the bootstrap procedure, with the 95th percentile of the distribution of deviations across sites used as a control limit.

Habitat Metrics

Physical habitat measures related to site size (width, depth, length, and area) and flow (velocity) were summarized using means for each reach. In 2007, continuous water quality sampling replaced discrete measurements, and a combination of discrete and continuous data are reported. For data collected from 2001-2006, averages (across sites in a reach) of discrete water quality measurements were calculated. For 2007- 2010 and 2013, continuous measurements were collected, and means of those measurements taken during fish sampling (i.e., the 2-3 hour time period fish were collected in that reach) as well as means of all data collected during the 24 – 48 time period are reported. Not all water quality parameters were collected every year at both reaches. Therefore, sample sizes vary depending on the reach and water quality variable sampled. Only water temperature measurements were collected in 2014.

Results

Fish Community

A total of 22 species (excluding specimens that could not be identified to species) were collected at the two sample reaches during 2001-2010 and 2013-2014 (Appendix A). Richness, diversity, and evenness at both reaches revealed considerable variability over time (Figures 2, 3, 4). Richness at the

Above Falls reach was typically less than the Lower reach (with the exception of 2002) and ranged from 2 to 7 species, while the Lower reach ranged from 7 to 14 species. Richness fell below the control limit at the Above Falls reach in 2004 when only 2 species were collected (Figure 2). At the Above Falls reach, diversity ranged widely from 0.27 to 0.81, whereas diversity at the Lower reach was less variable, ranging from 0.46 to 0.87 (Figure 3). Diversity and evenness at the Above Falls reach were near or at the control limit in 2008 (Figures 3 and 4) where 83% of the community consisted of Fathead Minnows (*Pimephales promelas*), most of which were young of the year (<30 mm). At the Lower reach, diversity and evenness fell below or near the control limit in 2004 due to the community consisting primarily of Common Shiners (*Luxilus cornutus*, 72%). Species richness, community diversity and evenness revealed no significant linear trends across years at the Above Falls (richness: $F_{1,10} = 0.406$, $P = 0.538$; diversity: $F_{1,10} = 0.509$, $P = 0.492$; evenness: $F_{1,10} = 0.044$, $P = 0.837$) or Lower reaches (richness: $F_{1,10} = 2.215$, $P = 0.167$; diversity: $F_{1,10} = 3.750$, $P = 0.082$; evenness: $F_{1,10} = 3.931$, $P = 0.076$).

The diversity metric accounts for both species richness and evenness of abundance across species. As expected, years with higher richness and evenness had higher diversity at the Lower reach (richness: $F_{1,10} = 14.195$, $P = 0.004$; evenness: $F_{1,10} = 78.587$, $P < 0.001$). At the Above Falls reach, years with high community evenness also had significantly higher diversity ($F_{1,10} = 74.964$; $P < 0.001$); however, years with higher richness showed lower diversity, although this relationship was not significant ($F_{1,10} = 1.829$, $P = 0.206$). Above the falls, the community was dominated by one or two species most years that would account for low diversity. Fathead Minnow dominated in 2002, 2003, 2006, 2007, and 2008. Creek Chub (*Semotilus atromaculatus*) were common in 2001, 2006, and 2013; and Blacknose Dace (*Rhinichthys atratulus*) were most abundant in 2013 and 2014 (Appendix A).

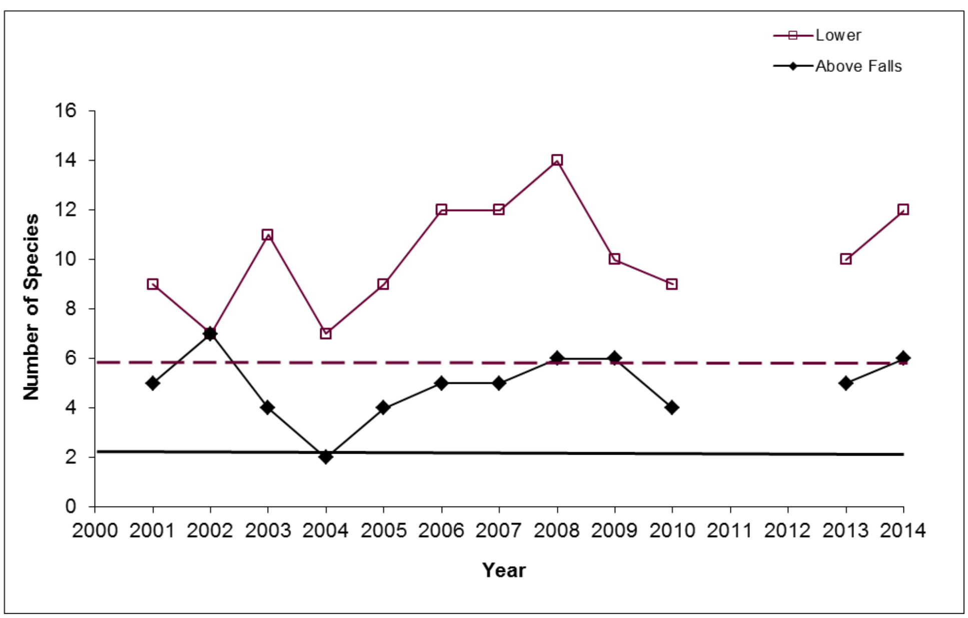

Figure 2. Species richness at the Above Falls (solid diamonds) and Lower (open squares) reaches sampled in 2001-2010, 2013-2014. The solid horizontal line is the 95% control limit for the Above Falls

reach. The dashed horizontal line is the 95% control limit for the Lower reach. The average and standard deviation of the first ten years of data were used to calculate control limits.

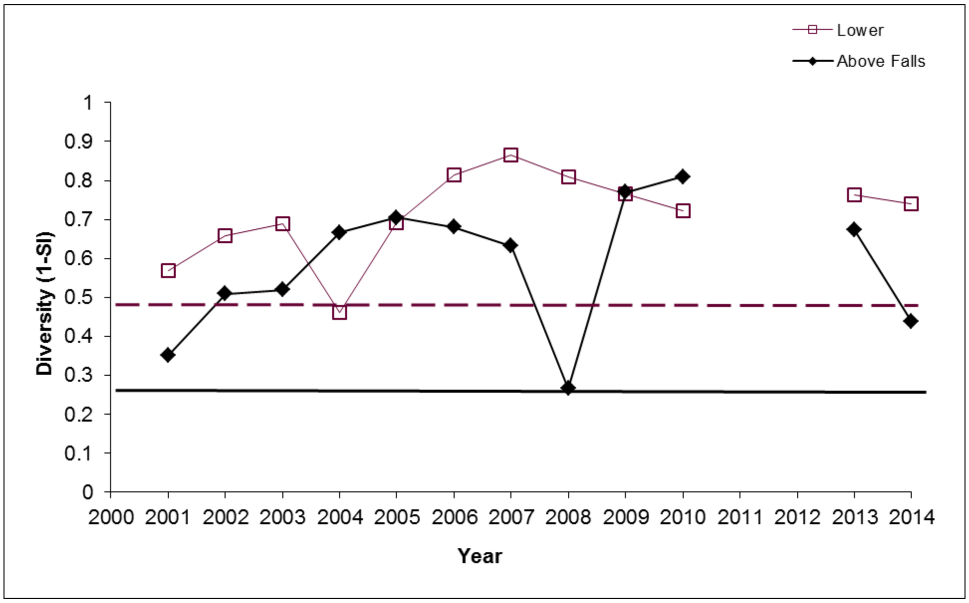

Figure 3. Diversity at the Above Falls (solid diamonds) and Lower (open squares) reaches sampled in 2001-2010, 2013-2014. The solid horizontal line is the 95% control limit for the Above Falls reach. The dashed horizontal line is the 95% control limit for the Lower reach. The average and standard deviation of the first ten years of data were used to calculate control limits.

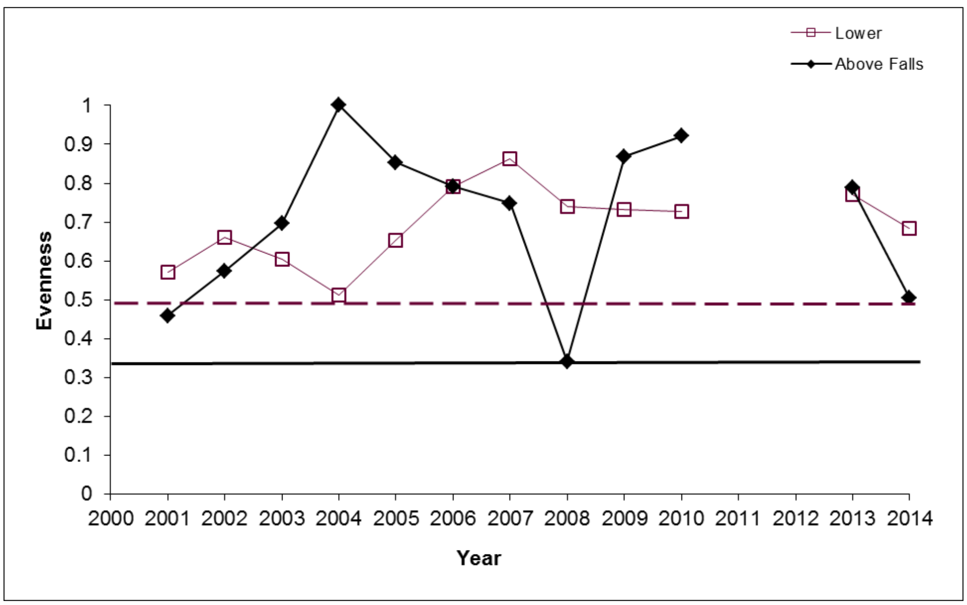

Figure 4. Evenness at the Above Falls (solid diamonds) and Lower (open squares) reaches sampled in 2001-2010, 2013-2014. The solid horizontal line is the 95% control limit for the Above Falls reach. The dashed horizontal line is the 95% control limit for the Lower reach. The average and standard deviation of the first ten years of data were used to calculate control limits.

The IBI modified from Fausch et al. (1984) was used to rate stream quality from poor to excellent. Because fish anomalies (deformities, eroded fins, lesions, tumors) were not recorded in 2001-2005, the range of IBI scores possible for those years are denoted as two separate lines for both reaches in Figure 5. The top line during 2001-2005 assumes there are no anomalies (best metric score = 5), and the bottom line assumes greater than 1% of fish with anomalies (worst metric score = 1). Regardless of accounting for fish anomalies, the Above Falls reach rated as poor to fair while the Lower reach rated as having fair to good stream integrity (Figure 5) due to higher richness, number of darter species (sensitive taxa), and proportion of insectivorous minnows. In 2006-2010 and 2013-2014 when anomalies were recorded, the anomaly metric scored as one (>1% of fish with anomalies) for both reaches each year. Therefore, it is highly probable that fish anomalies were present in 2001-2005 and that the IBI scores that accounted for greater than 1% of fish with anomalies is likely realistic for 2001-2005 data. IBI at the Above Falls and Lower reaches showed no significant temporal trends (Above: $F_{1,10} = 3.315$, P = 0.0987; Lower: $F_{1,10} = 4.915$, P = 0.051).

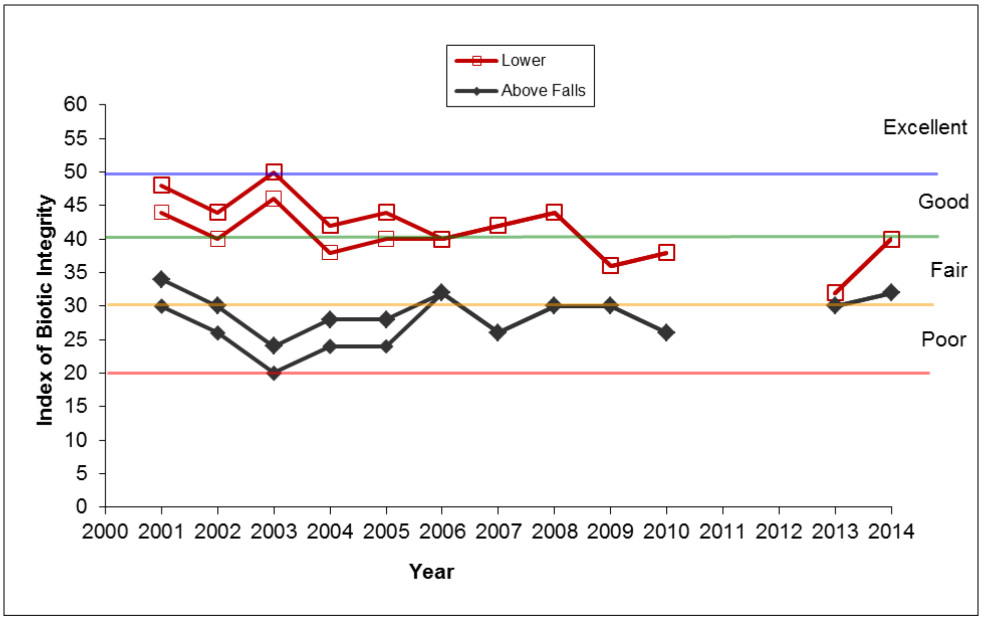

Figure 5. Index of Biotic Integrity (IBI) for the Above Falls (solid diamonds) and Lower (open squares) reaches sampled in 2001-2010, 2013-2014. Solid blue, green, yellow, and red horizontal lines represent boundaries between IBI rating categories. The secondary (bottom) set of IBI scores for Above Falls and Lower reaches during 2001 to 2005 represent the range of scores that were possible, given that the proportion of fish with an anomaly (disease, eroded fins, lesions, or tumors) metric was not recorded for those years.

In most years, fewer fish were collected above the falls compared to the Lower reach, with the exception of 2008 and 2014 when large numbers of young of the year Fathead Minnow and juvenile/adult Blacknose Dace (both tolerant species) were collected above the falls (Figure 6 top panel, Appendix A). At the Above Falls reach, catch ranged from 4 to 589 fish, and catch per area (CPA) ranged from 0.02 to 5.16 fish/m^2 (Figure 6). Catch and CPA ranged from 46 to 665 fish and 0.20 to 2.65 fish/m2 (Figure 6), respectively, in the Lower reach with a spike in abundance occurring in 2003 due to large numbers of Common Shiner (*Luxilus cornutus*; moderately tolerant species) and

Fathead Minnow (Appendix A). There were no significant temporal trends in catch or CPA found at either reach (catch Above: $F_{1,10}$ = 1.087, P = 0.322; CPA Above: $F_{1,10}$ = 0.909, P = 0.363; catch Lower: $F_{1,10}$ = 2.986, P = 0.115; CPA Lower: $F_{1,10}$ = 0.977, P = 0.346).

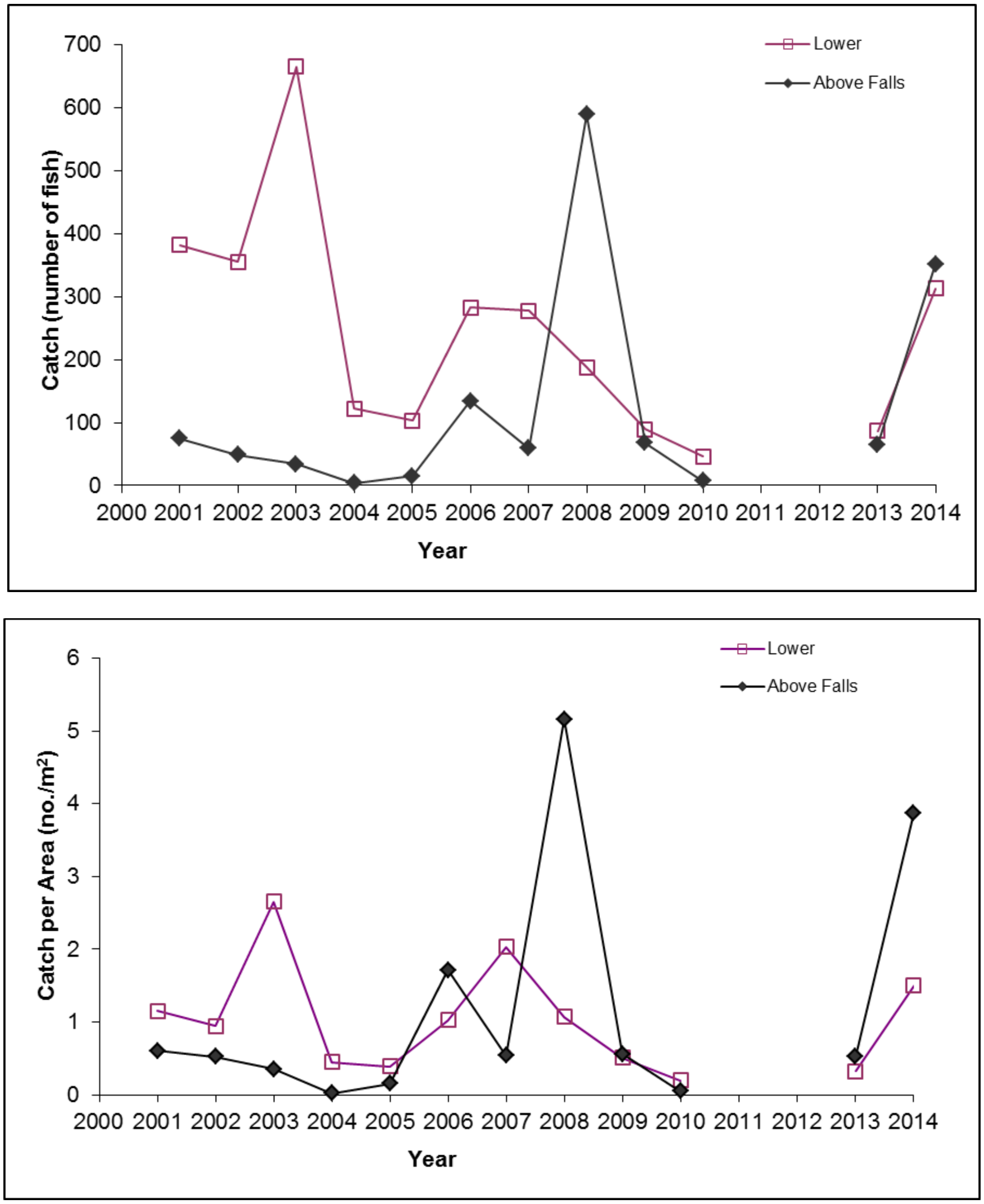

Figure 6. Catch (top panel) and catch per area (bottom panel) for the Above Falls (solid diamonds) and Lower (squares) reaches sampled in 2001-2010, 2013-2014.

Individual species catch (i.e., numbers collected of each species, excluding unidentified species) for both reaches remained below the control limit (solid line for Above Falls and dashed line for Lower reach; Figure 7 top panel) for most years sampled. However, species catch neared the control limit in 2008 and crossed the control limit in 2014 at the Above Falls, due to the high number of Fathead Minnows collected in 2008 and Blacknose Dace collected in 2014 (Appendix A). Species CPA at the Above Falls reach crossed the control limit (solid line) in 2004 and 2010 (Figure 7 bottom panel), years when total fish abundance was low (Figure 6 bottom panel). At the Lower reach, species catch never crossed but approached the control limit in 2005 and 2013. When sample area was taken into account for individual species, CPA for the Lower reach crossed the control limit in 2004, 2009, 2010, and 2013 (Figure 7 bottom panel).

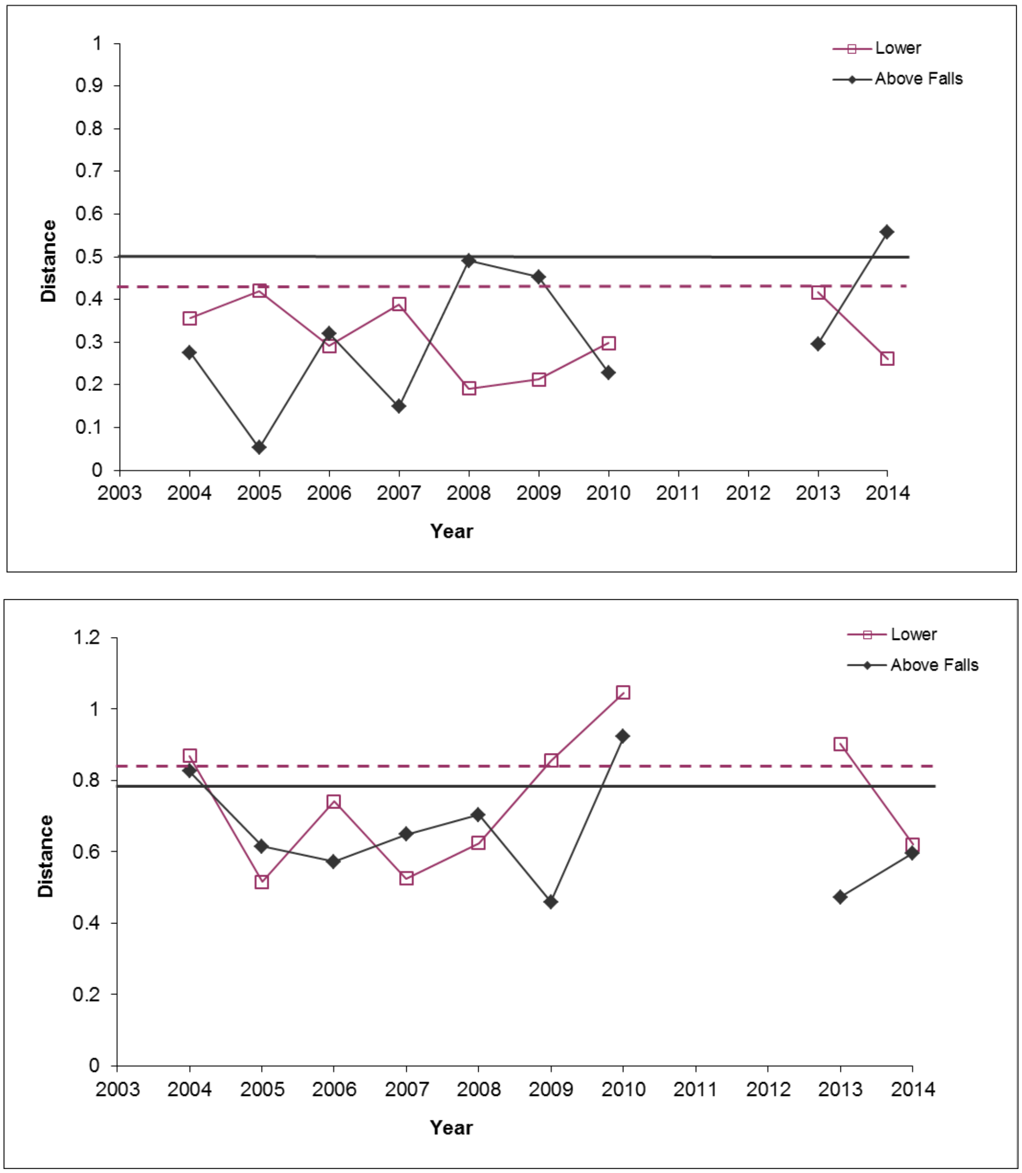

Figure 7. Multivariate control charts for individual species catch (top panel) and catch per area (bottom panel) at the Above Falls (solid diamonds) and Lower (open squares) reaches from 2004-2010, 2013-2014. Fish not identified to species were excluded. The solid horizontal line is the 95% control limit (based on 2001-2010 data) for the Above Falls reach. The dashed horizontal line is the 95% control limit for the Lower reach. The first three years of data were used as the centroid and, therefore, are not shown. Distance on the y-axis indicates the distance to the centroid.

Over the 12 year sampling period, species abundances were dominated by Fathead Minnow (45%), Blacknose Dace (22%), and Creek Chub (15%) at the Above Falls reach (Appendix A). In the Lower reach, abundant species included Common Shiner (32%), Fathead Minnow (17%), Bigmouth Shiner (*Notropis dorsalis*, 11%), and Central Stoneroller (*Campostoma anomalum*, 11%), which made up approximately 71% of the total abundance across the 12 years. A total of 153 Topeka Shiners were collected within the park during the 2001-2014 sampling period, with the Lower reach accounting for 87% of the abundance. No Topeka Shiners have been collected at the Above Falls reach. The remaining 13% of Topeka Shiners were collected in 2006 at two sampling reaches located between the Lower and Above Falls reaches. These two reaches were retired in 2007. There was no linear trend in Topeka Shiner abundance among years at the Lower reach ($F_{1,12}$ = 0.231, P = 0.640; Figure 8).

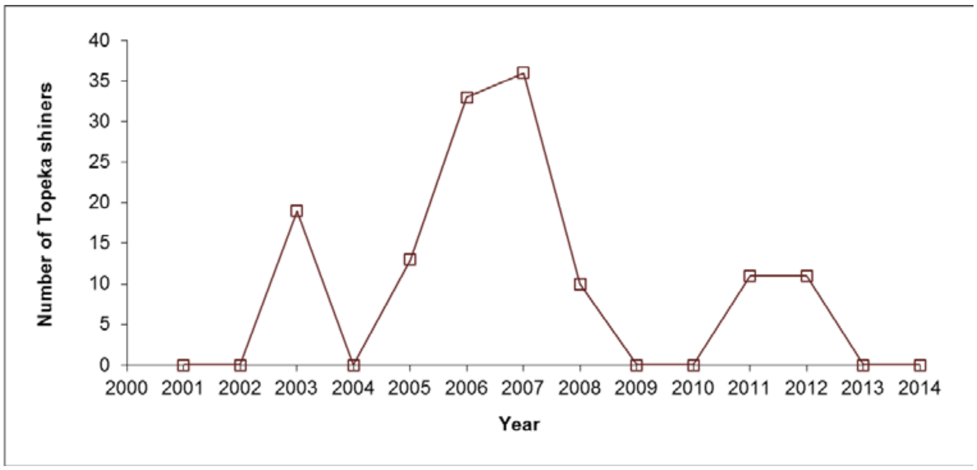

Figure 8. Number of Topeka Shiners collected at the Lower reach from 2001-2014.

Habitat and Water Quality Relationships

Because none of the analyzed fish metrics showed a significant temporal trend, no regression analyses were performed between fish metrics and environmental variables. For years in which specific fish metrics fell near or crossed their control limits, the measured habitat and water quality parameters provided little explanation for these deviations (Appendices B and C). Above the falls, site width and sample area were slightly larger in 2004 (Appendix B) when richness and species CPA crossed the control limits (only 2 species and 4 individuals were collected that year). In 2008, when diversity and evenness above the falls was near or at the control limit due to a spike in Fathead Minnow abundance (mostly young of the year), habitat parameters were within range of those collected in other years sampled (Appendices B and C). At the Lower reach, water temperature during sampling was lowest in 2004 (Appendix B) when diversity, evenness, and species CPA fell near or crossed their control limits. Although species CPA also crossed the control limit in 2009, 2010, and 2013, the habitat parameters collected those years were within range of those collected in other years where species CPA did not cross the control limit.

Discussion

The fish community in Pipestone Creek differed between the upstream reach (Above Falls) located near the east side of the park boundary and the downstream (Lower) reach near the west boundary. Much of the Pipestone Creek watershed is agricultural row crop land use. The creek originates as a channelized drainage ditch upstream of the park. This is reflected in the Above Falls reach where the stream channel is straight, uniform, and consists predominately of bedrock and steep banks (Appendix B). Pipestone Creek is listed as a 303(d) stream for impaired aquatic life (MNPCA 2014). Large diel fluctuations in dissolved oxygen (DO) were recorded above the falls, where levels dropped near or below 5 mg/L at night (see Appendices B and C), a lethal level for many fish species (USEPA 1988). High inputs of nutrients from agricultural land use coupled with an open canopy creates optimal conditions for periphyton and filamentous algae to flourish, creating high DO concentrations during the day (>13 mg/L) via photosynthesis and low DO levels at night (< 5mg/L) through respiration. These fluctuations in DO levels are likely the driving mechanism behind the poorer quality fish community above the falls where richness, diversity, stream integrity (IBI), and abundance were lower compared to the downstream reach. Above the falls, community diversity and evenness and individual species catch and species CPA crossed or neared control limits due to the dominance of young of the year Fathead Minnow in 2008 and juvenile/adult Blacknose Dace in 2014. Although no significant temporal trends were found in fish communities above the falls, years with higher richness typically had lower diversity due to dominance by one species each year (i.e., low evenness in species abundances). The most abundant species among the 12 year sampling period (Fathead Minnow, Blacknose Dace, and Creek Chub) are all tolerant of poor water quality and habitat conditions. It is typical for one or two species to dominate a degraded stream that experiences large daily changes in water quality or lacks habitat heterogeneity.

Below Winnewissa Falls, the stream begins to meander within the park, with the downstream reach having more heterogeneous physical habitat conditions of riffle, run, and pool channel units with a variety of substrate sizes (Appendix B), more gradual banks, and stable diel water quality conditions (Appendix C). As a result of these more suitable conditions, the downstream reach was characterized by higher richness, stream integrity, and diversity. Similar to the Above Fall reach, there were no significant temporal trends in fish communities at the Lower reach. However, the community at the Lower reach showed significantly higher diversity in years with both higher richness and greater evenness of species abundances. Because diversity accounts for both richness and evenness within the community, we would expect streams with more suitable habitat and stable water quality conditions would contain more species and that species abundances would be spread more evenly within the community, thus contributing to higher diversity. We did find that in 2004 the community was dominated by one species, Common Shiner, which is likely the reason diversity, evenness, and individual species CPA neared or crossed the control limits for these community metrics. In 2004, approximately three inches of rain fell within a 24 hour period, causing water levels to rise and sampling to be delayed by one day until water levels receded. The resulting high water levels may have displaced certain species downstream which would explain why one species was dominate and why the community composition deviated from baseline conditions at the Lower reach. This rain event may also explain why richness and species CPA at the Above Falls reach crossed control limits in 2004(2 species and 4 fish collected). Water temperature at the Lower reach in 2004 was the lowest among the 12 years sampled, but water temperature above the falls was within range of other years sampled. This low water temperature at the downstream reach is likely due to sample collection taking place in early morning hours and not due to a true deviation in water temperature as a result of the rain event. In later years where individual species CPA crossed the control limits (2009, 2010, and 2013), there was not one particular environmental variable or set of variables measured that could explain the deviation of fish communities from the baseline. Habitat and water quality parameters were within range of years where the community did not deviate from the baseline. The addition of sampling riffle habitats beginning in 2006 may appear to explain the deviation in species CPA in later years. However, no species were collected in riffles that were not collected in pool or run habitats in similar abundances; and richness, evenness, and diversity did not deviate from baseline conditions in those years.

Pipestone Creek showed greater biotic integrity (i.e., IBI) at the Lower reach due to a higher number of native fish species, number of darter species (sensitive taxa), and proportion of insectivorous minnows. Stream integrity based on fish community data did not change significantly across years and rated as fair to good quality. Based on aquatic invertebrate community data, overall stream quality also showed no change during 14 years of sampling Pipestone Creek (Bowles *et al.* 2013). The fish community consisted largely of species moderately tolerant to poor environmental conditions, including Common Shiner, Bigmouth Shiner, and Central Stoneroller. However, prairie streams, by nature, are harsh environments and often flood in the spring and dry in summer. Native prairie fishes are adapted and tolerant of these variable and harsh conditions.

Although Pipestone Creek is considered impaired for aquatic life and a small portion (~1 km) of the stream flows through the park, the conditions at the downstream boundary of the park are more favorable for native prairie fishes, including the Topeka Shiner. Because 80% of the land within the park's 1.2 km^2 boundary is native or restored prairie, PIPE may serve as refuge for this endangered species and other native fishes despite the creek's impaired status. Further study and data collection will be useful in determining environmental and biotic factors that allow for the existence of Topeka Shiners and a more healthy fish community at the downstream reach. Collection of additional water quality data, particularly DO and temperature, for several weeks seasonally (especially during summer low flows) would be useful at the reach above the falls, where water quality is suspected to have a large impact on the fish community. No substantial declines in fish communities were observed over time at either sample reach, and the park appears to play some role in protecting native fishes as evidenced by the higher quality fish community and presence of Topeka Shiners at the downstream reach. Through the partnership between HTLN and SDSU, opportunities are available to research fish community interactions, environmental factors affecting these interactions, and Topeka Shiner population dynamics and movement. This research will have implications for land use management within the park and throughout the watershed that may improve habitat conditions to sustain a healthy fish community and protect an endangered species.

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Appendix A. Fish species collected at PIPE, 2001-2010 and 2013-2014.

Common Name	Scientific Name	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2014
						Above Falls							
White Sucker	*Catostomus commersonii*	8	5	0	2	2	10	7	19	13	3	5	0
Bigmouth Shiner	*Notropis dorsalis*	0	2	0	0	0	0	0	0	0	0	0	42
Blacknose Dace	*Rhinichthys atratulus*	0	1	0	0	0	0	6	9	11	2	28	259
Bluntnose Minnow	*Pimephales notatus*	0	1	4	0	0	0	0	0	0	0	0	0
Brassy Minnow	*Hybognathus hankinsoni*	2	3	0	0	0	0	0	0	0	0	0	0
Central Stoneroller	*Campostoma anomalum*	0	0	2	0	1	17	0	0	0	0	0	3
Creek Chub	*Semotilus atromaculatus*	60	3	5	2	6	55	12	18	10	1	24	27
Fathead Minnow	*Pimephales promelas*	2	34	23	0	6	49	33	488	1	0	5	19
Non-carp minnow spp.	*Cyprinidae spp.*	0	0	0	0	0	0	0	16	0	0	0	0
Notropis spp.	*Notropis spp.*	0	0	0	0	0	0	0	1	0	0	0	0
Sand Shiner	*Notropis stramineus*	3	0	0	0	0	0	0	37	26	0	3	0
Brook Stickleback	*Culaea inconstans*	0	0	0	0	0	3	1	1	7	1	0	0
Johnny Darter	*Etheostoma nigrum*	0	0	0	0	0	0	0	0	0	0	0	2
TOTAL		75	49	34	4	15	134	59	589	68	7	65	352
						Lower							
White Sucker	*Catostomus commersonii*	12	3	14	8	5	23	2	3	5	10	2	5
Green Sunfish	*Lepomis cyanellus*	0	0	1	0	0	0	0	1	0	0	0	2
Orangespotted Sunfish	*Lepomis humilis*	3	1	1	0	1	0	0	1	0	0	0	0
Bigmouth Shiner	*Notropis dorsalis*	242	70	0	0	0	0	0	0	0	0	3	18
Blacknose Dace	*Rhinichthys atratulus*	0	0	0	0	1	17	8	6	5	0	11	37
Bluntnose Minnow	*Pimephales notatus*	0	62	0	15	29	21	18	3	0	0	38	26
Central Stoneroller	*Campostoma anomalum*	16	33	88	6	3	42	36	64	7	2	4	15
Common Shiner	*Luxilus cornutus*	19	183	302	88	48	102	64	35	29	22	13	15
Creek Chub	*Semotilus atromaculatus*	2	3	15	0	1	1	20	20	9	4	7	24
Fathead Minnow	*Pimephales promelas*	44	0	193	0	0	17	33	28	30	0	2	160
Luxilus spp.	*Luxilus spp.*	0	0	0	0	0	0	1	0	0	0	0	0
Non-carp minnow spp.	*Cyprinidae spp.*	0	0	0	0	0	0	0	3	0	0	0	0
Notropis spp.	*Notropis spp.*	0	0	0	0	0	0	2	0	0	0	0	0
Red Shiner	*Cyprinella lutrensis*	0	0	0	0	0	1	1	0	0	0	0	1
Sand Shiner	*Notropis stramineus*	43	0	24	2	0	16	11	3	1	0	0	8

Appendix A (continued).

Common Name	Scientific Name	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2014
Topeka Shiner	*Notropis topeka*	0	0	19	0	13	33	36	10	0	0	0	0
Brook Stickleback	*Culaea inconstans*	0	0	0	0	0	0	39	7	1	0	1	0
Black Bullhead	*Ameiurus melas*	0	0	1	0	0	0	0	0	0	3	0	0
Stonecat	*Noturus flavus*	0	0	0	2	0	0	0	0	0	1	0	0
Unknown madtom	*Noturus spp.*	0	0	0	0	0	0	1	0	0	0	0	0
Yellow Bullhead	*Ameiurus natalis*	0	0	0	0	0	1	0	0	0	0	0	0
Blackside Darter	*Percina maculata*	0	0	0	0	0	0	0	1	1	2	0	0
Iowa darter	*Etheostoma exile*	0	0	0	0	0	0	0	0	0	1	0	0
Johnny Darter	*Etheostoma nigrum*	1	0	7	1	2	9	5	3	1	0	6	2
Yellow perch	*Perca flavescens*	0	0	0	0	0	0	0	0	0	1	0	0
TOTAL		382	355	665	122	103	283	277	188	89	46	87	313

Appendix B. Habitat and water quality parameters collected at PIPE, 2001-2010 and 2013-2014.

Reach	2001	2002	2003	2004	2005	2006	2007[A]	2008[A]	2009[A]	2010[A]	2013[A]	2014
Mean Width (m)												
Above	3.6	3.8	3.6	4.5	3.5	3.6	3.6	3.4	3.7	3.7	3.5	
Lower	4.0	4.5	3.8	4.2	3.7	4.4	3.5	3.7	4.2	4.1	4.6	
Mean Length (m)												
Above	7.0	4.9	5.3	7.7	5.4	4.4	6.1	6.7	6.5	7.1	6.9	
Lower	16.4	16.6	13.2	12.9	14.4	12.6	7.7	9.5	8.3	11.2	11.6	21.5
Total Area (m^2)												
Above	123.9	93.5	96.1	173.4	95.4	78.3	109.1	114.1	120.8	133.8	121.5	90.9
Lower	331.7	376.8	250.6	272.5	262.8	275.9	136.5	175.0	175.0	231.6	268.6	208.4
Mean Depth (cm)												
Above	25.4	32.2	20.6	43.2	33.8	20.2	20.5	20.3	22.8	40.4	19.5	
Lower	28.0	57.2	30.2	51.6	46.6	22.9	23.5	23.8	32.8	45.7	23.1	6.5
Mean Velocity (m/s)												
Above						0.23	0.17	0.07	0.50	0.57	0.09	
Lower						0.15	0.17	0.10	0.60	0.46	0.10	
Mean Water Temperature (^{o}C)												
Above	15.0	20.0	20.9	15.1	19.0	14.2		19.0	21.3	20.8	15.4	
Lower	15.6	16.3	15.6	13.7	15.8	17.5	22.3	17.4	20.5	22.1	15.6	11.0
Mean Dissolved Oxygen (mg/L)												
Above	5.94	16.56	13.66	7.68	13.45	4.98		8.99	12.40	4.53	9.35	
Lower	8.22	8.76	7.56	9.25	9.22	7.58	8.20	8.03	7.29	7.34	9.34	
Mean pH												
Above		8.40	8.28	7.75	8.10	6.92		7.83	7.96	7.55	7.65	
Lower		8.30	8.24	8.15	8.30	7.72	8.17	8.13	8.21	7.93	8.18	
Mean Specific Conductance (uS/cm)												
Above			692.2	731.4	584.2	495.0		709.7	761.5	489.0	590.0	
Lower			645.6	704.2	570.8	472.6	714.5	686.5	814.0	595.0	549.0	
Mean Turbidity (cm)												
Above	56.6	69.6	75.6	26.8		78.2	[B]	[B]	[B]	[B]	[B]	
Lower	60.1	91.0	59.2	20.2	87.2	91.6	[B]	[B]	[B]	[B]	[B]	

[A] Water quality data were collected hourly using dataloggers. Averages for these years include only data collected during the hours of fish sampling.
[B] Turbidity was collected using a probe that records data in nephelometric turbidity units (NTU) rather than cm of visibility.

Empty fields indicate data were not collected in that year.

Appendix C. Mean water quality parameters collected hourly for 24 – 48 hours at PIPE, 2007-2010 and 2013.

	Water Temperature (^oC)	Dissolved Oxygen (mg/L)	pH	Specific Conductance (uS/cm)	Turbidity (NTU)
Above Falls					
2007[A]					
2008	18.6 (15.2 - 22.0)	8.00 (4.40 - 12.89)	7.82 (7.56 - 8.12)	696.6 (679 - 711)	8.8 (1.9 - 23.4)
2009	21.4 (17.6 - 25.5)	10.21 (6.83 - 18.01)	7.88 (7.64 - 8.21)	770.0 (563 - 819)	9.9 (3.5 - 17.6)
2010	21.0 (17.4 - 23.9)	6.16 (4.12 - 9.22)	7.69 (7.55 - 8.03)	586.0 (203 - 797)	19.1 (0 - 76.1)
2013	16.9 (15.0 - 19.3)	10.64 (8.88 - 12.01)	7.78 (7.65 - 7.95)	601.9 (588 - 618)	4.2 (3.3 - 7.2)
Lower					
2007	22.3 (18.5 - 25.9)	7.95 (6.87 - 10.05)	8.21 (8.12 - 8.39)	713.0 (690 - 731)	23.7 (22.8 - 26.3)
2008	19.4 (17.0 - 22.2)	8.03 (6.79 - 10.72)	8.20 (8.05 - 8.38)	682.9 (671 - 690)	2.0 (0 - 12.2)
2009	21.9 (18.7 - 23.9)	7.49 (6.73 - 9.37)	8.23 (8.16 - 8.32)	771.8 (638 - 819)	3.7 (2.0 - 5.1)
2010	21.5 (17.8 - 24.5)	6.95 (5.09 - 7.64)	7.95 (7.81 - 8.02)	617.1 (189 - 784)	12.5 (0 - 40.6)
2013	18.6 (15.7 - 21.7)	10.45 (7.87 - 14.87)	8.33 (8.12 - 8.58)	521.3 (489 - 545)	5.93 (4.6 - 8.6)

[A] Water quality data loggers were not deployed at the Above Falls reach in 2007.

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