2016 Cahaba River Report

Results of Biological Community Surveys

January 2020
V2

Environmental Indicators Section –
Field Operations Division

SUMMARY OF RESULTS

Water quality sampling in 2005 and 2016 show a distinct decrease in water column total phosphorus concentrations in the Cahaba River. Annual sampling at seven locations show total phosphorus concentrations to be meeting the instream target established by the Cahaba River Watershed Nutrient TMDL, with median total phosphorus concentrations at Cahaba River stations ranging from 14 µg/L to 24 µg/L in 2016.

During the 2002-2016 surveys of the Cahaba River, diatoms have consistently proved to be the most effective tool to document nutrient impacts to aquatic communities, and to link community conditions to nutrient concentrations. In the 2002-2005 surveys, the diatom community was dominated by species tolerant of nutrient enrichment. Results of the 2016 diatom community suggest that the community is responding to decreased total phosphorus concentrations with a shift to taxa intolerant of nutrient enrichment.

The decreased nutrient concentrations were not generally reflected in macroinvertebrate or fish community metric results. Both communities are less sensitive to nutrient enrichment issues. Conditions within these communities may reflect other impairments to the Cahaba River, such as siltation/habitat alteration.

BACKGROUND

The Cahaba River drainage encompasses 1,824 mi^2 in central Alabama, spanning six counties—St. Clair, Jefferson, Shelby, Bibb, Perry, and Dallas. The upper portion of the Cahaba River watershed is located in the Ridge and Valley (67) ecoregion. The river crosses the Fall Line in Bibb County, and the lower portion of the watershed flows through the Southeastern Plains (65) ecoregion. This abrupt change in geomorphology creates a very unique array of habitats along the river continuum, and, as a result, the diversity of freshwater organisms within the Cahaba River drainage is among the highest found in the United States. The Cahaba River is home to 128 native species of fish, 24 species of snails, and about 50 freshwater mussels, many of which are endemic to the river (CRS 2019).

In recognition of this tremendous biodiversity, portions of the river have been designated as Outstanding Alabama Waters (OAWs) since 1998. In 2004, the U.S. Fish and Wildlife Service (USFWS) categorized the Cahaba River as critical habitat for eleven endangered or threatened fish and mollusk species. In 2006, the USFWS designated the Upper Cahaba River watershed as a Strategic Habitat Unit (SHU) (Wynn et al. 2012). Currently, the basin is categorized as critical habitat for 36 fish and mussel species identified as extirpated, endangered, threatened, or a high conservation concern (Wynn et al. 2018).

Between 1996 and 1998, the Alabama Department of Environmental Management (ADEM) and Region 4 of the U.S. Environmental Protection Agency (EPA R4) listed four segments of the Cahaba River as impaired under §303(d) of the Clean Water Act (ADEM 2002). The segments were listed in large part to improve habitat conditions for eleven endangered or threatened fish and mollusk species whose historic ranges included the Cahaba River. The segments were listed for impairment from nutrients, siltation, habitat alteration, and pathogens from municipal sources, urban and storm sewer runoff, and land development.

The impaired segments extend from Alabama Highway 82 at Centreville upstream approximately 105 river miles to Highway 59 at Trussville, and encompass an area of 1,027 mi^2. In 2004, the original four listed segments were divided into eight to more precisely identify and track waterbody segments with respect to designated uses, and to be consistent with new listing and reporting guidelines under Sections 303(d) and 305(b) of the Clean Water Act.

Streams located within the same ecoregion are expected to have similar climate, landform, soil, natural vegetation, hydrology, and other ecologically relevant factors (Griffith et al. 2001). The numeric nutrient target derived from reference reaches in the Ridge and Valley ecoregion was consistent with EPA guidance (Stevenson 2003, ADEM 2006a), and provided a target inherently protective of designated uses because it was based on data from high quality waterbodies that supported designated uses (ADEM 2006a). However, the ADEM recognized that the chemical, physical, and biological conditions of large and small streams are affected as much by their drainage areas, widths, and depths as they are by their climate, soils, and other regional characteristics.

The ADEM conducted intensive surveys of the periphyton and macroinvertebrate communities in the Cahaba River in 2005. Hatchet Creek, a high quality tributary of the Tallapoosa River, was used as a reference watershed because of its similarity to the Cahaba River in drainage area, width, depth, and substrate composition. The Geological Survey of Alabama (GSA) conducted fish community surveys for EPA R4 in 2002 (O'Neil 2002). A second set of fish IBI surveys were conducted by GSA and ADEM in 2004 (ADEM 2006b).

A Total Maximum Daily Load (TMDL) for nutrients was developed and approved by USEPA in September 2006. This document identified phosphorus as the limiting factor in the eutrophication issues and algal blooms in the river that result from nutrient enrichment. It established a total phosphorus nutrient target of 35 µg/L for the river. Meeting this target required significant reductions in waste load allocations (WLA) from NPDES-permitted point sources along the river. A phased approach was used to decrease permit limits over time, with Phases I and II being implemented between 2012 and 2016.

Annual sampling at seven locations show total phosphorus concentrations to be meeting the instream target, with median total phosphorus concentrations at Cahaba River stations ranging from 14 µg/L to 24 µg/L in 2016.

Figure 1. Cahaba River at the "Cahaba Lily" reach (CABB-2A) in the Cahaba River National Wildlife Refuge.

Figure 3. Hatchet Creek at the "Cahaba Lily" reach at HATC-4.

ADEM's adaptive management strategy uses a phased approach with respect to implementation of the Cahaba River Watershed Nutrient TMDL. Continuing this approach, intensive macroinvertebrate, periphyton, and fish community surveys were conducted in the Cahaba River in 2016. The purpose of these surveys was to assess biological conditions, and measure biological response to the current reduction in total phosphorus concentrations.

BIOLOGICAL RESPONSE TO NUTRIENT ENRICHMENT

The direct impact of nutrient enrichment on streams is to increase autotrophic (algae and aquatic macrophytes) production and to shift taxonomic composition of these communities to species able to increase growth rates at moderate and high nutrient concentrations. Nutrient enrichment also accelerates litter breakdown by bacteria and fungi.

Macroinvertebrates and fish are less sensitive indicators of nutrient enrichment, and adverse impacts to these higher trophic levels can lag behind increased nutrient concentrations and primary production, making it difficult to detect impacts of nutrient enrichment in the earliest stages (Paul et al. 2013). However, increased primary production and changes in the composition of aquatic algae and macrophytes can indirectly affect these communities. Changes in plant and algal community structure can change the amount, type, and palatability of plant/algal food sources and increase the presence of algal taxa that produce substances toxic to fish, invertebrates and humans. Increased algal biomass and photosynthesis can result in decreased dissolved oxygen concentrations and increased pH levels that may stress macroinvertebrate and fish communities.

The primary impact of nutrient enrichment to the Cahaba River system has been habitat degradation caused by a shift in the algal periphyton community from a historically diatom-dominated community to a community dominated by nuisance filamentous algae. The excessive and widespread growth of filamentous algae smothers stable substrates and interstitial spaces needed by threatened and endangered species for refuge, feeding, physical attachment, and reproduction. (Howard et al. 2002, O'Neil 2002, ADEM 2012)

INDICATORS SENSITIVE TO NUTRIENT ENRICHMENT

State progress toward adopting numeric nutrient criteria has been limited in flowing waters, in part because of the technical challenge of developing numeric nutrient criteria when multiple factors (e.g., light, flow) can influence responses (e.g., algal biomass) and confound nutrient response models. Such conditions can make it difficult to predict nitrogen and phosphorus concentrations that adversely affect aquatic life.

To address these issues, EPA's Office of Science and Technology convened a workshop, *Nutrient Enrichment Indicators in Streams*, April 16-18, 2013 (Paul et al. 2013). The goals of the workshop were to identify a suite of indicators most sensitive to changes in nutrient concentrations and predictive of changes to aquatic life or other designated uses; and, identify combined approaches for: 1) indicators readily available for most states; and 2) any combination of chemical, physical, or biological indicators that would yield an accurate assessment of adverse effects on aquatic life from nutrient pollution. The indicators sensitive to nutrient pollution, and available to most states were listed in three categories:

1) *Nutrients: Total Nitrogen (TN) and Total Phosphorus (TP)*: provide a direct measure of nutrient pollution. Concentrations above a set criterion or threshold known to adversely affect aquatic life should indicate impairment;
2) *Primary producers: Chlorophyll a (Chl a), percent visual coverage of algae and in-stream macrophytes, and measures of algal assemblage (diatoms, and soft-bodied algae)*: are the most sensitive response indicators to nutrient pollution in streams, and are widely recommended as indicators of nutrient enrichment;
3) *Ecosystem function*: Continuously measured DO and pH capture the autotrophic and heterotrophic responses, are generally sensitive to nutrient enrichment, and provide a clear linkage to aquatic life.

The following combination of indicators were found to be sensitive to nutrient pollution and to provide an early warning of impairment: nutrient concentrations (TN and TP), a measure of algal biomass (Chl a, ash-free dry mass, or visual percent cover), a measure of the primary producer assemblage (mostly based on diatoms), and to a lesser extent, a measure of ecosystem function (diel DO or pH).

Cahaba River Nutrient Target and Instream Concentrations

In their 2002 study of the Cahaba River, the EPA recognized that the most effective tool to set an appropriate nutrient target to restore essential habitat for threatened and endangered fish and mussel species would require determining the relationship between algal community structure and instream TP/TN concentrations. The 2004 numeric nutrient target of 35 µg/L was derived and supported using data from reference reaches in the Ridge and Valley ecoregion and reference reaches characterized by similar drainage and geomorphology. Based on ADEM data from large riffle-run streams throughout the state, the median concentration at which metric results indicated declining conditions to the macroinvertebrate community ranged from 50-60 µg/L. This range is consistent with reference guidelines for the Piedmont, Ridge and Valley, and Southwestern Appalachian Ecoregions within Alabama, but slightly higher than the total phosphorus nutrient criterion of 40 µg/L established by EPA and the Tennessee Department of Environment and Conservation for streams in three Ridge and Valley sub-ecoregions. (ADEM 2012, Denton et al. 2001)

Recent annual sampling at seven locations show total phosphorus concentrations to be meeting the instream target, with median total phosphorus concentrations at Cahaba River stations ranging from 14 µg/L to 24 µg/L in 2016. These concentrations are consistent with concentrations of 12 to 27 µg/L recommended by EPA R4 in 2002 to maintain a mean periphyton chlorophyll a <100 mg/m^2, and a mean periphyton cover <10% stable substrate.

Periphyton Community Survey Results

Within the Cahaba River system, diatoms have repeatedly been shown to be the most reliable indicator of nutrient enrichment (ADEM 2012). The primary impact to aquatic communities within the Cahaba River is the shift from a diatom-dominated community to an algal community dominated by filamentous algae. This shift occurs at relatively low nutrient concentrations (nutrient indicators), and generally does not tend to cause extreme depletions in instream dissolved oxygen concentrations (ecosystem function indicators). Although percent cover by filamentous algae is the direct cause of nutrient impacts to the river, this measure has proved to be highly variable, and an unreliable indicator of nutrient impairments (Howard et al. 2002, ADEM 2006b, ADEM 2012).

Comparison of percent filamentous algae and flow data suggest the high percent bedrock substrates and high percent impervious surface within the Cahaba River basin combine to create very high peak flows that scour bottom substrates clean of filamentous algae. Scouring during these events has made it difficult to link increased phosphorus concentrations to increased algal biomass, and to document the extent of filamentous algal cover (Fig. 1).

Within the Cahaba River system, diatoms have consistently proved to be the most effective tool to document impacts to aquatic communities, and to link community conditions to nutrient concentrations. The 2002 EPA study recognized the primary impact of nutrient enrichment within the Cahaba River to be a result of the shift from an algal community dominated by diatoms to one dominated by filamentous algae (Howard et al. 2002). The composition of the diatom assemblage has also shifted from species intolerant of pollution to species more tolerant of nutrient enrichment. ADEM's 2004 and 2005 surveys showed distinct correlations with nutrient concentrations using three diatom community indices recommended by EPA Region 4, listed below (Stevenson 2003, ADEM 2012). Results of the diatom community surveys showed the strongest response to the decreased total phosphorus concentrations again in 2016.

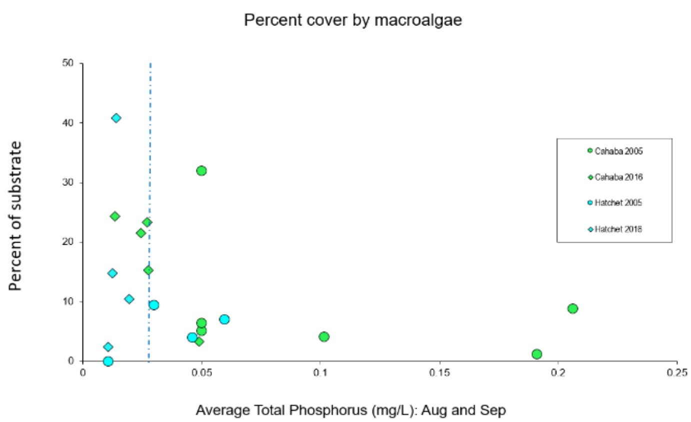

Fig. 1. Percent cover by macroalgae and average total phosphorus concentrations at the Cahaba River and Hatchet Creek stations. Within the Cahaba River, percent substrate cover by macroalgae was generally lower at higher concentrations of total phosphorus.

Similarly, in a multi-agency study of Oregon streams, Sobota et. al (2015) reported very weak relationships between algal biomass metrics and nutrient concentrations and strong, non-linear relationships between algal community composition metrics and nutrient concentrations. Numerous other studies have found diatoms to be a reliably strong indicator of nutrient enrichment (Sonneman et al. 2001, Griffith et al. 2005, Paul et al. 2013, Taylor et al. 2014, Mangadeze et al. 2016).

Van Dam Oxygen Tolerance Index (VDOXY): Many diatom species have been assigned to an oxygen requirement category. The index has five categories, with Category 1 species requiring close to 100% DO saturation and Category 5 requiring 10% saturation or less. The index uses the abundance and oxygen requirement category of each species to place each site into one of five categories, with a Category 1 community requiring close to 100% DO saturation, and a Category 5 community requiring 10% saturation or less.

Results of the VDOXY index show a shift to taxa intolerant of low dissolved oxygen conditions throughout the Cahaba River basin from 2005 to 2016 (Figs. 2 and 3).

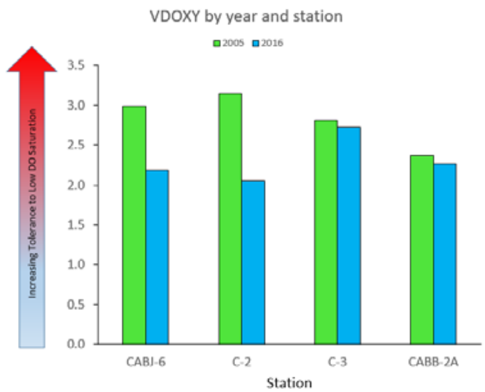

Fig. 2. Four stations located within the Cahaba River basin were sampled during both 2005 and 2016. At each of these stations, there was at least a slight decrease in the VDOXY index from 2005 to 2016, suggesting improved water quality, particularly at CABJ-6 and C-2. Station descriptions listed in Table 2.

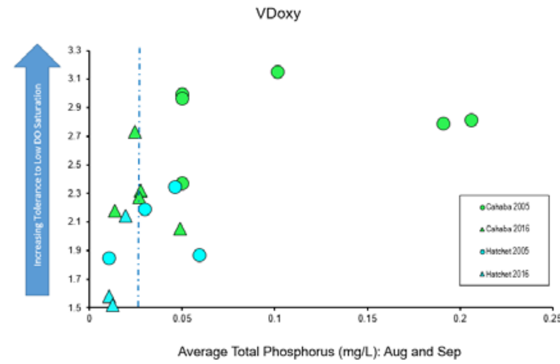

Fig. 3. Although VDOXY results are higher in the Cahaba River than in Hatchet Creek during both years, VDOXY results indicate a shift to taxa intolerant of low dissolved oxygen conditions throughout the Cahaba River basin from 2005 to 2016.

Van Dam Saprobic Index (VDSAP): The Van Dam Saprobic Index has five categories describing a species' ability to live in an organic rich environment lacking O_2 (high BOD, low O_2), with 1 being high-O_2 saturation and relatively low BOD, and 5 being low-O_2 saturation and high BOD (J. Stevenson, personal communication). The index uses the abundance and saprobic category of each species to place each site into one of five categories, with a Category 1 community being intolerant of low DO and high BOD conditions, and a Category 5 community being tolerant of low DO and high BOD conditions.

Figs. 4 and 5 summarize the 2005 and 2016 VDSAP results. Comparison of results from 2005 to 2016 indicate a trend towards taxa intolerant of low dissolved oxygen and high biochemical oxygen demand.

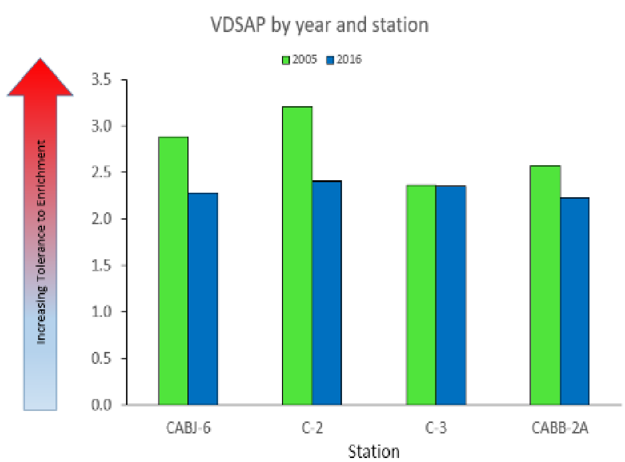

Fig. 4. At the four Cahaba stations sampled during both 2005 and 2016, VDSAP decreased at CABJ-6, C-2, and CABB-2a. At C-3, there was no change in VDSAP index results between 2005 and 2016. Station descriptions listed in Table 2.

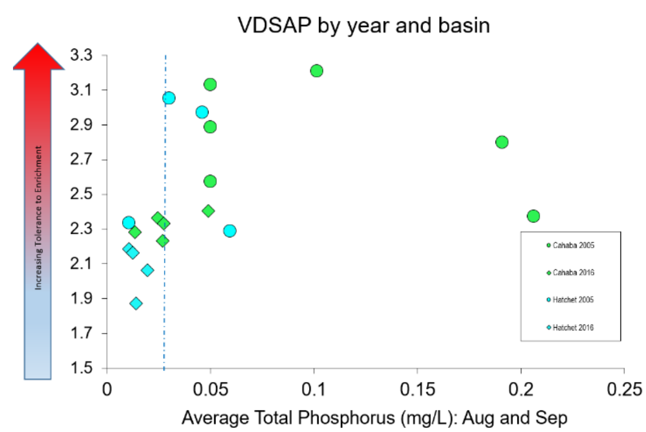

Fig. 5. Although VDSAP results are generally higher in the Cahaba River than in Hatchet Creek during both years, VDSAP results indicate a shift to taxa intolerant of low dissolved oxygen and high biochemical oxygen demand throughout the Cahaba River basin from 2005 to 2016.

Mid-Atlantic Trophic Status Index (MA TSI): Developed using data from a large probabilistic monitoring study in the Mid-Atlantic Highlands. It uses species abundance and total phosphorus optima categories to place each site into one of six categories, with category one being most sensitive to enriched conditions and category six being more tolerant of enriched conditions.

Results of the MA TSI were generally higher in 2005 than in 2016, suggesting improved diatom community conditions in response to decreased total phosphorus concentrations (Figs. 6 and 7).

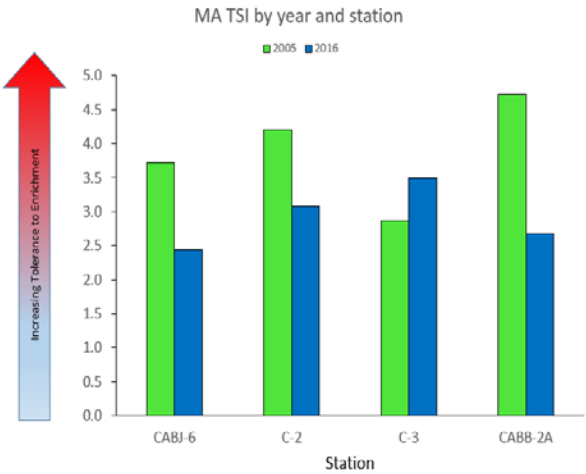

Fig. 6. At the four Cahaba stations sampled during both 2005 and 2016, MA TSI decreased at CABJ-6, C-2, and CABB-2a, suggesting improved diatom community conditions in response to the decreased total phosphorus concentrations. However, MA TSI increased at C-3 from 2005 to 2016. Station descriptions are provided in Table 2.

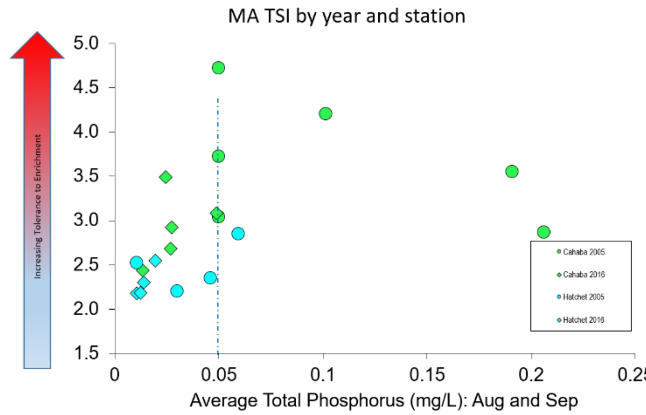

Fig. 7. MA TSI results were generally higher in the Cahaba River in 2005 than in 2016, indicating improved diatom community conditions.

Macroinvertebrate Community Survey Results

There is some evidence of improved conditions within the macroinvertebrate community between 2005 and 2016. Plecopteran taxa, a pollution intolerant order of aquatic insects, was completely absent from all Cahaba River stations in surveys conducted by Samford University, EPA, and ADEM, 2001-2005 (Howell and Davenport 2001, Howard et al. 2002, ADEM 2012). In 2016, Plecoptera were collected at two stations. Percent Attribute 2 and 3 (sensitive) organisms also increased within the Cahaba River from 2005 to 2016.

However, there was little change overall in macroinvertebrate community survey results between 2005 and 2016. This is not unexpected, as macroinvertebrates are less sensitive to, and may take more time to recover from, impacts caused by nutrient enrichment (Paul et al. 2013). Impacts from nutrient enrichment to the macroinvertebrate community may also be confounded by other factors, such as siltation and flow. Impacts to macroinvertebrates in a 2002 EPA study were primarily attributed to siltation (Howard et al. 2002).

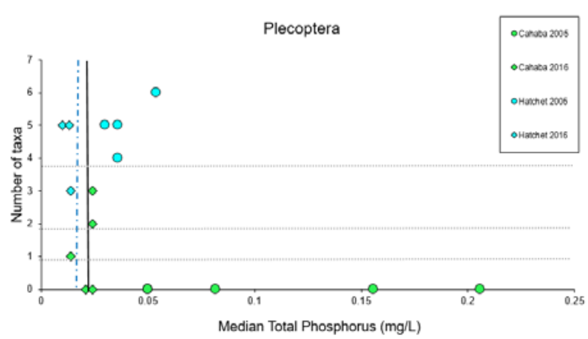

Fig. 8. Median total phosphorus concentrations (mg/L) and Plecoptera (stonefly) taxa collected from the Cahaba River (green) and Hatchet Creek (blue) stations in 2005 (circles) and 2016 (diamonds). Numbers of Plecoptera taxa collected from the Cahaba River stations increased from 2005 to 2016.

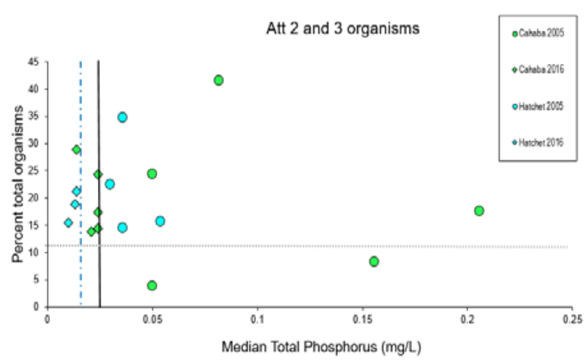

Fig. 9. Median total phosphorus concentrations (mg/L) and the percent of Attribute 2 and 3 (pollution-sensitive) organisms collected from the Cahaba River (green) and Hatchet Creek (blue) stations in 2005 (circles) and 2016 (diamonds). Percent of Attribute 2 and 3 taxa collected from the Hatchet Creek stations ranged from 16-34% during both 2005 and 2016. In the Cahaba River, percent of Attribute 2 and 3 organisms ranged from 4-41% in 2005 to 14-29%, suggesting a shift in community composition to more pollution sensitive organisms.

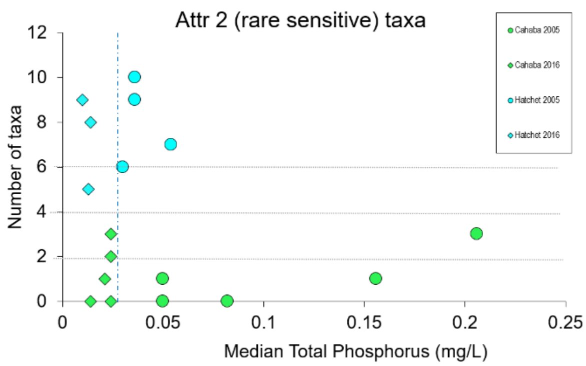

Fig. 10. Median total phosphorus concentrations (mg/L) and number of Attribute 2 taxa collected from the Cahaba River (green) and Hatchet Creek (blue) stations in 2005 (circles) and 2016 (diamonds). Numbers of Attribute 2 taxa collected from the Cahaba River stations were similar during 2005 and 2016.

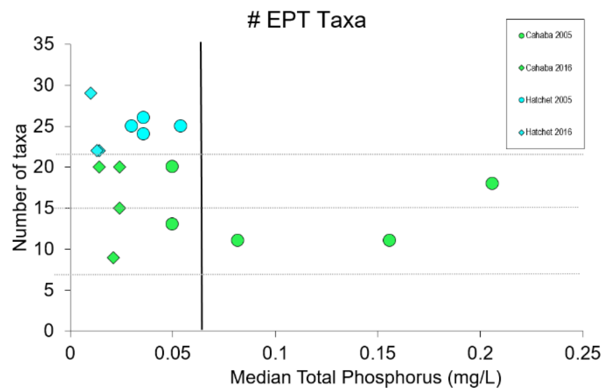

Fig. 11. Median total phosphorus concentrations (mg/L) and number of EPT taxa collected from the Cahaba River (green) and Hatchet Creek (blue) stations in 2005 (circles) and 2016 (diamonds). Numbers of EPT taxa collected from the Cahaba River stations were similar during 2005 and 2016.

Fish Community Survey Results

Fish community surveys were conducted at two locations in 2004 and 2019. Small improvements in the condition of the community were observed as shifts from pollution tolerant to pollution intolerant species and increased trophic diversity. Results are summarized in Table 1.

Table 1. Results of fish IBI community surveys conducted at C-1 and CABJ-6 in 2004 and 2019.

Metrics	**C-1**			**CABJ-6**		
	10/7/2004	**7/3/2019**	**Trend**	**10/7/2004**	**7/3/2019**	**Trend**
Taxonomic richness and diversity metrics						
Total native species	23	23	No change	21	22	No change
Num shiner species	4	4	No change	4	3	No change
Num *Lepomis* species	3	3	No change	4	5	No change
Num darter+madtom sp	5	6	No change	4	4	No change
Tolerance metrics						
Num intolerant sp (total)	1	1	No change	1	1	No change
% tolerant	8.86	1.37	Improved	13.05	2.86	Improved
% *Lepomis*	9.79	8.52	No change	34.48	13.47	Improved
Trophic metrics						
% omnivores	24.94	14.31	Improved	4.93	6	No change
% insectivorous cyprinids	38.23	49.77	Improved	35.22	53.71	Improved
% top carnivores (piscivores)	1.63	0.91	No change	1.72	4.57	Improved
Abundance, condition, and reproductive metrics						
% anomalies + hybrids	0	0	No change	0.25	0.29	No change
% simple miscellaneous	25.17	37.29	Improved	25.17	29.14	No change
Total IBI score	42	48	Improved	38	40	No change
Fish Community Rating	Fair	Good	Improved	Fair	Fair	No change

Threatened and Endangered Species

The decreased total phosphorus concentrations and the shift in the diatom community to more pollution intolerant species have not yet translated to improved condition of the macroinvertebrate and fish communities. However, the Cahaba River was listed as impaired by nutrient enrichment that degraded critical habitat for 11 specific threatened and endangered species. The macroinvertebrate and fish survey methods, designed to accurately and consistently assess biological conditions across the state, do not require collecting all rare species present at every site, and may therefore not be an accurate measure of the status of these specific populations.

The endangered species, *Notropis cahabae* (Cahaba Shiner), and the threatened species, *Percina aurolineata* (Goldline Darter), were listed as negatively impacted by habitat degradation caused by increased cover by filamentous algae. It has been several years since detailed status assessments of these two species have been conducted within the Cahaba River, but there are indications that the two populations are responding positively throughout the basin to the decreased concentrations of total phosphorus. *N. cahabae* has been collected recently from Shades Creek, as well as one location on the Cahaba River. *P. aurolineata* occurs at locations within the Cahaba River from Bains Bridge down to Centreville, the Little Cahaba River, and Shades Creek. Detailed status assessments are needed to confirm these patterns.

Since 2004, the mollusk community of the Cahaba River has been monitored multiple times using both qualitative and quantitative survey methods. Four long-term fixed locations were established in 2005. They have been monitored quantitatively every five years to accurately document trends in mussel and snail densities and taxa richness. In 2015, a fifth fixed station was dropped, and the quantitative collection methods were revised to be better suited to the bedrock substrates and flashy flows characteristic of the Cahaba River (M. Buntin 2019). Qualitative surveys have been conducted to establish long-term trends in species status and distribution. There has been significant effort to compile information collected during various quantitative and qualitative studies into centralized databases for mussels and snails. These have been collaborative efforts by state and federal agencies, state universities, and local stakeholder groups.

There are indications that mussels and snail populations are improving or remaining steady at some locations throughout the basin, including the Grants Mill area of the Cahaba River and the lower Shades Creek watershed. Additionally the large land purchases in Bibb County have resulted in obvious improvements to biotic conditions along this stretch of Cahaba River. Based on increased abundance throughout its range, the USFWS has recently been petitioned to delist the threatened Round Rock Snail (*Leptoxis ampla*). The endangered *Pleurobema decisum* (Southern Clubshell), thought to be extirpated since 1973, has also been observed at multiple locations. (P. Johnson, personal communication)

However, mollusk communities continue to decline within several segments of the river due to channel damage and a lack of stable, rock-bar shoals, siltation and sedimentation, and degraded habitat. Instream water quality also continues to be a concern. (P. Johnson, personal communication)

Other Stressors

Siltation/sedimentation

The lack of significant improvement in the condition of invertebrate, fish, and mollusk communities, despite decreased concentrations of total phosphorus and a return to a more natural diatom community composition, may also be linked to the presence of significant siltation impacts. The entire 105 mile segment of the Cahaba River, from US Hwy 82 at Centreville upstream to I-59 near Trussville, listed for nutrients, was also listed for siltation/habitat degradation in 1998. Several previous studies have documented the loss of pollution-sensitive fish species due to siltation impacts related to extensive urbanization within the basin (Howell et al. 1982, Oronato et al. 1998, Oronato et al. 2000, O'Neil 2002).

Fig. 12. Eroded bank at CABB-7, on Lower Cahaba River, downstream of Centreville, Alabama, March 19, 2019. Photo by Cal Johnson.

Impacts to the macroinvertebrate (Howard et al. 2002) and mollusk communities (Johnson et al. 2005, Fobian et al. 2011, Johnson 2015, and Johnson and Buntin 2015) have also been documented. Impacts from sediment loading include increased turbidity due to suspended particulate matter, increased scouring during high flow events, and increased sediment deposition and subsequent modification of streambed composition (Jones et al. 2011).

Siltation has impacted aquatic communities within the Cahaba River by filling in the interstitial spaces used as habitat by aquatic macroinvertebrates, and for spawning by some fish species. Recent studies have shown percent cover by filamentous algae to vary greatly due to scour during the extremely high peak stream flows in the Cahaba River (EPA 2002, ADEM 2006b, ADEM 2012). Scouring of substrate during peak flow may also impact mussel populations within the Lower Cahaba River basin. Mussel surveys conducted within that area of the basin indicate the assemblage to be negatively affected by the lack of stable, rock-bar shoals needed for mussel colonization (Fobian et al. 2011). Although heavy siltation has been well documented in habitat surveys and pebble count estimates, few studies have documented increased total suspended solids or turbidity during routine monthly monitoring of the Cahaba River. Continuous flow and turbidity measurements, and collection of total suspended solids during high flow events may be needed to more fully understand sediment loading within the Cahaba River system.

Several recent studies have attempted to characterize the “multiple-stressor” effect of nutrient enrichment and sediment loading. Results have been variable, and suggest that the biotic response to concurrent nutrient and sediment impacts to be highly complex and not easily predicted (Chase et al. 2017). Some studies have indicated that the interaction of multiple stressors produce impacts to aquatic communities distinct from impacts that would be expected from each individual stressor (Lemly 1982, Townsend et al. 2008, Wagenhoff et al. 2011). A mesocosm study of the effect of increased nutrients, increased fine sediment, and decreased flow found the combined impacts to be mainly additive, and recognizable as impacts caused by nutrient enrichment, siltation, and low flow (Elbrecht et al. 2016). Chase et al. (2017) found that nutrient loading and sedimentation interact to deteriorate lotic systems beyond levels attributable to each individual stressor, suggesting that the two stressors are positively cumulative, and need to be jointly managed.

The interaction between stresses from nutrients, sediment, and flow within the Cahaba River are complex. Through turbidity and scouring, siltation may decrease algal growth and accumulation of biomass. However, excess sediment may also serve to maintain highly episodic nutrient inputs in the river system long enough for autotrophs to make use of them (Mainstone 2010).

Assessment of Aquatic Life Use

While the Cahaba River was listed as impaired, based on the status and health of threatened and endangered fish and mussel species within the river, the causes of impairment were identified using fish and macroinvertebrate community surveys. Fish and macroinvertebrate surveys were also the primary indicators used to measure the biological response to the TMDL. While fish community surveys directly measure the status and health of rare and endemic fish species, macroinvertebrates do not directly measure the status and health of mussel species. Coordination of ADEM’s water quality monitoring with the mussel surveys conducted by the Alabama Department of Conservation and Natural Resources (ADCNR) could greatly assist in directly measuring the status and health of mussel species, correlating condition and status of mussel communities to water quality conditions, and begin to define environmental requirements and tolerances of these species.

In 1998, when the Cahaba River was listed for siltation and nutrient enrichment, primarily for physical impacts to critical habitat for threatened and endangered species, little was known about the environmental requirements and tolerances of these species. Development of ambient water quality criteria and other environmental guideline values did not include data for freshwater mussels until recently, in part because mussel toxicity testing methods are comparatively new and data may not have been available when criteria and guidelines were derived. In 2006, the American Society for Testing and Materials (ASTM) provided new guidelines for freshwater mussel toxicity testing. With these methods in place, and advancements in culturing and propagating mussel species for bioassay and recolonization work, there has been an increase in the number of chronic and acute toxicity tests documenting the sensitivity of mussels (larvae, glochidia, and adults) to metals, ammonia, and organic compounds. This information has enabled the EPA to accurately update the water quality criteria for copper (2007), carbaryl (2012), ammonia (2013), selenium (2016), and cadmium (2016) to be protective of mussel species.

ADEM collects and analyzes water samples for concentrations of each of these compounds, which has provided a good baseline dataset going back three decades. However, incorporating collection and analysis of sediment samples for metals, organics, and ammonia can provide more accurate measures of the environmental conditions and potential stressors to mussels within the river.

Future Activities

Table 2 summarizes the monitoring scheduled on the Cahaba River, Hatchet Creek and Shades Creek by the ADEM, the Alabama Department of Conservation and Natural Resources, and US Fish & Wildlife Service during 2020. Quantitative survey sampling of mussel and snail populations will be conducted at the four long-term fixed locations established in 2005 (P. Johnson, personal communication). Concentrations of metals and organic compounds in the water column and sediment at long-term mussel survey sites will be analyzed to evaluate potential toxicity to mussel species. ADEM is also developing methods to evaluate siltation impacts within the Cahaba River and Shades Creek.

Summary

Water quality sampling in 2005 and 2016 show a distinct decrease in water column total phosphorus concentrations in the Cahaba River. Annual sampling at seven locations show total phosphorus concentrations to be meeting the instream target, with median total phosphorus concentrations at Cahaba River stations ranging from 14 µg/L to 24 µg/L in 2016.

During the 2002-2016 surveys of the Cahaba River, diatoms have consistently proved to be the most effective tool to document nutrient impacts to aquatic communities, and to link community conditions to nutrient concentrations. In the 2002-2005 surveys, the diatom community was dominated by species tolerant of nutrient enrichment. Results of the 2016 diatom community suggest that the community is responding to decreased total phosphorus concentrations with a shift to taxa intolerant of nutrient enrichment.

Recommendations

- Continue to monitor and maintain current nutrient concentrations within the river.
- Continue to conduct macroinvertebrate, fish, and diatom surveys at locations along the Cahaba River on a 3-yr basin rotation to monitor the condition of these communities over time.
- Complete the T&E status surveys scheduled for 2020 to evaluate the impact, if any, of the decreased nutrient concentrations on these specific species.
- Establish long-term fixed locations to monitor fish community conditions, as well as the status of T&E fish species, every three to five years to document trends in species abundance and range over time.
- Use ADEM's Rain Event Sampling Techniques to quantify sediment loads carried in the river during high flow events.
- Add additional parameters as needed to fully understand impacts and stressors to T&E species.
- Continue to coordinate comprehensive monitoring, assessment, and restoration activities among state, federal, and local agencies and stakeholders.

Table 2. Summary of 2020 Monitoring Activities to be conducted in Cahaba River and Shades and Hatchet Creeks.

StationID	County	Location	Fish	Macro-invertebrates	Peri-phyton	Habitat Only	Siltation	Water Quality	Sampling Summary	Sampling Protocol	Eco-region	Area (Sq mi)	LATITUDE	LONGITUDE	Comments
C-1	St Clair	Cahaba R at St. Clair Co Rd 10 (Roper Rd) at Whites Chapel		X	X		X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67H	50.84	33.60503	-86.54924	
C-2	Shelby	Cahaba R at Shelby Co Rd 29–Caldwell Mill Rd Caldwell Ford Bridge						X	3X Monthly (JunAugOct)	Wadeable-Bioassessments	67H	200.26	33.41546	-86.74002	
C-3	Shelby	Cahaba R at Shelby Co Rd 52 Bridge west of Helena						X	12X Monthly (Jan-Dec)	Wadeable-Bioassessments	67H	353.39	33.28469	-86.88281	
CABB-1	Bibb	Cahaba R at AL Hwy 219.						X	3X Monthly (JunAugOct)	Wadeable-WQS	65P	1025.8	32.94631	-87.14026	
CABB-3*	Bibb	Cahaba R at Old Coal Rd						X	1X (Sep-Nov)		67H		33.16561	-87.02948	
CABB-4*	Bibb	Cahaba R at Bibb Co Rd 26						X	1X (Sep-Nov)		67F		33.01913	-87.07853	
CABB-7	Bibb	Cahaba R at Brentwood Farms	X				X		SWQMP Sampling Period	Wadeable-Bioassessments	65P	1076.9	32.90038	-87.13686	
CABJ-6*	Jefferson	Cahaba R at Grants Mill Rd		X	X		X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67H	128.84	33.51152	-86.65258	
CABS-2	Shelby	Cahaba R at the end of Sandpiper Lane					X	X	8X Monthly (Mar-Oct)	Wadeable-Bioassessments	67H	218	33.38390	-86.77788	
CAHD-1A	Dallas	Cahaba R at confluence with Alabama R						X	7X Monthly (Apr-Oct)	Nonwadeable Boat	65P		32.32677	-87.10463	
CAHB-1*	Bibb	Cahaba R at new U.S. 82 bridge in Centreville.						X	1X (Sep-Nov)		65I		32.95780	-87.13970	
CAHS-1	Shelby	Cahaba R at Shelby Co Rd 175 Bains Bridge (Old Montomery Hwy)		X	X		X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67H	229.16	33.36350	-86.81320	
SHDJ-10	Jefferson	Shades Ck at Jemison Park, Mountain Brook at Watkins Ck input	X	X			X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67H	19.87	33.47600	-86.76300	Requested by TNC; E. coli, sediment, and spiked hydrograph
SHDJ-6	Jefferson	Shades Ck at Dickey Springs Rd	X				X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67G	71.3	33.32586	-86.94863	
SHDJ-7	Jefferson	Shades Ck at Elder St, near Irondale, AL	X				X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67F	9.59	33.52093	-86.71690	Requested by TNC; below impact zone from Easwood Mall stormwater and E. coli input; E. coli, sediment, and spiked hydrograph
SHDJ-8	Jefferson	Shades Ck near I-20	X				X	X	SWQMP Sampling Period	Wadeable-Bioassessments	67F	7.91	33.53167	-86.70381	Requested by TNC; above impact zone from Easwood Mall stormwater and E. coli input; E. coli, sediment, and spiked hydrograph
SHDJ-9	Jefferson	Shades Ck at the stormwater culvert outfall above the Elder St bridge				X		X	SWQMP Sampling Period	Wadeable-Bioassessments	67F		33.52120	-86.71620	Requested by TNC; at impact zone for major stormwater commercial development; sediment and spiked hydrograph
HAT-2	Coosa	Hatchet Ck, approx. 0.75 mi downstream of Topopkin Ck (Coosa R Basin)		X	X		X		SWQMP Sampling Period	Wadeable-Bioassessments	45A	132.43	32.99980	-86.14250	
HAT-3	Clay	Hatchet Ck at East Mill (Co Rd 4) (Coosa R Basin)		X	X		X	X	SWQMP Sampling Period	Wadeable-Bioassessments	45A	59.51	33.13045	-86.05469	
HATC-1A	Coosa	Hatchet Ck approx. 0.5 mi us of Coosa Co Rd 29 (Coosa R Basin)						X	8X Monthly (Mar-Oct)	Nonwadeable Grab-Shallow	45A	284.26	32.86486	-86.33390	
HATC-2	Coosa	Hatchet Ck at US Hwy 280 (Coosa R Basin)				X		X	SWQMP Sampling Period	Wadeable-Bioassessments	45A	117.45	33.03639	-86.12333	
HATC-4	Coosa	Hatchet Ck approx. 4 mi us of Coosa Co Rd 18 (Coosa R Basin)		X	X		X	X	SWQMP Sampling Period	Wadeable-Bioassessments	45A	237.04	32.94392	-86.23579	

*mussel survey location

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