Stream Habitat and Mussel Populations Adjacent to AAWCM Sites in the Lower Flint River Basin

Nathalie D. Smith[1], Stephen W. Golladay[2], Brian A. Clayton[3], and David W. Hicks[4]

Affiliation: [1]Lead Research Technician, [2]Associate Scientist, [3]Monitoring Technician, [4]Scientist, Joseph W. Jones Ecological Research Center, 3988 Jones Center Drive, Newton, Georgia, 39870, 229-734-4706.

Reference: McDowell RJ, CA Pruitt, RA Bahn (eds.), *Proceedings of the 2015 Georgia Water Resources Conference*, April 28-29, 2015, University of Georgia, Athens.

Abstract. Freshwater mussel communities of the Flint River Basin (FRB) in southwestern Georgia are among the richest mussel assemblages in the southeastern United States. Declines in these populations appear to be associated with periodic droughts along with increasing water withdrawal for irrigation and other uses. Concerns about stream health and recognition of the need to manage water efficiently led to the development of Advanced Agricultural Water Conservation Measures (AAWCM). In 2012 and 2014, we examined the effects of AAWCM installed in operational settings on in-stream habitat, flow, and mussel populations in two watersheds of the lower Flint River Basin: Spring Creek and Ichawaynochaway Creek.

Mussel abundance was relatively low in the sites sampled during the 2012 field season (in comparison to historic 1999/2001 surveys). In 2014, Spring Creek mussel abundance increased at sites adjacent to AAWCM farms and at two of three downstream locations. Increases followed the end of drought conditions and the apparent recruitment of mussels likely resulted from normal growing season stream flow. In 2014, Ichawaynochaway Creek mussel abundance remained constant or decreased at all sites.

Historic surveys noted 2-11 mussel species at sampling sites. In 2012, 1-10 species were noted and in 2014, 0-8 species were noted. Abundance also declined from 8-1028 individuals per 100m reach to 0-629 individuals. Endangered species were rare at all sites and surveys. Rapid declines or extirpation of species at many sites occurred during the 1999-2001 drought, followed by an ongoing decline of surviving individuals through 2014. It appears that long-term declines in freshwater mussels continue in the tributaries of the lower Flint River.

INTRODUCTION

Freshwater mussel communities of the Flint River Basin (FRB) in southwestern Georgia are among the richest mussel assemblages in the southeastern United States. Historically, 29 species of mussels, seven of which were endemic, existed in the Flint River system (Clench and Turner 1956). Surveys conducted between 1991 and 1993 found that several Flint River tributaries within the Coastal Plain (lower FRB) continue to harbor diverse mussel faunas, numbering from 9 to 16 species, including several endangered species (Brim Box and Williams 2000). However, only 22 of the 29 species originally found in the Basin were observed during the 1999-2001 survey. The area in which the highest concentration of endangered species were found, and the most abundant and diverse communities were noted, was in the tributary streams of the Flint River flowing through the Coastal Plain portion of the watershed, the lower FRB.

BACKGROUND

In southwestern Georgia, drought conditions from 1999-2001 resulted in extreme low flows in the tributaries of the lower FRB. Across the region, perennial streambeds went dry, while other stream segments became intermittent, with aquatic habitat limited to isolated pools (Golladay et al. 2004). In some locations, headwater sections sustained flow, while downstream sections stagnated (Johnson et al. 2001). In larger streams, flowing water persisted throughout the drought; however water levels dropped to unprecedented lows (USGS 2000). During the 1999 to 2001 drought, declines in mussel abundance (up to 93%) were observed in streams subject to record low flow conditions (Golladay al. 2004). Greatest declines in mussel abundance were observed in the mid-reaches of the major tributaries of the lower Flint River.

Water use in the lower FRB has increased dramatically since the development of center pivot irrigation technology in the mid 1970s (Hicks et al. 1987). Declines in mussel populations appear to be associated with periodic droughts along with increasing demand for irrigation water supply. Drought-caused low flows stress remaining populations and accelerate the loss of freshwater mussel diversity from the lower FRB. Ongoing rainfall deficits, from 1998-2013, continued to raise concerns about water use within the region and its potential impact on stream flows and stream biota.

Concerns about stream health and recognition of the need to manage water efficiently led to the development of Advanced Agricultural Water Conservation Measures (AAWCM). Technologies including variable rate irrigation, detailed soil mapping, field sensors, and remote controlled triggering mechanisms have been used in research settings to optimize water application rates. In this project we are examining the effects of AAWCM installed in operational settings on in stream habitat, flow, and mussel populations in adjacent tributary streams sensitive to drying during droughts.

Specific objectives included:

- Using quantitative census techniques to assess the status of native and introduced mussel populations in the lower FRB.
- Conducting surveys of in stream habitat conditions, flows, and water quality using previously established measures important to mussel persistence and survival.

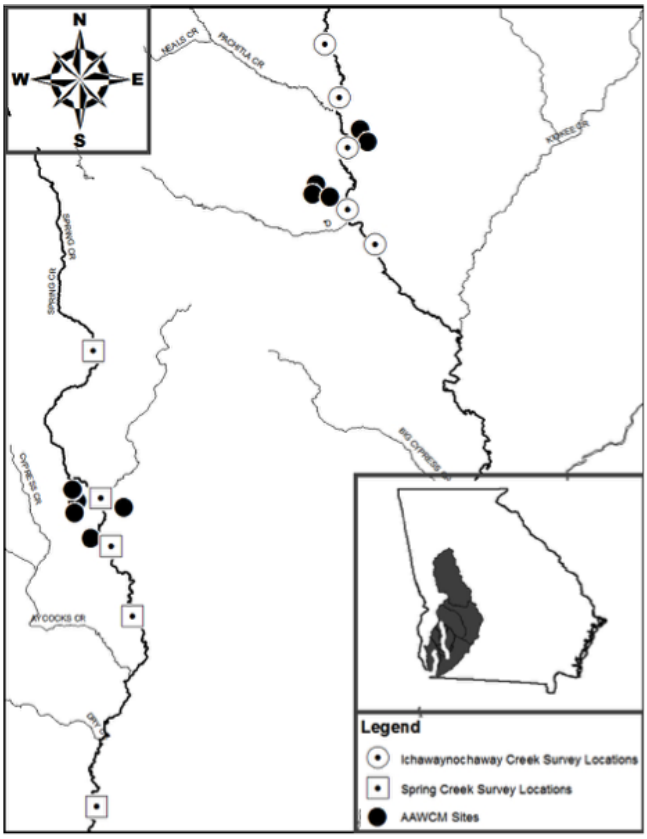

Figure 1: Survey locations and Advanced Agricultural Water Conservation Measures (AAWCM) farms.

METHODS

Mussel surveys

This study was conducted in two watersheds of the lower Flint River Basin: Spring Creek and Ichawaynochaway Creek (Fig. 1). At AAWCM sites, 100-m study reaches were established for intensive surveys. Prior to establishment of study reaches, extended qualitative surveys were conducted along the stream adjacent to AAWCM sites. The extended surveys, up to 2 km in length, were used to ensure that study reaches were representative of stream conditions at each AAWCM site. Where possible, historical mussel survey reaches (Johnson 2001; Golladay et al. 2004) were incorporated into the study design.

Study reaches were positioned upstream, adjacent to, and downstream of AAWCM sites. Within each reach, the streambed was searched for mussels. In small streams (less than 12-m wide), this included the entire bed surface within the 100-m survey reach (i.e., surface sediments were sieved with fingers to a depth of 5 cm) or visually searched for live unionids. In large streams (fourth order or larger; greater than 12-m wide), visual and tactile searches for live and dead mussels were conducted along five transects placed parallel to stream flow along the length of the stream reach. Transects were two meters wide and evenly spaced across the width of the stream, with one transect on each bank. Live native mussels were identified and immediately returned to the stream bottom. Unionids were identified to species, except for a group collectively known as Eastern Elliptios (*Elliptio spp.*), because taxonomy and field identification remain ambiguous.

Habitat surveys

At study reaches delineated above, intensive field measures of in stream habitat, channel form, flow characteristics, and watershed characteristics were made. Parameters measured were based on previous studies determining physical habitat characteristics that influence suitability of habitat for native mussel species (e.g., Johnson 2001; Johnson et al. 2001; Golladay et al. 2004). Channel cross sections were established at 0, 25, 50, 75, and 100 m at

each study reach. Canopy density, benthic flow velocity, depth, stream substrate, dissolved oxygen, and stream temperature were measured at uniformly spaced points across each transect (minimum of 10 points). Routine water quality samples were collected during the summer survey period and analyzed for NO_3-N, NH_4-N, PO_4-P, pH, alkalinity, suspended solids, and organic carbon using standard laboratory methods.

RESULTS

Survey reach habitat characteristics

Survey sites on Ichawaynochaway Creek were generally wider (wetted width), deeper, and had greater average flow velocity than Spring Creek. Stream width, depth, and velocity were lower during the summer of 2012 compared to 2014, reflecting the rapid transition from below-normal to above-normal rainfall. The wetted width of both streams ranged from 12 to 30 m and average channel depth was less than a meter. Occasional deep pools were encountered at all survey sites, but they represented a small proportion of channel areas. Deeper areas occurred on the outside of stream meanders, where scouring likely occurs during high flows. Deep pools were also observed within the channel and often appeared to be sinks, likely formed when fractures in the underlying limestone collapsed. In Spring Creek these deeper areas were often where we encountered listed species, especially *Hamotia subangulata*. In Ichawaynochaway Creek, these areas often had small clusters of *Elliptio crassidens* and *Elliptio spp.* Pools may represent long term refugia for individuals in reaches prone to low flows or drying.

Stream water temperature (day time) ranged from 18 to 27 C (64 to 81 F). In both streams, temperatures observed during 2012 were generally lower than 2014. Spring Creek generally had lower temperatures than Ichawaynochaway Creek. Dissolved oxygen (DO) concentration (day time) ranged from 4 to 8 mg/L. DO concentration was generally greater in Ichawaynochaway Creek and during 2012 compared to 2014. Canopy cover was highly variable (range 7-90%) depending upon stream width and riparian land use. At most survey sites, stream banks were vegetated and stable, however, in some agricultural areas, riparian buffers were narrow. We also encountered evidence of historical trash disposal and water diversions.

Mussel populations

During summer 2012, ten study reaches were established, five on Ichawaynochaway Creek and five on Spring Creek. Sites immediately adjacent to the AAWCM installations were established and sampled for the first time during 2012. Other sites, generally upstream or downstream from AAWCM sites were sampled previously and provide a long term record of changes in mussel abundance and diversity in Ichawaynochaway Creek and Spring Creek.

Table 1: Occurrence of mussel species in 100-m survey reaches in Ichawaynochaway (IN) and Spring Creeks.

	IN Creek		Spring Creek	
	2012	2014	2012	2014
Elliptio sp.	X	X	X	X
Elliptio crassidens	X	X	X	-
Hamiota subangulata	-	-	X	X
Lampsilis floridensis	-	-	X	-
Megalonaias nervosa	X	-	-	-
Pleurobema pyriforme	-	-	X	X
Quadrula infucata	X	-	-	X
Toxolasma paulum	X	-	X	X
Uniomerus columbensis	-	X	-	-
Utterbackia imbecillus	-	-	X	-
Villosa sp.	X	-	X	-
Villosa lienosa	X	X	X	X
Villosa vibex	X	-	X	X

Mussel abundance was relatively low in the sites sampled during the 2012 field season. In Ichawaynochaway Creek, very few mussels were observed at sites adjacent to AAWCM installations. Values reported are for the established 100-m survey reaches, but qualitative surveys also indicated low mussel abundance in the mid reaches of Ichawaynochaway Creek. Survey sites above and below had greater mussel abundance. The most abundant species observed in Ichawaynochaway Creek was *Elliptio crassidens*, the Elephant Ear. Seven species of mussels were observed in Ichawaynochaway Creek (Table 1).

In 2012, Spring Creek mussel abundance was also low adjacent to AAWCM sites. However, in 2014 overall mussel abundance increased at sites adjacent to AAWCM farms. Small individuals of two taxa, *Elliptio spp.* and *Villosa spp.* accounted for much of the increase in abundance. Most of the small individuals captured were found associated with stream bank habitat. In 2012, relatively high mussel abundance was observed downstream from AAWCM sites. In 2014 an increase in mussel abundance was observed at two downstream locations while a decline in mussel abundance was observed at the site furthest downstream from AAWCM farms. During the summer of 2014 no species were captured at site 97090 due to low flows and a dry creek bed. Nine mussel species were observed on Spring Creek including two listed species, *Hamotia subangulata* and *Pleurobema pyriforme* (Federally endangered) (Table 1). The listed species were

found in low abundance at the three downstream sites on Spring Creek.

Comparison with historical mussel data

Ichawaynochaway Creek and Spring Creek were sampled for mussels in 1999, 2001, and 2012, 2014 (this study). Surveys noted 2-11 mussel species at sampling sites in 1999 and only 1-8 species in 2012 (Fig. 2, bottom). Abundance also declined from 8-1028 individuals per 100m reach to 1-429 individuals (Fig. 2, top). Endangered species were rare at all sites and surveys. Rapid declines or extirpation of species at many sites occurred during the 1999-2001 drought, followed by an ongoing decline of surviving individuals through 2012. Little evidence of recruitment, i.e., presence of smaller individuals, was observed until the summer of 2014 at 2 sites on Spring Creek. It appears that long-term declines in freshwater mussels continue in the tributaries of the lower Flint River. Remaining individuals are widely dispersed and it is uncertain whether they represent viable populations.

CONCLUSIONS

This study, while not designed to evaluate drought conditions, observed very low flow conditions associated with the end of the 2010-2012 drought. Observations included the minimum 1-day flow of record on Ichawaynochaway Creek (July 2012) and extensive drying of Spring Creek throughout much of the study area. We also observed a very rapid transition from above normal flows in Ichawaynochaway Creek to below normal flows (April-August 2014) during dry summer conditions. In Spring Creek, flow ceased above Arlington, GA during this period. During low flows and stream drying, instream habitat is reduced in availability and quality. As flows diminish, bank habitat is lost first.

While not quantified in this study, stream banks often have relatively high mussel abundance compared to other areas. *Elliptio spp.*, *Villosa spp.*, and *Toxolasma spp.* appear to prefer bank habitats (personal observation). Bank habitat was also where mussel recruitment was observed in Spring Creek during 2014. Ongoing reduction of stream flow causes exposure of shoals and bank habitat, and eventually stream drying. Mussels, having limited mobility, are particularly susceptible to stranding as portions of the stream dry (Golladay et al 2004). Stranding exposes mussels to dehydration, low DO, excessive temperatures, and predation (Golladay et al. 2004).

Declines in mussel populations were apparent in tributaries of the lower FRB during the droughts from 1998

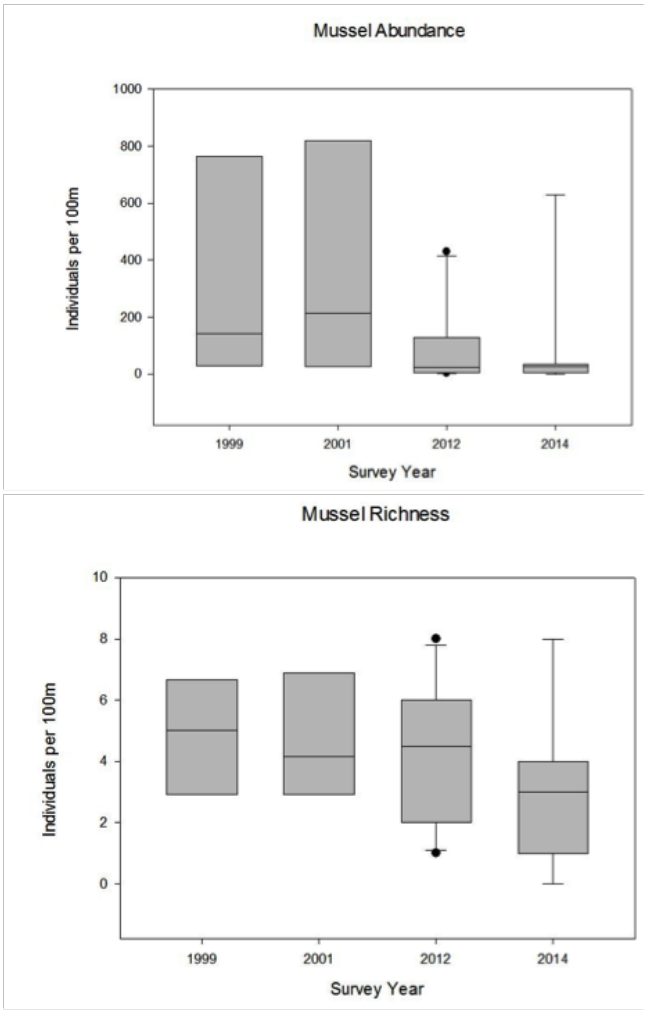

Figure 2: Long term changes in mussel abundance (top) and richness (bottom) in Spring and Ichawaynochaway Creeks (combined data).

through 2012. Even sites where mussels survived the initial 1999-2001 drought (Golladay et al. 2004), mussel abundance appeared to be lower during summer 2012 and 2014 sampling. Both common species, i.e. those generally assumed to be stress tolerant, and rarer species showed declines. During the summer of 2010 through 2012, record growing season minimum flows were observed throughout the lower Flint River and its tributaries. Extended low flow conditions undoubtedly contributed to ongoing declines in mussel abundance through loss of habitat, failures of recruitment, and mortality.

This study did show limited evidence of mussel recruitment in Spring Creek in 2014. This was likely attributable, in part, to the restoration of more normal stream flow with the end of the 2010-2014 drought. Whether recruitment was attributable to water availability (normal seasonal rainfall), increased efficiency of water use (associated with AAWCM installation and

flow augmentation) or decreased demand (lower rates of irrigation) is uncertain. The extent and magnitude of recruitment is unknown and beyond the scope of this study. Certainly, understanding factors associated with mussel recruitment are a high research priority. Determining adequate levels of growing season flows is also essential for developing water management plans that preserve in stream communities and ecological processes.

The results of this study combined with data on historical freshwater mussel distributions points to a long term decline for many mussel species in the Apalachicola, Chattahoochee, and Flint Basin attributable to a history of multiple disturbances (e.g., Brim Box and Williams 2000). Many species classified as endangered or of special concern disappeared from the mainstem of the Chattahoochee River and, to a lesser extent, the Flint River by 1991 (Brim Box and Williams 2000). More recently, extended droughts and water withdrawal have caused declines in the mussel fauna of mid-reaches of tributaries in the lower FRB (e.g., Golladay et al 2004).

Once the distribution of a species becomes disjunct or is confined to smaller tributaries, the pattern of decline continues, eventually leading to extirpation or extinction of the species. Apparently, recolonization does not occur, or occurs infrequently compared to the frequency and severity of decline-causing disturbances. Unfortunately, little is known about the metapopulation dynamics of many freshwater mussels beyond that their reproduction is linked to fish hosts. Once the mussel populations decline over large areas, remaining isolated populations, like those documented in historical studies of the lower FRB, may have little chance of contributing to recovery through the larger basin.

REFERENCES

Brim Box J, JD Williams, 2000. "Unionid mollusks of the Apalachicola basin in Alabama, Florida, and Georgia" *Alabama Museum of Natural History* Bulletin 21. Tuscaloosa AL.

Clench WJ, RD Turner, 1956. "Freshwater mollusks of Alabama, Georgia, and Florida from the Escambia to the Suwanee River" *Bulletin of the Florida State Museum* 1:97-239.

Golladay SW, P Gagnon, M Kearns, JM Battle, DW Hicks, 2004. "Response of freshwater mussel assemblages (Bivalvia: Unionidae) to a record drought in the Gulf Coastal Plain of southwestern Georgia" *J North American Benthological Society* 23:494-506.

Hicks DW, HE Gill, SA Longsworth, 1987. "Hydrogeology, chemical quality, and availability of groundwater in the upper Floridan Aquifer, Albany Area, Georgia" *USGS Water-Resources Investigations Report 87-4145*, Atlanta GA. 40 pages.

Johnson PM, 2001. "Habitat associations and drought responses of freshwater mussels in the lower Flint River basin", *MS Thesis*, University of Georgia, Athens [electronic resource].

Johnson PM, AE Liner, SW Golladay, WK Michener, 2001. "Effects of drought on freshwater mussels and instream habitat in Coastal Plain tributaries of the Flint River, southwest Georgia (July-October 2000): Final Report", submitted to *The Nature Conservancy Apalachicola River and Bay Project*. Apalachicola FL.

USGS, 2000. "Georgia drought watch website. Summary of hydrologic conditions: September 2000 and earlier". United States Geological Survey. *http://ga.water.usgs.gov/news/drought99*. Accessed October 2000.