

Recent Developments in Our Macroinvertebrate Water Quality Monitoring Program

The Aquatic Science Programs (ASP) section of South Carolina DHEC is continually striving to improve the macroinvertebrate monitoring program while still producing comparable data of the highest quality. Over the last five decades, our monitoring has evolved along with the evolution of the science of water quality determination itself. Some of our more recent improvements are detailed below.

The expansion of sampling in large, non-wadable rivers

Beginning in 2014, we expanded our macroinvertebrate sampling to regularly include the larger rivers of the state. Until then, most sampling was restricted to easily wadeable streams, or in the early years used Hester Dendy artificial substrate samplers which required no wading. The new rivers methodology maintains as much of the multi-habitat, wadeable streams methodology as possible. Adjustments naturally include the use of a boat or kayak to reach the sampling site and to travel between the available habitats. These individual habitats are sampled as wadeable where shallow enough to allow it. Otherwise portions of the various habitats are brought into the boat and picked there. For example, limbs and logs caught up in the current as well as rootbank debris from the D-frame net can be picked in the boat. The greater distances between habitat types necessitate the expansion of the 3 person-hour sampling time usually observed for smaller streams. Each river site is sampled until the biologists feel that all available habitats have been adequately sampled.

For rivers sampling, some additional equipment is helpful. If there are no shallow areas where the sieve can be used, a ponar dredge takes its place. Likewise, there are often no suitable places available to use a kick net. Dragging limbs and logs into the boat are a substitute and this process is easier with the use of a long-handled clam rake to reach down and hook the deeper limbs. It can even bring up rocks from the bottom. Naturally it can also be used as an aid in searching for Unionid mussels which in rivers may constitute a significant portion of the invertebrate diversity.

There are no special criteria used just for rivers. The same ecoregion-based criteria that are applied to wadeable sites are also used for rivers with one caveat. We found that the character of the invertebrate community of a river tends to reflect not the ecoregion where the sampling site is located so much as the ecoregion where most of the watershed (upstream of the site) is located. That being the case, we apply criteria based on location of the watershed instead of the site. While it only effects a few sites, we are also expanding this notion to assure that we choose appropriate criteria for our wadeable stream stations as well.

In the years before our expansion of large rivers sampling, we increased our use of species-level identification of the taxonomically difficult family Unionidae, the fresh water mussels. This timely effort not only improves our water quality assessments but is also allowing us to better document the range and diversity of these imperiled animals.

Megalodon Index and Count

SCDHEC macroinvertebrate bioassessment methodology is designed to assess the water quality of permanent, flowing streams. For years we have known the importance of continuous flow and presence of water to a macroinvertebrate community and have tried to avoid sampling sites that appear to be in such a condition. What is more difficult to determine, but equally likely to affect our assessment, is whether a site has in the past few months or a year been dry or lacking flow. We have now developed a method which uses biology to help us answer those questions and avoid an incorrect water quality assessment. These new tools are still in a testing phase but appear very promising.

The megalodon count can help to determine whether a sampled stream has been permanent for the past year or has gone dry. The megalodon index can help to confirm that the stream has been consistently flowing. The condition of the stream on the day of sampling is not necessarily indicative of its condition throughout the remainder of the year. Incorrectly assuming that a sampled stream hasn't been dry and has been consistently flowing could lead to the inappropriate application of our assessment criteria and an erroneous water quality assessment due to unreasonably high expectations for the stream's biotic diversity.

For us the term "megalodon" has nothing to do with extinct sharks as you might imagine, but is a combination of the names of the orders of invertebrates used – *Megaloptera* and *Odonata*. Beginning on Aug 1, 2018, we have kept a count of the total number of mature individuals in these two orders (megalodons) in each sample. The animals in these two orders are especially useful to us because they are common, not particularly sensitive to poor water quality and most live as aquatic larvae for a year or more before emerging as flying adults. For our purposes, Odonates are considered to be mature if they have wing pads that extend posteriorly beyond the attachment point. Maturity of the *Megaloptera* is determined by the larva having reached approximately half of the mature length. Since these live for at least a year in the water and likely grow more length/month as they age, this length should indicate having lived in the water for 6 months to a year. For our purposes, we consider *Sialis* mature at 7 mm, *Nigronia* and *Chauliodes* mature at 15 mm, and *Corydalus* mature at 30mm. The presence of mature megalodons in a sample should indicate the continuous presence of water for 6 months to a year. We think that perhaps 4 or 5 are enough to demonstrate the continuous presence of water but continue to consider this as we collect more data. (Some species of *Cordulegaster* are known to survive brief periods of desiccation.) The absence of megalodons would suggest that the waterbody has been dry at some point during the past 6 months to a year and would be cause to question the validity of a sample's results and lead to use of professional judgement for the final water quality assessment.

We created the megalodon index to help us confirm that a stream has been flowing consistently during the past year and began using it on a trial basis at the same time. Using professional judgement, recent literature and associations of taxa within our database, taxa within the *Odonata* and *Megaloptera* orders were assigned values ranging from 1 - 10 indicative of that taxon's preference for lotic (flowing) or lentic (still) conditions. Calculation of the index averages these preference values in the same way as the tolerance values are averaged in the calculation of our biotic index (see our SOP). Also like the biotic index, abundance values are converted to 1, 3 or 10 before averaging. When plotted out, index values have a natural cut off at 4.0-4.5. We believe that index values below 4.0-4.5 indicate a stream with reliable flow. Values above that suggest that the stream has little or inconsistent flow and therefore should be assessed only with caution and professional judgement.

Development of Macroinvertebrate Criteria for the Mid-Atlantic Coastal Plain Ecoregion

Communities of aquatic macroinvertebrates have proven to be widely-used and reliable indicators of water quality across our state and nation. Unfortunately, for decades we have found reliable criteria for the Mid-Atlantic Coastal Plain ecoregion of South Carolina to be elusive. We have come to believe that seasonal lack of flow and permanence of water in these swampy streams plays a large part in the depressed diversity we find there. If that is indeed the case, then our new megalodon index and counts could be the key to the establishment of solid criteria for these coastal streams. Employing these new tools, we have developed some criteria which we are now optimistically testing.

Acceptance of these criteria would be in two phases. In the first phase, the new criteria are based on a much-modified version of the "S" swamp bioclassification score used by North Carolina averaged with the South Carolina Southeastern Plains bioclassification score plus 10%. This would apply only to streams shown (using megalodons) to have been consistently permanent and flowing. Streams with a pH of less than 4 or those shown to have been dry (by the megalodon count) would not be scored. In the second phase we will consider an additional graduated boost applied to streams with little or less-consistent flow as indicated by the presence of lentic biota (megalodon index). If this also proves to be reliable, we would be able to score a much larger percentage of our coastal streams as many seem to have issues with flow for at least a portion of the year. Otherwise, the first part could be used alone and streams with poor flow would not be scored.

While we are optimistic, this all remains very tentative and must still undergo much testing and tweaking until we feel confident with its use. We are currently collecting data from sites in this region having a wide range of development densities for use in calibration of these potential criteria. Again, at this time we do not have final criteria for the Mid-Atlantic and continue to rely on professional judgement until this process of testing and calibration is complete.