

PROPOSED SURVEY OF FRESHWATER MUSSELS, MUSSEL HABITAT, AND SEDIMENT CONTAMINATION ON THE BIG RIVER, MISSOURI

INTRODUCTION

In 2008, an assessment of heavy metal sediment contamination and freshwater mussel populations was conducted in the Big River, in eastern Missouri (Roberts et al 2009). Sediment was collected at 39 locations in the lower 209 km (130 mi.) of the river and tributaries and mussel population data was collected at 19 of those sites. The results of this study showed that Big River sediments are contaminated with heavy metals (at levels above the probable effects concentration) for long distances downstream of mining sites. Sites extending 158.7 km (98.6 river miles) downstream from mining sites appear to have impacted mussel communities. Documented impacts included reduced species richness and abundance compared to reference sites and a negative correlation between heavy metal concentrations and mussel populations.

The results of the 2008 study revealed the need for an additional assessment of sediment contamination, mussel populations, and distribution of suitable mussel habitat in the Big River. In particular quantitative data is needed from stream reaches between previously surveyed sites. This information will be used to more accurately characterize the longitudinal downstream extent of sediment contamination and downstream trends in mussel population parameters. More information is also needed on suitable habitat availability, including substrate composition and layering within suitable mussel habitat in the Big River. Subjective habitat assessments in 2008 suggested a negative correlation between the presence of smaller sediment particles (sedimentation) and diversity and abundance of mussels at sampling sites. However, this habitat assessment protocol was not designed for mussels. Some habitat parameters assessed in 2008 generated low scores for conditions that can be beneficial to mussels (e.g. substrate embeddedness). A more quantitative analysis of substrates within suitable mussel habitat will allow comparison of fine sediments between robust mussel habitat and metal-contaminated sites. The study will complement the Natural Resource Damage Assessment conducted in 2008.

The objectives of the proposed study are to: 1) identify and delineate suitable mussel habitat in river reaches between known mussel survey sites; 2) quantify substrate grain-size composition of suitable mussel habitat; 3) provide more quantified data on the relationship between heavy metal concentrations in sediment and the abundance of mussel populations in suitable habitat; ; and 4) provide additional data on the longitudinal extent of heavy metal contamination of sediment.

METHODS

This study will be conducted in two phases. Phase I includes conducting a reconnaissance survey to identify all sites with suitable mussel habitat in the lower 80 miles of the Big River. Sites identified in Phase I will be the subject of further site characterization in Phase II, which includes sampling of mussels, sediments, and substrates.

Phase I: Mussel Habitat Reconnaissance

In Phase I, the Big River will be traveled by boat from Cole's Landing (River Mile 80) to the confluence of the Meramec River to identify and delineate all suitable mussel habitat encountered in stable river reaches in riffles, runs, and/or glides. Potential suitable habitat will first be identified by the presence of stable substrate within riffles, runs, and/or glides, (, and then confirmed by the presence of living unionid mussels. Freshwater mussels require stable river channels; river reaches with active channel migration are not conducive for the formation of mussel beds. For purposes of this assessment study, a stable river reach is where the channel has not migrated more than ½ its width in the last 20 years as indicated on historic channel maps of the Big River provided by Pavlowsky (in draft). (All other areas not meeting this criteria will be excluded from the reconnaissance survey. Another feature of suitable mussel habitat is a stable substrate. For purposes of this assessment study, a stable substrate is a compact, consolidated substrate composed of a mixture of small particles (i.e. sand or sediment) and larger sized substrate (e.g. gravel or cobble). The surface of stable substrate is usually covered with a layer of diatoms or algae and the margins of the channel will often have growths of aquatic plants (e.g. *Justicia Americana*).

When stable habitat is encountered during the reconnaissance survey, timed searches will be conducted in the area to determine the presence of mussels. All mussels will be identified and enumerated. If the habitat is occupied by at least five living unionid mussels in one person hour of search time, all similar habitat in that area will be delineated (the boundary marked with a GPS) as suitable mussel habitat for additional sampling in Phase II. These sites will be delineated such that only the portion of the channel with suitable, occupied mussel habitat will be included for Phase II sampling, minimizing the variance in population estimates (Strayer and Smith 2003). Because mussels typically do not persist in portions of the channel that become emersed during dry periods, searches will be conducted during low flow to ensure only the wetted portion of the channel is included. Based on past surveys, it is expected that at least 50 sites may be delineated during this process.

Phase II: Mussel and Sediment Sampling

Phase II includes sediment sampling and intensive mussel surveys at up to 20 of the sites delineated in Phase I. If more than 20 sites are delineated in Phase I, then 20 sites will be randomly selected for more intensive sampling. Three additional sites will be sampled for mussels, substrate composition, and sediment toxicity. These sites will include: one reference site on the Bourbeuse River, one reference site on the Big River, and one randomly selected known mussel site upstream of river mile 80. More sites may be sampled in the study area to gain a better understanding of downstream trends.

Mussel Sampling

Quantitative sampling will be conducted at the selected sampling sites to provide estimates of mussel densities (individuals/m²) using a ¼ m² quadrat, which is the most efficient size quadrat (Strayer and Smith 2003). This involves collecting mussels within ¼ m² quadrats placed randomly within the delineated area of each site. Prior to sampling, 75 to 100 random points will be generated for each delineated area using the Random Points tool of ArcGIS 10. These random points will be downloaded onto a precision GPS (Trimble Geoexplorer 6000 Series) and used to position quadrats in the field. At each random point, the quadrat will be placed on the stream bottom, and all visible mussels will be collected while cobble and flat rocks are removed. Following this initial search, the remaining gravel substrate will be searched by mixing and fanning by hand until no more mussels are found. Lastly, the gravel will be gradually removed from the quadrat while continuing to search for mussels until gravel is removed to a depth of 10 cm (or to bedrock). All living mussels collected within the quadrats will be identified and the length measured. The age of each mussel will be estimated by counting external growth lines. After processing, substrate and mussels will be replaced into the original quadrat location.

Dead shells that are not represented by live individuals in the quantitative samples will be noted for species and classified as fresh-dead, dead, or subfossil. Fresh-dead shells represent individuals in which the soft anatomy has not fully decomposed, and indicate the individual has recently perished. Dead shells have some luster to the nacre (innermost layer of the shell) and have a relatively intact periostracum (outermost layer of the shell). Subfossil shells have chalky and lusterless nacre and are missing considerable amounts of the periostracum (Buchanan 1980). The rate at which shell material decomposes following the death of a mussel depends on a variety of factors, including whether the shell was above or below the substrate, whether the shell was in the water or immersed, species, and shell thickness. In general, dead shells represent mussels that have been dead for less than a year and subfossil shells represent mussels that have been dead for more than a year.

Mussel Sampling Data Analysis

Analysis of mussel data will be similar to Roberts et al (2010). Mean mussel densities from quantitative mussel survey data will be statistically compared among study sites. Potential analyses include a one-way ANOVA with rank-transformed data and Tukey's test for pair-wise comparisons of the means (Conover and Iman 1981). The statistical approach that will be used to evaluate associations of mussel survey data (mussels/m²) with sediment metal concentrations may include: (a) rank correlation analysis; (b) principal component analysis of the correlation matrix; and (3) multiple regression analysis.

Sediment Sampling

Sediment sampling will be conducted at each Phase II site where mussel data is collected. Before the substrate sample is taken and the site is disturbed, underwater photos will be taken of the substrate at each of the subsample points to document the make-up of the top layer of substrate. Approximately 7 to 15 kilograms of sediment will be collected at each location. GPS readings will be taken and recorded as described in a log book.

One composite substrate sample will be taken at each site that will consist of five subsamples or aliquots taken from random points within the delineated mussel habitat. These samples will be taken by driving a small bucket into the substrate to a depth of 10 cm angling the opening downstream and rapidly bringing the bucket to the surface to capture the sample. The five aliquots will be placed in a labeled 5 gallon plastic bucket and sealed with a lid. Labels will include a unique sample identifier, site name, date, and name of collector.

A McNeill sampler will be used to compare sampling methodologies designed to collect fine sediments under water. McNeill samplers are designed to fully capture all grain-sizes in a flowing stream by isolating the sediment sample from the surrounding water during collection. A subset of the total sample sites (a minimum of five) will have additional sediment collected, using the McNeill sampler. However, these samplers can only be used in relatively shallow water, less than 2 feet deep.

Subsamples for metals analysis will be collected in the laboratory from the 5 gallon bucket composite sample after thorough mixing. Approximately 0.25 kg of sediment will be placed in a plastic bag for analyses with the same label identifiers as the bucket. Duplicate sediment material will be collected at certain sampling locations for the purpose of quality control/verification of metals analysis. Duplicate samples will be selected to reflect a relative range of metal concentrations: high, medium, and low. One quality control (QC) sample will be analyzed for every tenth sample, or one QC sample will be collected by each team per day, whichever number is greater. Two separate bags should be collected with alternating spoonfuls of sample placed in each bag.

All sediment samples will be recorded in a log book and a chain of custody form. The chain of custody form will be maintained with the samples and will accompany the samples to the laboratory. At the laboratory the samples and chain of custody will be signed over to the sample custodian.

Metals Analysis

Sediment samples will be analyzed using an XRF meter and quality control samples will be analyzed by both XRF and by Inductively Coupled Plasma or Atomic Adsorption in a laboratory. Samples will be thoroughly mixed within a bag by shaking and/or hand manipulation. Samples will be analyzed by XRF after drying at room temperature for at least seven days or until less than 20% moisture has been achieved. A portion of each sediment samples will be sieved to less than 250 microns. Both the less than 250 micron and the bulk sample will be analyzed by XRF. Each sample will be analyzed for one minute with the XRF by placing the instrument directly against the bag with the sediment in full contact with the portion of the bag in contact with the XRF window. Three separate readings will be collected for each sample. These results will be recorded in a log book and stored electronically in a database spreadsheet.

A suite of calibration verification check samples will be used to check the accuracy of the XRF instrument and to assess the stability and consistency of the analysis for the analytes of interest. Check samples will be analyzed at the beginning of each working day, during active sample analyses, and at the end of each working day. The measured value for each target analyte should

be within ± 20 percent (%D) of the true value for the calibration verification check to be acceptable. If a measured value falls outside this range, then the check sample should be reanalyzed. If the value continues to fall outside the acceptance range, the instrument should be recalibrated, and the batch of samples analyzed before the unacceptable calibration verification check will be reanalyzed (USEPA 1998).

Quality control samples will be analyzed by XRF as described above. In addition, QC samples will be submitted to a laboratory for analysis of total Pb, Zn, Cd, and Ba using Inductively Coupled Plasma or Atomic Adsorption following EPA method 3050b “Acid Digestions of Sediment, Sludges, and Soils”.

A summary of the analytical parameters and methods are provided below:

Table 1. Analytical Parameters

Sample Type	Analytical Method	Analyte	Fraction analyzed	Estimated Number of samples
Contamination characterization	Office/laboratory XRF	Pb, Zn, Cd, Ni, Ba	Bulk and <250 micron	25
QC samples	Office/laboratory XRF and ICP or AA EPA 3050b	Pb, Zn, Cd, Ni, Ba	Bulk and <250 micron	5
Sediment grain-size fraction	Wet seive	Relative grain size	<63 μm , 63-250 μm , 250 μm -2mm, >2 mm, and Bulk fractions	28

Sediment Grain-size Analysis/Habitat Evaluation

The sediment samples will also be wet sieved using site water to determine metals content and the percentage of sediments that fall within the following fractions: <63 μm , 63-250 μm , 250 μm -2mm, and >2 mm. The composition of sediment sizes will be analyzed by the U.S. Geological Survey by calculating the volume of each substrate size class after sieving.

Surface Water Quality

Surface water quality analyses (i.e., temperature, pH, conductivity, dissolved oxygen, turbidity) will be measured in situ at each riffle within a site with a multi-parameter water quality instrument (e.g. YSI 556).

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