



Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network

Data Quality Standards—Version 1.0

Natural Resource Report NPS/CUPN/2018/1696



ON THE COVER

Clockwise from top left: Unidentified cave amphipod (Kurt Lewis Helf), *Caecidotea* sp. (Rick Olson), *Palaemonias ganteri* (Michael Durham), *Gyrinophilus palleucus* (Kurt Lewis Helf), *Orconectes pellucidus* (Rick Olson), *Amblyopsis spelaea* (Rick Olson).

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Contents

	Page
Tables.....	iv
Abstract.....	v
Introduction.....	1
Protocol Overview.....	1
Protocol Activities and Modules	2
Sampling Design	6
Data Quality Objectives.....	7
Data Quality Values	7
Literature Cited	14

Tables

	Page
Table 1. Project activity matrix for <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative</i> (Helf et al. 2018).....	4
Table 2. Activity-level sample design matrix for <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative</i> (Helf et al. 2018).	6
Table 3. Data Quality Values for <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative</i> (Helf et al. 2018).	8
Table 4. Measurement Quality Objectives for <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative</i> (Helf et al. 2018)	10
Table 5. Laboratory method performance requirements and analysis methods to be used for nutrient chemistry analysis of field samples taken during implementation of <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network</i> (Helf et al. 2018).	12
Table 6. Taxonomic standards to be used for <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative</i> (Helf et al. 2018).	12
Table 7. Data protection standards for <i>Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative</i> (Helf et al. 2018)	13

Abstract

The purpose of this report is to document the standards used by the National Park Service (NPS) Cumberland Piedmont Network Inventory and Monitoring Network (CUPN) for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018). This report also serves as a guide for all CUPN personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Introduction

The purpose of this report is to document the standards used by the Cumberland Piedmont Network (CUPN) for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018). The policies and procedures documented in this quality-assurance plan for activities complement the quality-assurance plans for other monitoring activities conducted by the Cumberland Piedmont Network and supplement the National Inventory & Monitoring Division Quality Management Plan (in prep). The plan also serves as a guide for all CUPN personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Protocol Overview

The cave aquatic biota monitoring protocol is focused on a suite of cave aquatic biota (CAB) that regularly inhabit three parks in the Cumberland Piedmont Network: Cumberland Gap National Historical Park (CUGA), Mammoth Cave National Park (MACA), and Russell Cave National Monument (RUCA). We identified a total of seven cave streams among the three cave parks conducive to visual survey for CAB while walking, wading, or snorkeling. Due to logistical constraints all seven streams cannot be visited during a single sampling season so they were divided into two separate panels. The sampling season occurs during the dry season from July–October since the probability of detecting cave aquatic biota during sampling events is highest when water levels and turbidity are low. Sampling events, consisting of two independent surveys of each cave stream on two nonconsecutive dates, will be conducted at one panel per sampling season such that, conditions permitting, all cave streams in both panels will be surveyed four times every two years. A single sampling event consists of two teams, one observer and one recorder each. The teams collect data on water quality and quantity, conduct staggered, independent visual surveys for CAB in a fixed number of noncontiguous, probabilistically distributed 40-meter (m; 131.2 feet [ft]) transects, and also collect data on habitat characteristics. One set of water quality and quantity data are collected (Objective 3) upstream of the transects to be surveyed using opportunistic grab sampling and water level/temperature data loggers, respectively. Visual surveys for CAB (Objectives 1 and 2) typically involve the observer moving slowly and quietly upstream and, using a powerful headlamp or dive light, conducting a timed count in each transect. Each detected CAB, along with a size estimate, where they were found (e.g., open or under cover), and any noticeable characteristics (e.g., damage), is called out to the data recorder. Finally, field personnel collect limited qualitative data on habitat characteristics (Objective 3) such as habitat type (e.g., riffle/pool/glide) and percent substrate composition (e.g., gravel or pebbles). Sampling techniques differ depending on whether the cave stream being sampled is wadeable or non-wadeable. Wadeable cave streams or pools are generally shallow and transects can be surveyed while walking along the bank or wading in the stream. Cave streams with a majority of non-wadeable habitat must be surveyed by a snorkeling observer, with the recorder paddling an inflatable kayak behind.

The primary goals of this protocol are to identify changes in CAB abundance and occupancy for resource managers at Cumberland Gap NHP, Mammoth Cave NP, and Russell Cave NM. In order to meet this goal, we must account for the variation in detectability over time and space to provide reliable data for effective resource management. Hierarchical models are a flexible framework in which a complex system may be modeled using multiple sub-models. This framework is particularly suited to inference about abundance, occupancy, species richness, and demographic characteristics because it can accommodate multiple data sets, sources of variability, scales of measurement, and varying data quality inherent in the kinds of data we will collect.

Data handling procedures are in place to ensure data collected under this protocol are of an acceptable quality and are available for current and future data users. Data recorded in the field onto field data sheets or collected by data loggers are entered and stored in several databases: discrete water quality and continuous data (water level and temperature) are stored in NPSTORET and Aquarius databases, respectively. Cave aquatic biota detection/nondetection data will be stored in a Microsoft Access database to be developed by the network in cooperation with National Park Service IMD contractors. The network's data verification and validation procedures will be conducted before electronic data sets are archived. Queries and reports in the database are used to retrieve data for analysis and to generate Annual Summary Reports and six-year Trend Analysis Reports for park management.

Protocol Activities and Modules

Data are collected or derived as a part of the *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018) in 13 different activities or modules (Table 1).

We conduct biological surveys while walking, wading, or snorkeling in seven subterranean streams among three CUPN cave parks (i.e., Cumberland Gap NHP, Mammoth Cave NP, and Russell Cave NM). Sampling events are scheduled during the dry season (i.e., July–October) when the probability of detecting cave aquatic biota is highest, due to low turbidity, and it is the safest time to access cave streams. During these surveys we gather data on the occupancy and abundance of cave aquatic biota, their detectability, and hypothesized critical habitat covariates that will enable us to amass baseline data to determine status and trends in their metapopulations before major natural and anthropogenic changes occur. Our primary monitoring goal is to provide information required to address management questions regarding the potential impacts of habitat degradation, management practices, or other identified stressors on their cave aquatic ecosystems. Our three monitoring objectives are:

1. For common cave aquatic biota, estimate status and long-term trends in abundance within monitored cave stream reaches in three parks in the Cumberland Piedmont Network.
2. For uncommon target cave aquatic biota, determine status and long-term trends in the probability of occupancy and proportion of reaches occupied within monitored cave stream reaches in three parks in the Cumberland Piedmont Network.

3. Sample selected cave stream habitat characteristics and water-quality and water-quantity parameters that we hypothesize are relevant to gaining an understanding of cave aquatic biota abundance, occupancy, or detectability within monitored cave stream reaches in three parks in the Cumberland Piedmont Network.

Table 1. Project activity matrix for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018).

Activity type	Activity number	Activity	Description
Site Recon, Establishment, and Maintenance	1	Transect selection and documentation	Permanent 40-meter (131.2-ft) transects. Includes development of a cave stream reach map with transect locations.
	2	Stilling well establishment and maintenance	Detailed written descriptions of the data logger and landmark locations are recorded on the field data sheet, both the landmark and the data logger are photographed in situ, and the approximate location of each data logger and corresponding landmark is plotted and labeled on the field copy of the Cave Stream Reach Map. Includes deployment and removal date.
Field Observations	3	General event data collection	Includes general information about CAB field sampling activities.
	4	Data logger servicing	Metadata collected during data offloading, redeployment (i.e., restarting automatic data collection), examining, cleaning, replacement and removal.
	5	Core Water Quality (WQ) parameter data collection	Opportunistic grab samples are collected with pre-calibrated handheld sensors in a convenient location upstream of the transects to be surveyed; this is from the same location as the data logger in its stilling well (i.e., upstream of the transects). Measured parameters include specific conductance, water temperature, dissolved oxygen, and pH.
	6	CAB observations	Staggered, independent 15-minute counts of CAB by walking, wading or snorkeling in cave stream transects. Observers carefully search the water column, bottom, and any cover (e.g., rocks, woody debris, etc.), call out any species detected, its estimated size, and where they were found (e.g., open or under cover) and recorders write the data on the CAB field data sheets.
	7	Stream habitat data collection	Limited quantitative and qualitative data on CAB habitat covariates using modified NAWQA methods for biological surveys (Fitzpatrick et al. 1998). Habitat covariates such as habitat type (i.e., riffle, pool, or glide), stream/pool width and depth, an estimate of the percent substrate composition for the transect or pool, and estimated percent cover searched.

Table 1 (continued). Project activity matrix for Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative (Helf et al. 2018).

Activity type	Activity number	Activity	Description
Sensor Data	8	Continuous water depth and temperature measurements	Water level, the height of the water column above the data logger, and water temperature will be sampled hourly in all monitored cave stream reaches by HOBO U20L data loggers in stilling wells located upstream of the transects. Loggers are placed to capture the frequency and timing of flood events.
Field Sample & Specimen Collection and Processing	9	WQ grab samples	During each sampling event water samples will be collected upstream of the transects, from the same location as the data logger, and analyzed in the lab for turbidity, nitrates and <i>E. coli</i> by trained NPS personnel. Includes analysis upon return to the office.
External Data	10	Meteorological data	Correlative data on precipitation, gathered continuously by Soil Climate Analysis Network weather stations, will be downloaded from USDA National Water and Climate Center website prior to performing data analysis.
Quality Control Data	11	Replicate data - CAB observation and habitat data	Transects are scheduled to be sampled for CAB observation and habitat data twice during each sampling event and a total of four times per season. These data will be reviewed for outliers, as well as interobserver variability.
	12	Replicate data – WQ grab samples and core WQ data	A second grab sample is collected at two randomly selected sampling events per year and run through an independent round of lab analyses for comparison between the two samples. Readings taken with field sensors are also duplicated in the field. Results must overlap the resolution of the stabilization criteria of the primary sample (Meiman 2018).

Sampling Design

Information regarding the sampling design is provided in Table 2.

Table 2. Activity-level sample design matrix for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018).

Activity Type	Activity Number	Activity	Sampling Design	Revisit Design
Field Observations	5	Core WQ parameter data collection	Opportunistic grab samples are collected for 7 reaches in a convenient location upstream of the transects to be surveyed; this is at the same location as the data logger in its stilling well.	Each stream reach revisited once within a sampling season. Sampling occurs in two separate annual panels: Year 1=4 MACA sites Year 2=1 MACA site, 1 CUGA site and 1 RUCA site
	6	CAB observations	Targeted to seven cave stream reaches in CUGA (1), MACA (5), and RUCA (1). Probability (GRTS) sample of 40 m transects within each stream reach. During each sampling event two teams independently survey each transect.	Same as Activity 5
	7	Stream habitat data collection	Same as Activity 6	Same as Activity 5
Sensor Data	8	Continuous water depth and temperature measurements	Targeted to seven cave stream reaches in CUGA (1), MACA (5), and RUCA (1). Specific site upstream of the transects selected by professional judgment.	Continuous, every hour
Laboratory Data	9	WQ Grab Samples	Same as Activity 5	Same as Activity 5

Data Quality Objectives

Data Quality Values

Data quality values and standards for implementation are provided in Table 3 through Table 7.

Table 3. Data Quality Values for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018).

Data Quality Category	Data Quality Value	Definition	Protocol Considerations
Intrinsic Data Quality	Accuracy	Measurements reflect the true value of the parameter being observed. This applies to measures (length, width, position) or classes (species, types, or categories). Includes components of precision and bias.	Pre-survey and pre-deployment calibration of sensors is conducted in a laboratory environment in accordance with methods described in SOP #4 of the CUPN Water Quality Monitoring Protocol (Meiman 2018). Continuous monitoring operation and maintenance site visits are conducted in accordance with schedule and methodologies described in SOP #3 of the CUPN CAB monitoring protocol (Helf et al. 2018). All CAB are properly identified to the lowest taxonomic level for all observations.
	Representativeness	Measurements represent conditions at the time of sampling. Combined with accuracy, leads to repeatable data collection.	Parameters and methods are chosen such that they measure representative conditions at subjectively selected index sites (i.e., cave stream reaches). Area of inference restricted to those sites. Measurements may be direct measures, indexes, or indicators of conditions.
Contextual Data Quality	Comparability	The degree to which data can be compared among sample locations, data sources, or periods of time.	Field data at all sites, whether continuous or grab samples, will be collected using identical equipment. All equipment are maintained on a consistent schedule using standardized procedures described in SOP #4 Field Measures—Version 1.2 of the CUPN Water Quality Monitoring Protocol (Meiman 2018). Data management and editing is conducted in accordance with SOP #5 of the CUPN CAB monitoring protocol.
	Timeliness / Currency	How recent the data need to be to be considered valid for their intended use. Data represents conditions and/or is available and in a format for use at the appropriate time in the decision-making process.	All data are processed the same year they are collected according to their panel. For example, all data collected at MACA stream reaches in Panel 1 are processed that same year. Data will be certified within one year of collection. Data will be delivered to parks at the appropriate time in the decision-making process to allow managers to apply findings. Annual summary reports are produced for CUPN parks according to their panel and will provide a summary of the current status of cave aquatic biota and water quality/quantity parameters. Every six years trend analysis reports will consist of updated analyses of all data, in both graphic and tabular statistical test summary formats, evaluations and predictions of relationships between key ecosystem drivers/attributes/stressors and key population measures, a Natural Resource Condition Summary Table, and interpretive discussion.

Table 3 (continued). Data Quality Values for Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative (Helf et al. 2018).

Data Quality Category	Data Quality Value	Definition	Protocol Considerations
Contextual Data Quality (continued)	Completeness	All data/ measures required to evaluate accuracy representativeness are present. Data records contain values as planned across the period of record.	Methods, sampling plans, and analyses are designed and implemented (as described in the peer-reviewed CUPN CAB monitoring protocol) such that they result in a complete dataset across space and the planned period of record. Note that this value is for a collection of data records; how many measures are deemed valid and suitable for use at the completion of all QA/QC procedures. The flexibility inherent in our data analysis, which involves hierarchical models, can accommodate sources of variability, scales of measurement, and varying data quality such as missing sampling events (Kéry and Royle 2015).
Representational Data Quality	Consistent Representation	Use of standard definitions when describing data quality or resource quality based on data	Provisional data are reviewed but not certified. Certified data are reviewed, QA/QC checked, and edited according to procedures described in SOP #5 of the CUPN CAB monitoring protocol. Data are reported and flagged in comparison to established management, ecological, or regulatory thresholds according to the procedures described in SOP #3 and SOP #6 of the CUPN CAB monitoring protocol. Data collection and management plans, products, services, and reports will be disseminated using the same formats and templates to the greatest extent practicable.
Data Accessibility	Secure	Access to data, products, and systems limited to appropriate audiences.	CUPN staff will continue to work with park resource contacts to ensure protected data are identified, labeled, and protected from inadvertent release.

Table 4. Measurement Quality Objectives for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018). Measurement Quality Objectives for chemical or lab analyses are referenced in Table 5 where MQOs are specified by analyte. Activities match those in the Protocol Activity Matrix Table (Table 1).

Activity	Measure/Quality Indicator	Quality Objective
Transect selection and documentation	Location Accuracy	Most sample locations are entered through publicly accessible entrances. Remote cave entrances are mapped and described with enough detail to relocate without the use of GPS equipment. Transect location within +/- 0.5m of established GRTS draw. Start and end of stream reaches/transect prominently and permanently marked to ensure their relocation. Narrative directions on site maintenance sheet provide enough detail for ease of relocation in conjunction with use of cave maps.
	Location Description Detail	Permanent landmark installed or located as a reference point for relocation of stilling well. Detailed written descriptions of the stilling well and specific landmark locations, including azimuth, inclination, distance from the obvious permanent landmark (e.g., a permanent benchmark) and photographed in situ. Approximate location of stilling well and corresponding landmark plotted and labeled on Cave Stream Reach Map.
	Image resolution	10 megapixel
Core Water Quality (WQ) parameter data collection (stabilization criteria for measurements where variability is within value shown)	Image format	Jpeg
	Water Temperature	+/- 0.2°C
	Specific Conductance	+/- 5%
	pH	+/- 0.1 Standard Unit (of pH)
CAB observations	Dissolved Oxygen	+/- 0.3 mg/L
	Taxonomic Resolution	Identifications made to the lowest practical taxonomic level; most to species, but small crustaceans to order or family.
	Identification Accuracy	95% accuracy for observations
	Identification Completeness	95% of CAB observations made to species level
	Count Accuracy	Observer avoids counting the same individual twice within a reach
	Estimated length	CAB >1 cm estimated length within +/- 5 mm.

Table 4 (continued). Measurement Quality Objectives for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018). Measurement Quality Objectives for chemical or lab analyses are referenced in Table 5 where MQOs are specified by analyte. Activities match those in the Protocol Activity Matrix Table (Table 1).

Activity	Measure/Quality Indicator	Quality Objective
CAB observations (continued)	Cover	Location (i.e., open or cover type) of all detected CAB identified with 95% accuracy.
	Riffle	Habitat (i.e., riffle or non riffle) outside of the transect's dominant geomorphic channel unit in which CAB are detected identified with 95% accuracy.
	Ancillary condition assessment	95% of individuals observed for eggs/larvae, tumors/lesions/deformations, and fat bodies; accurate identification of the condition to be reinforced in training.
Stream habitat data collection	Habitat Characteristics	100% accurate in identification made at the categorical level of either 'Pool', 'Riffle', or 'Glide'; accurate identification of the characteristic to be reinforced with pre-season training.
	Estimated Percent Cover Searched	Given cover is present in a transect the team consensus estimate made of percent cover searched for CAB.
	Percent Substrate Type	Identification made at the categorical level of 'Fines', 'Granules', 'Pebbles', 'Cobbles', 'Boulder', or 'Bedrock' or some combination thereof; accurate identification of the characteristic to be reinforced with pre-season training.
	Maximum Pool Length/Width/Depth	Measured to the nearest +/- 0.1 meter.
Continuous water depth and temperature measurements	Water Level Accuracy	Detect frequency and magnitude of flooding events
	Temperature Accuracy	$\pm 0.44^{\circ}\text{C}$ from 0° to 50°C .
Water quality grab samples	Turbidity	Standard deviation not to exceed 5% of measured value (National Handbook of Recommended methods for Water-Data Acquisition).
	Nitrate (NO ₃)	See lab method performance requirements for specifications by analyte.
	Escherichia coli	See lab method performance requirements for specifications by analyte.

Table 5. Laboratory method performance requirements and analysis methods to be used for nutrient chemistry analysis of field samples taken during implementation of *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network* (Helf et al. 2018).

Analyte	Units	MDL Objective	Precision Objective	Accuracy Objective	Potential Methods conforming to NELAC guidance
Nitrate (NO ₃)	mg/L	0.01	±10%	±10%	-Standard Method 9210A -STORET Number: 334: Nitrate, Ion Selective Electrode method
<i>Escherichia coli</i>	Most Probable Number/100 mL	One colony	One colony	±5%	Standard Method -IDEXX Colilert procedure listed as Method 9223B in the American Public Health Association's 21st edition of <i>Standard Methods for the Examination of Water and Wastewater</i> (Eaton 2005)

Table 6. Taxonomic standards to be used for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018).

Activity	Activity Number	Data collected	Standard to be used	Reference / authority
Collection of Observational Data	7	CAB observations	Scientific Publication	Holsinger (1978), Holsinger and Culver (1988), Zhang and Holsinger (2003), and Niemiller and Poulson (2010).
Reporting of Observational Data	7	CAB observations	Scientific Publication	Holsinger (1978), Holsinger and Culver (1988), ITIS, Zhang and Holsinger (2003), and Niemiller and Poulson (2010).

Table 7. Data protection standards for *Monitoring Cave Aquatic Biota at Selected Parks in the Cumberland Piedmont Network: Protocol Narrative* (Helf et al. 2018). With the exceptions noted, all data collected are to be made publicly available in a timely fashion.

Type of Data	Data	Level of Protection	Rules for Dissemination
Resource Data and Information	T&E Species Locations	Legally Protected. Only applicable if covered under existing statute as exempt from dissemination.	MACA is type locale for the Kentucky cave shrimp (<i>Palaemonias ganteri</i>) a federally listed endangered species. Locations of observations reported at park centroid only.
	Non-T&E Species Locations	Operationally Protected	Redacted where appropriate/requested
Water Quality/Quantity Data and Information	Water Quality/Quantity Data	Unprotected	Data available on-line as public information.
Location Data and Information	Cave entrances	Legally protected	Redacted where appropriate.
Personally Identifiable Information	Non-NPS Staff Information	Operationally Protected	All but first name and last initial redacted from public release.

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