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Aquatic Macroinvertebrate and Physical Habitat Monitoring for Hermit Creek in Grand Canyon National Park

2009 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2011/287

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Grand Canyon National Park
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Aquatic Macroinvertebrate and Physical Habitat Monitoring for Hermit Creek in Grand Canyon National Park

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1 Introduction and background

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a strong scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. The Southern Colorado Plateau Network (SCPN) is monitoring aquatic macroinvertebrates as an overall indicator of aquatic ecosystem integrity (Thomas et al. 2006).

In 2009 SCPN implemented annual monitoring of aquatic macroinvertebrates on Hermit Creek in Grand Canyon National Park (GRCA). During 2009 the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data from one monitoring site.

Hermit Creek below Tonto Trail (GRCAHER01), identified in this report as HER01 (see appendix A for location, code, and common name of monitoring site), is located just over 0.2 km downstream from a stream flow gauge—*Hermit Creek above Tonto Trail*, Grand Canyon, AZ (09403043)—maintained by GRCA staff (fig. 1). The channel substrate at this site is primarily embedded cobble and bedrock. The stream flows through a sparse willow (*Salix* sp.) shrubland with a dense monkey flower (*Mimulus* sp.) understory.

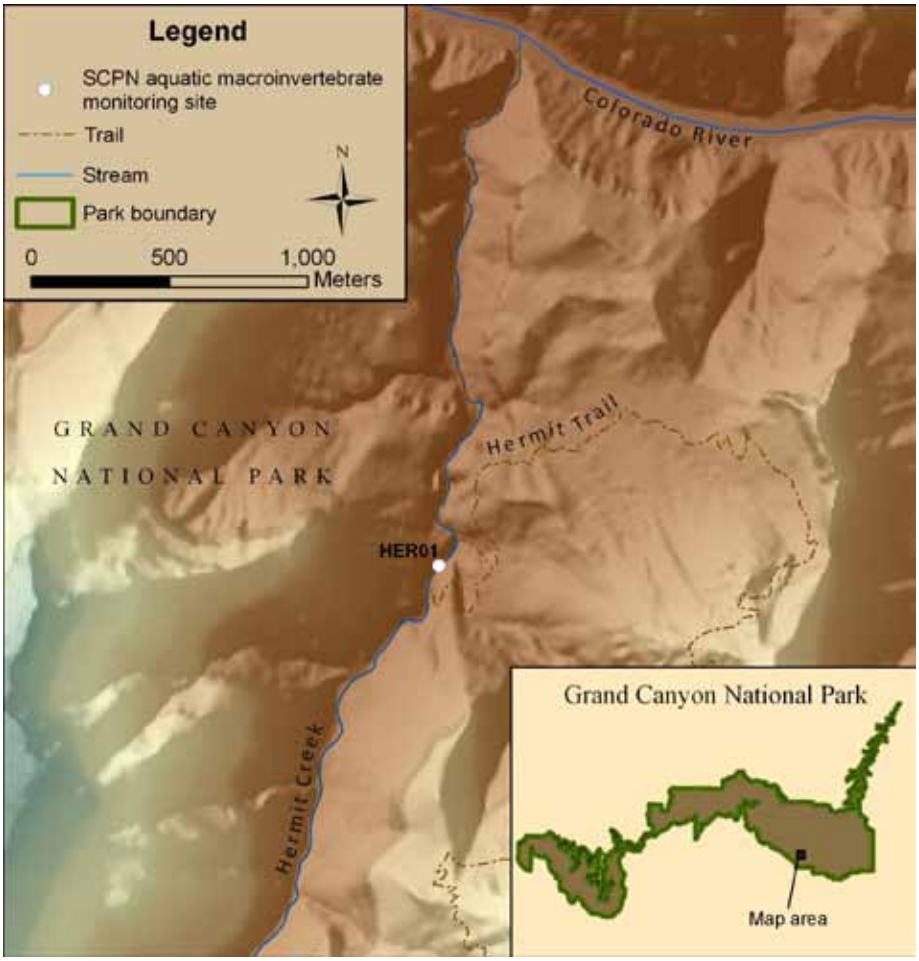


Figure 1. Map of Hermit Creek, Grand Canyon National Park, Arizona, with the location of the HER01 monitoring site in 2009

The Hermit Trail runs 8.9 miles from Hermit's Rest on the south rim of Grand Canyon to Hermit Rapids on the Colorado River, following the Hermit Fault for most of its route. The trail was used by early inhabitants of the Grand Canyon and was improved by prospectors in the late 1800s. It was further developed in the early 1900s by the Santa Fe Railroad, and at that time travelers used the route to traverse the 7 miles from the south rim to the Hermit Camp (Santa Fe Railroad 1915). The trail was later extended to run along the length of the Hermit Creek to its confluence with the Colorado River. The Hermit Trail intersects the popular Tonto Trail about a mile east of Hermit Camp. Today the Santa Fe Railroad camp no longer exists but a primitive backcountry camp, which holds up to 23 people, is maintained by the National Park Service directly upstream from the monitoring site. Many portions of the modern trail are in the stream channel and backcountry travelers commonly hike through Hermit Creek on their way to the Colorado River. Periodically, backcountry visitors create small dams that pool water, altering stream flow through the monitoring site.

The Hermit Fault acts as one of the main pathways for the flow of groundwater from the south rim. Consequently, Hermit Creek is one of the larger streams in this section of the Grand Canyon. The *Hermit Creek above Tonto Trail* streamflow gauging station was established in 1994 and GRCA monitors streamflow and periodically samples water quality at the site. Aquatic macroinvertebrate data has been collected sporadically at Hermit Creek by the state of Arizona from 1992–2009 (Lawson 2007).

The primary purpose of this report is to (a) document the monitoring activities that occurred at HER01 in 2009, (b) summarize data that were collected, and (c) where appropriate, place these data in the context of aquatic habitat, biological condition, and management actions within the park through time.

2 Methods

2.1 Field methods

In Arizona, the sampling window for streams <1,500 m elevation is from April to May. On April 22, 2009, we collected aquatic macroinvertebrate samples and physical habitat data at the monitoring site, HER01. This site consists of a 150 m reach, composed of 11 transects, spaced 15 m apart (fig. 2). A brief description of field methods is provided here, and a detailed description of sampling methods can be found in Brasher et al. (in press).

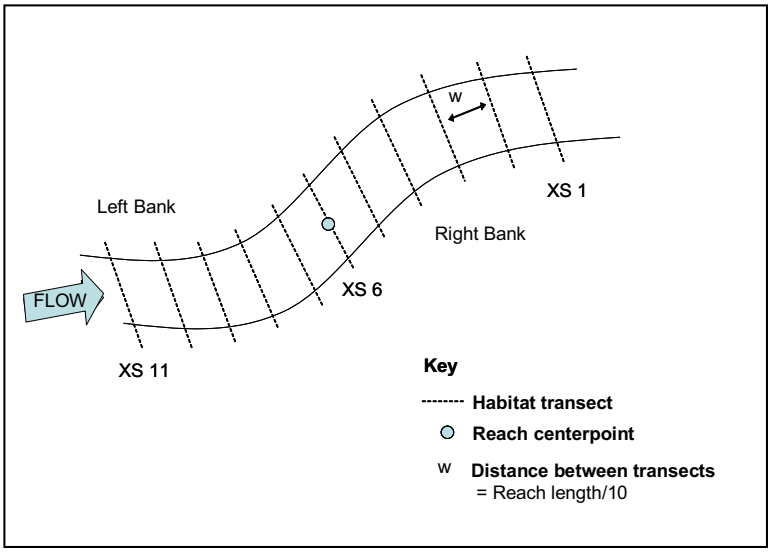


Figure 2. General aquatic-macroinvertebrate sampling reach layout

We collected two types of aquatic macroinvertebrate samples:

- Replicate quantitative samples from five targeted riffle habitats were collected to provide estimates of abundances of organisms. We used a Slack sampler to collect a timed sample from a 0.25 m^2 area at each targeted riffle.
- A qualitative sample to develop a comprehensive list of species present in the reach. A Slack Sampler was used to collect samples from all habitat types within the sampling reach and compiled into one composite sample. A list of the habitat types from which qualitative samples were collected can be found in section 3.2 of this report.

We collected physical habitat data at three spatial scales: microhabitat, transect, and reach:

- For each of the quantitative targeted riffle microhabitats, we
  - measured depth
  - measured velocity
  - measured particle size
  - measured particle embeddedness
- For each of the 11 transects, we
  - measured wetted and active channel widths
  - measured water depth, velocity, and canopy closure at multiple points along each transect
  - observed and recorded the presence or absence, and types of macroinvertebrate habitats, represented by point data (5 points/transect) across the entire reach
  - measured geomorphic channel units (GCU) at multiple points along each transect
- For the entire reach, we
  - identified and measured the length of GCUs (reach characterization data represents the proportion of the reach characterized by that particular GCU)
  - conducted a zig-zag pebble count measuring the size of a minimun of 400 randomly-selected particles using a modified Wolman pebble count across the length of the entire reach
  - identified the dominant vegetation and land cover
  - recorded descriptions of flow conditions
  - recorded weather conditions
  - observed and recorded evidence of anthropogenic or natural disturbances
  - measured NPS core water quality parameters of temperature, specific conductivity, pH, dissolved oxygen, and turbidity

2.2 Laboratory methods

Aquatic macroinvertebrate samples were sent to the National Aquatic Monitoring Center's Bug Lab, a Bureau of Land Management laboratory at Utah State University in Logan, Utah. There, samples were sorted under a dissecting scope at 10× magnification, and a 500-organism, fixed-count method was used for sub-sampling large samples. Ten percent of the sorted samples were resorted for quality assurance.

A taxonomist, certified by the North American Benthological Society, identified all aquatic macroinvertebrates to the family or genus level. To ensure data quality, 10 percent of the identified samples

were re-identified by a second certified taxonomist.

Quantitative and qualitative macroinvertebrate samples will be maintained by the contract aquatic laboratory for at least five years to allow for repeat subsampling should any data questions arise. For a more detailed description of laboratory methods see Brasher et al. (in press).

2.3 Data analysis

In this report we summarize aquatic macroinvertebrate data in terms of community structure and function. Genera were classified into functional feeding guilds using the classifications presented in Barbour et al. (1999). If functional class information was not available for a particular genus, we applied a more generalized, family-level classification.

We selected aquatic macroinvertebrate metrics that are generally considered to be sensitive, reliable indicators of water quality and/or stream health (see appendix B for a table of metrics and their definitions). Most of these metrics have been used to detect changes in water quality and habitat conditions in other streams in the Southern Rocky Mountains ecoregion (Griffith et al. 2005). They also enable a comprehensive assessment of multiple aspects of community structure because they represent a range of ecological characteristics. SCPN will periodically evaluate the interpretive value of the listed metrics and may drop or add additional metrics based upon these evaluations.

3 Results

3.1 Aquatic macroinvertebrate community data

Tables 1 and 2 present qualitative and quantitative data and key metrics describing aquatic macroinvertebrate communities from samples collected from HER01. Figures in this section refer to quantitative data unless otherwise noted. Appendix C lists all aquatic macroinvertebrate species detected at the site, from both quantitative and qualitative methods.

Abundance. Overall mean abundance for quantitative targeted riffle samples taken from HER01 averaged 603.4 individuals (fig. 3).

Taxa richness. Total richness of taxa collected from our quantitative targeted riffle samples averaged 20.2 taxa per sample. Total richness for our qualitative multi-habitat sample was slightly higher at 23 taxa (fig. 4).

Diversity. We calculated taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity was nearly twice as high as functional diversity at our monitoring site. Taxonomic diversity averaged 0.69 per sample compared to an average of 0.35 for functional diversity (fig. 5).

Tolerant taxa. Relative abundance of taxa defined by their ecological tolerance was dominated by moderately tolerant taxa. Moderately tolerant taxa averaged 45.2% of the individuals collected from our monitoring site. Intolerant taxa were the next most abundant, averaging 37.9% of the individuals collected, followed by tolerant taxa at 16.8%. Taxa richness by ecological tolerance followed a similar pattern, where moderately tolerant taxa dominated at 46.1%. Intolerant taxa made up 31.4% of the taxa collected and intolerant taxa made up 22.6% of the taxa from HER01 (fig. 6).

EPT taxa. Relative abundance of EPT taxa (orders Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) was low at this site. Total EPT taxa accounted for only 4.4% of the individuals collected at HER01. Ephemeroptera abundance accounted for 2.6%, and

Table 1. Qualitative metrics for aquatic macroinvertebrate samples collected from HER01 at Hermit Creek in Grand Canyon National Park, 2009. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group.

Qualitative metric	2009
Taxa richness	23.00
Tolerance group	
Richness of tolerant taxa (%)	28.57
Richness of moderately tolerant taxa (%)	47.62
Richness of intolerant taxa (%)	23.81
Functional group	
Richness of collector-filterers (%)	9.09
Richness of collector-gatherers (%)	31.82
Richness of scrapers (%)	4.55
Richness of shredders (%)	0.00
Richness of predators (%)	54.55
Taxonomic group	
Number of EPT taxa	4.00
Richness of EPT taxa (%)	17.39
Richness of Ephemeroptera (%)	8.70
Richness of Plecoptera (%)	0.00
Richness of Trichoptera (%)	8.70
Richness of noninsect taxa (%)	21.74
Richness of Chironomid Diptera (%)	13.04
Richness of non-Chironomid Diptera (%)	34.78
Richness of Coleoptera (%)	4.35
Richness of Odonata (%)	8.70

Trichoptera accounted for 1.8%. We did not collect any Plecopteran individuals in our samples at this site (fig. 7).

Aquatic macroinvertebrate orders. Of the aquatic macroinvertebrate orders collected, Dipterans, belonging to the family Chironomidae (midges), were the most abundant in our samples, making up 38.7% of the individuals collected. Coleoptera (beetles) were the second most abundant group at 32%. Odonates (damselflies/dragonflies) were the least abundant group, at 1% of the individuals collected at our monitoring site (fig. 8).

Functional feeding groups. Functional feeding group abundance was dominated by collector-gatherers, which made up 73% of the individuals collected. Predators were the second most abundant at 23.4%, then collector-filterers at 2.9%, and finally, the least abundant were the scrapers at 0.72% of the organisms collected. We found no shredders in our samples (fig. 9).

3.2 Physical habitat characteristics for Hermit Creek

This section describes physical habitat characteristics recorded at HER01 during 2009. These data are summarized in Table 3. Additional transect and microhabitat data can be found in Appendix D.

Table 2. Quantitative metrics for aquatic macroinvertebrate samples collected from HER01 at Hermit Creek in Grand Canyon National Park, 2009. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

Quantitative metric	Mean	SD
Total abundance	603.40	60.04
Total richness	20.20	1.64
Simpson's Diversity—taxonomic	0.69	0.08
Simpson's Diversity—functional group	0.35	0.15
Dominant taxa	46.91	10.51
Tolerance group		
Relative abundance of tolerant taxa (%)	16.83	20.65
Relative abundance of moderately tolerant taxa (%)	45.25	19.14
Relative abundance of intolerant taxa (%)	37.92	16.69
Richness of tolerant taxa (%)	22.56	4.44
Richness of moderately tolerant taxa (%)	46.06	3.26
Richness of intolerant taxa (%)	31.38	3.51
Functional group		
Relative abundance of collector-filterers (%)	2.89	1.85
Relative abundance of collector-gatherers (%)	72.97	20.60
Relative abundance of scrapers (%)	0.72	0.49
Relative abundance of shredders (%)	0.00	0.00
Relative abundance of predators (%)	23.42	20.36
Richness of collector-filterers (%)	10.48	4.02
Richness of collector-gatherers (%)	33.33	3.93
Richness of scrapers (%)	5.24	0.43
Richness of shredders (%)	0.00	0.00
Richness of predators (%)	50.95	4.14
Taxonomic group		
Number of EPT taxa	4.40	0.55
Relative abundance of EPT taxa (%)	4.43	1.59
Relative abundance of Ephemeroptera (%)	2.59	1.10
Relative abundance of Plecoptera (%)	0.00	0.00
Relative abundance of Trichoptera (%)	1.84	0.98
Relative abundance of noninsect taxa (%)	6.66	3.91
Relative abundance of Chironomid Diptera (%)	38.69	19.29
Relative abundance of non-Chironomid Diptera (%)	17.31	20.15
Relative abundance of Coleoptera (%)	31.96	16.70
Relative abundance of Odonata (%)	0.96	0.81

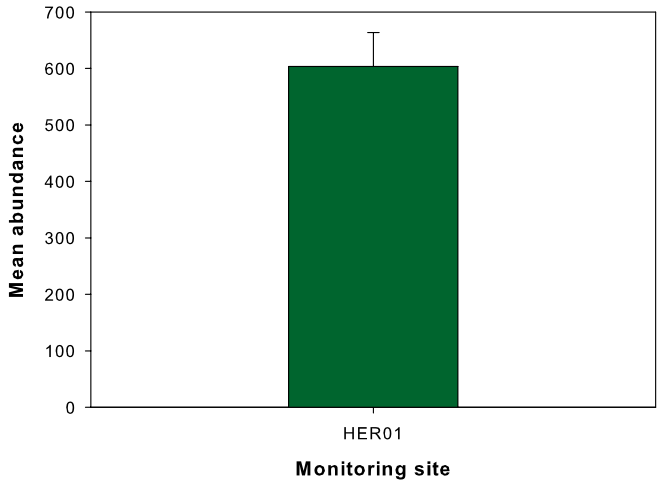


Figure 3. Total abundance expressed as the mean number of individuals per sample collected from HER01 at Hermit Creek in GRCA, 2009

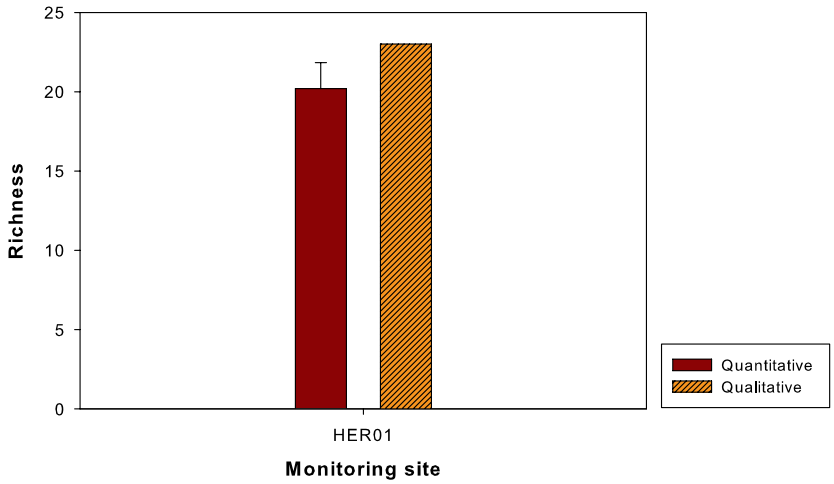


Figure 4. Mean number of taxa found in quantitative targeted riffle samples and the qualitative multihabitat sample collected from HER01 at Hermit Creek in GRCA, 2009

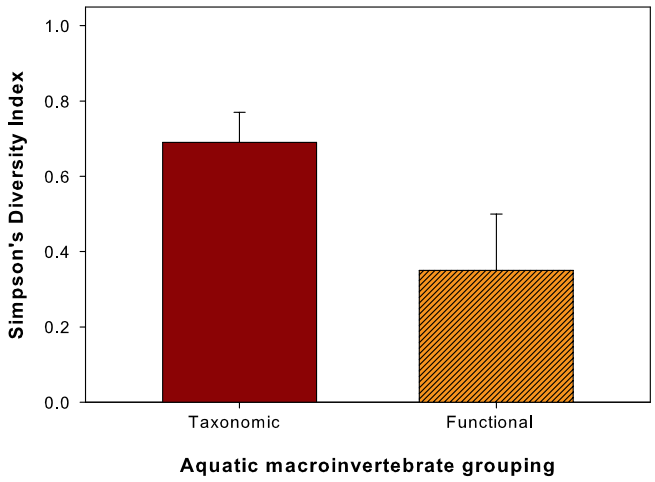


Figure 5. Simpson's Diversity Index for Taxonomic and Functional Feeding Group Diversity calculated for quantitative targeted riffle samples collected from HER01 at Hermit Creek in GRCA, 2009. Values expressed are means of all samples collected from the site.

Figure 6. Mean relative abundance (left) and richness (right) of aquatic macroinvertebrate taxa considered to be tolerant, moderately tolerant, and intolerant to perturbation in samples collected from HER01 at Hermit Creek in GRCA, 2009

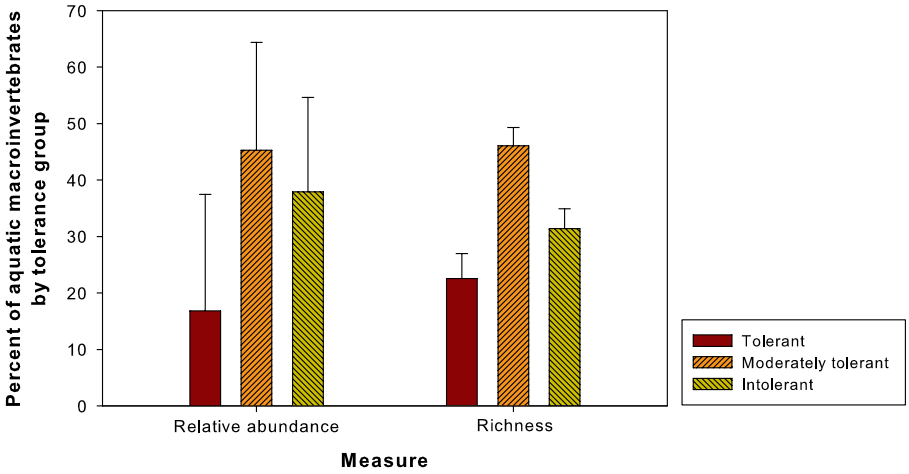


Figure 7. Relative abundance of sensitive EPT orders in samples collected from HER01 at Hermit Creek, GRCA, 2009

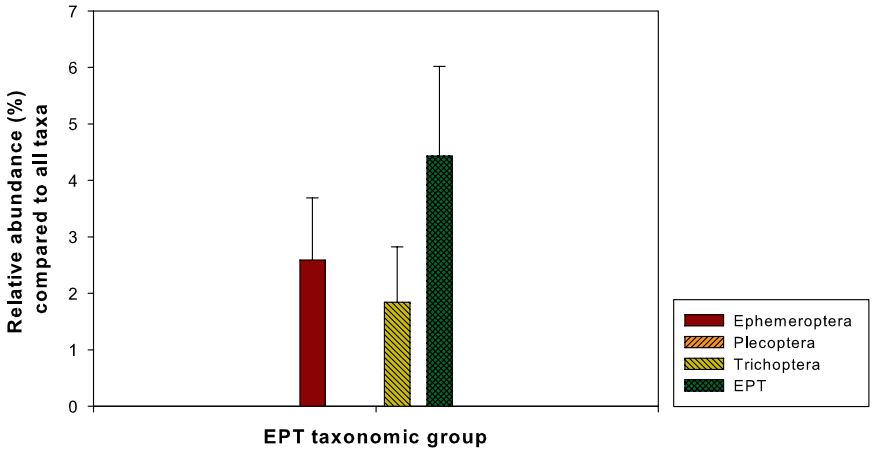
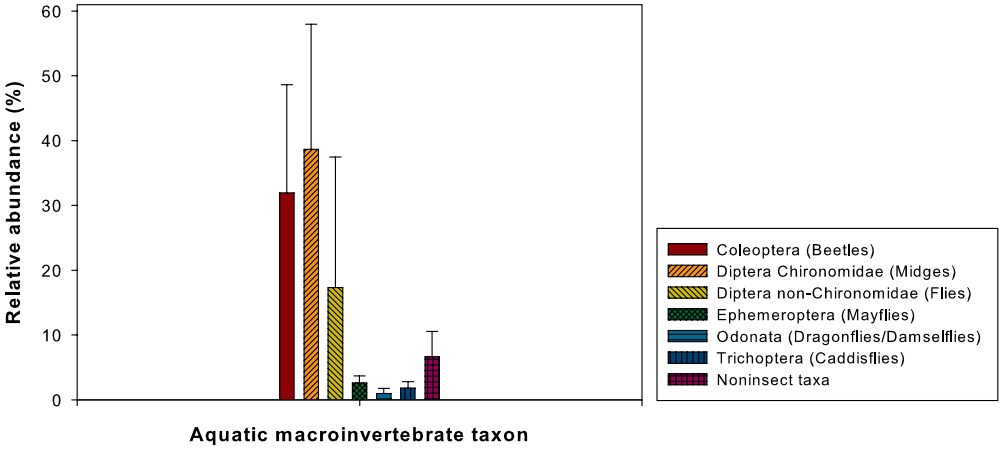


Figure 8. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from HER01 at Hermit Creek, GRCA, 2009



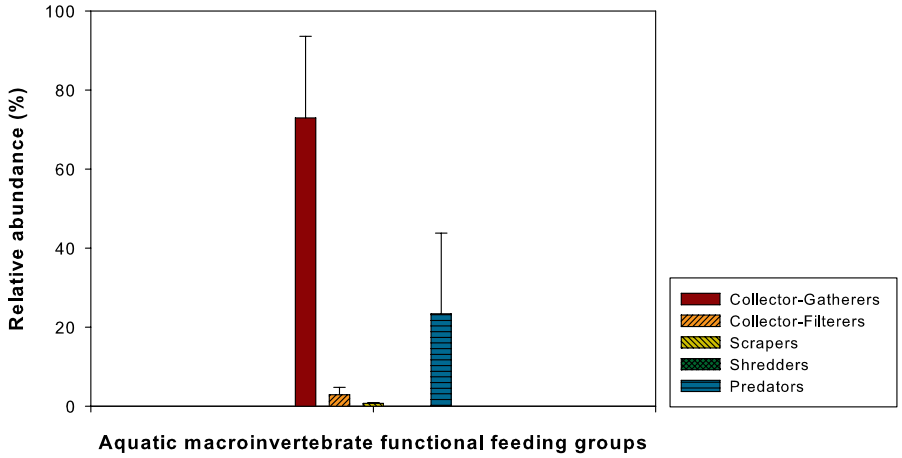


Figure 9. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from HER01 at Hermit Creek, GRCA, 2009

Table 3. Physical habitat transect data from HER01 at Hermit Creek in Grand Canyon National Park, Arizona, 2009. Particle embeddedness and canopy closure measurements are expressed as percentages.

Physical habitat metric	Mean	SD
Microhabitat level		
Riffles		
Velocity (m/s)	0.42	0.15
Depth (m)	0.08	0.02
Embeddedness (%)	25.68	20.22
Transect level		
Channel dimensions		
Velocity (m/s)	0.19	0.11
Depth (m)	0.09	0.04
Wetted channel width (m)	1.92	0.72
Active channel width (m)	10.00	2.43
Riparian cover		
Canopy closure (%)	14.40	27.90
Reach level		
Water quality[a]	**Value**	
Temperature (°C)	17.4	
Specific conductivity (µS/cm)	429	
pH	8.4	
Dissolved oxygen (% saturation)	111.0	
Turbidity (NTU)	0.41	

Note: See Appendix B for detailed description of metrics in this table.
[a]One water quality measurement only is reported for the site, based on the sampling event closest to 12:00 noon on the sampling day.

Microhabitat. Stream velocity at the targeted riffle habitat we sampled averaged 0.42 m/s. Stream depth of riffles averaged 0.08 m. Riffle particles sampled were distributed over two size classes: coarse gravels (72%) and cobbles (28%). Embeddedness of riffle particles averaged 25.7%.

Transect. Mean velocity along each transect averaged 0.19 m/s at HER01. The average depth at each habitat transect was 0.09 m. The wetted channel at our site was quite narrow compared to the active channel width. Wetted channel width averaged 1.9 m compared to the 10.0 m width of the active channel. Riparian canopy closure averaged 14.4% at our monitoring site (table 3).

Aquatic macroinvertebrate habitat was dominated by rocky habitat, which made up 64.8% of our monitoring site. Algal mats was the next most abundant at 18.7%, followed by vegetation at 14.3%. Only 2.2% of the habitat at our site did not fit into one of our habitat types delineated as aquatic macroinvertebrate habitat ("Other") (fig. 10). This was typically sandy substrates.

Reach. Channel structure dynamics are represented by particle size distributions in Figure 11, based on modified Wolman pebble counts. Coarse gravels (16–64 mm) were the most abundant particle size at our monitoring siste at 39.2%. Boulder/bedrock (>256 mm) was the next largest class at 22.5%. Fine gravels (2–16 mm) and fine particles (<2 mm) made up 6.2% and 21.1% of the site respectively (fig. 11).

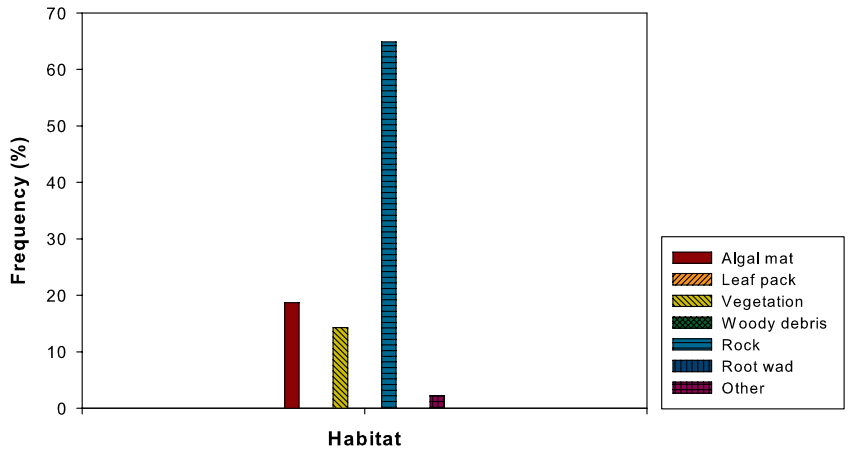


Figure 10. Macroinvertebrate habitat characterization based upon line point intercept data collected from transects at HER01 in Hermit Creek, GRCA, 2009. Some habitat structure types were not observed.

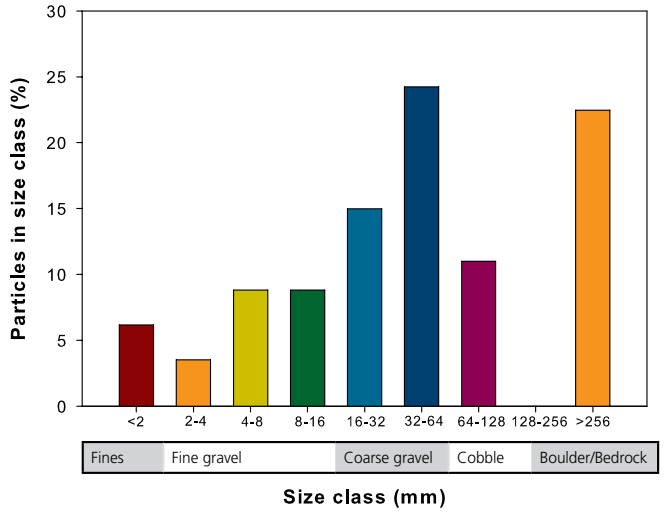


Figure 11. Particle size distribution, based on modified Wolman pebble counts of a minimum of 400 particles, for macroinvertebrate sampling from HER01 at Hermit Creek in GRCA, 2009

Geomorphic channel units (GCUs) along HER01 were dominated by runs, which made up 40.5% of the monitoring site. Cascades existed along 28.0% of the site and glides occurred along 10.8%. Of the GCUs sampled, scour pools were the least abundant, making up only 0.009% of the monitoring site (fig. 12). For a complete description of GCUs see Brasher et al. (in press).

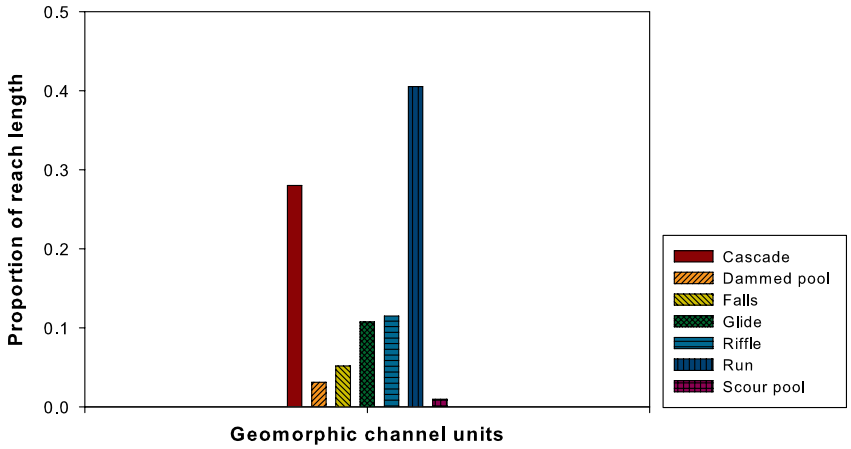


Figure 12. Geomorphic channel unit characterization of HER01 at Hermit Creek, GRCA, 2009

Water quality core parameters are reported as the measurement recorded at midday during our sampling effort at Hermit Creek. Temperature measured 17.5°C, specific conductivity was 429 µS/cm, and pH was 8.5. Dissolved oxygen measured 107.9% saturation. Turbidity for our sampling period averaged 0.41 NTU per sample (table 3).

4 Discussion

This report presents data from SCPN's first year of monitoring aquatic macroinvertebrates and physical habitat at Hermit Creek in Grand Canyon National Park, Arizona. We stress that the data included in this report are not to be interpreted as an ecologically significant trend, as trends cannot be determined from one year of sampling data. Results from one year of sampling data should not be interpreted as a trend in physical habitat or the aquatic macroinvertebrate community.

Differences may be attributed to multiple factors, including ecological variability and sampling error or may be a result of observer bias. SCPN attempts to minimize sampling error and observer bias by thoroughly training crew members in the proper field techniques prior to each sampling season.

4.1 Aquatic macroinvertebrate communities

In 2009 abundance and total richness values at Hermit Creek were quite robust, while both taxonomic and functional diversity values were low. The majority of the individuals sampled belonged to either the collector-gatherers or the predators (96%). As a result, any energetic inputs in the aquatic ecosystem may not be retained as biomass by the macroinvertebrate community.

4.2 Ecological tolerance

Another interesting finding in our first year of sampling is that a majority of the individuals and taxa sampled at Hermit Creek have some degree of susceptibility to environmental perturbation or degradation. Eighty-three percent of the individuals sampled were either moderately tolerant or intolerant of perturbation. Similarly, of the taxa collected, 77% belonged to these same groups. The high percentage of these individuals suggests that there is little disturbance affecting the aquatic macroinvertebrate community. Contrary to these findings were the results from our EPT taxa. EPT

taxa are typically tracked by ecologists because of their sensitivity to physical changes in water quality. Relative abundance of EPT taxa was quite low (4.43%) and we found no Plecoptera in any of our samples. These findings conflict with our ecological tolerance findings in that they suggest there may be some form of disturbance (i.e., poor water quality) that may be responsible for the exclusion of EPT taxa from our samples.

The data in this report should be viewed as a snapshot of conditions existing within the aquatic community at the time of our visit. Data and analyses within this report are provisional and subject to change. When sufficient data are available, SCPN plans to produce an interpretive report including trend analysis of macroinvertebrate metrics and physical habitat data for Hermit Creek.

5 Literature cited

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Appendix A Hermit Creek monitoring site at Grand Canyon National Park, Arizona, 2009

Site Code	Common name	Report name	UTM X	UTM Y	Elevation (m)
GRCAHER01	Hermit Creek below Tonto Trail	HER01	390736.841	3993596.425	865

Appendix B Selected aquatic macroinvertebrate metrics

Metric type	Metric	Definition
Abundance	Total abundance	Total number of individuals.
Richness	Taxa richness	Total number of taxa (measures the overall diversity of macroinvertebrates in a sample).
Diversity	Simpson's diversity	A measure of the variety of taxa that takes into account the relative abundance of each taxon. $DS = 1-[(\sum n(n-1))/(N(N-1))]$
Tolerance	Dominant taxa	Measures the dominance of the most abundant taxa. Typically calculated as dominant 2, 3, 4, or 5 taxa.
	Relative abundance for tolerant taxa	Percent of individuals considered to be tolerant to perturbation.
	Percent richness for tolerant taxa	Percent of taxa considered to be tolerant to perturbation.
Functional-feeding	Relative abundance collector-filterers	Percent of individuals that filter fine particulate organic matter from the water column.
	Percent richness collector-filterers	Percent of taxa that filter fine particulate matter from the water column.
	Relative abundance scrapers	Percent of individuals that scrape or graze upon periphyton.
Functional-habit	Relative abundance burrowers	Percent of individuals that move between substrate particles (typically finer substrates).
	Percent richness burrowers	Percent of taxa that move between substrate particles (typically finer substrates).
	Relative abundance clingers	Percent of individuals that have fixed retreats or adaptations for attachment to surfaces in flowing water.
	Percent richness clingers	Percent of taxa that have fixed retreats or adaptations for attachment to surfaces in flowing water.
Composition	Number of EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).
	Relative abundance EPT	Percent of individuals in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).
	Relative abundance Ephemeroptera	Percent of individuals that are mayflies.
	Relative abundance Plecoptera	Percent of individuals that are stoneflies (for streams > 1,500 m in elevation).
	Relative abundance Trichoptera	Percent of individuals that are caddisflies.
	Relative abundance of Hydroptilidae or Hydropsychidae within Trichoptera	Percent of Trichopteran individuals belonging to Hydroptilidae or Hydropsychidae families (ratio of tolerant caddisfly abundance to total caddisfly abundance).
	Relative abundance non-insect taxa	Percent of individuals that are not insects.
	Relative abundance Chironomidae	Percent of individuals that are midges.

Source: Data from Brasher et al. (in press)

Appendix C Aquatic macroinvertebrate species list from the HER01 monitoring site, Grand Canyon National Park, Arizona, 2009

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name
Arthropoda	Arachnida	Trombidiformes	Lebertiidae		*Lebertia* sp.		water mites
Arthropoda	Arachnida	Trombidiformes	Sperchonidae		*Sperchon* sp.		water mites
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae		*Torrenticola* sp.		water mites
Arthropoda	Insecta	Coleoptera	Elmidae		*Microcylloepus* sp.	*pusillus*	riffle beetles
Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	*Hemerodromia* sp.		dance flies
Arthropoda	Insecta	Diptera	Empididae		*Neoplasta* sp.		dance flies
Arthropoda	Insecta	Diptera	Stratiomyidae		*Caloparyphus* sp.		soldier midges
Arthropoda	Insecta	Diptera	Stratiomyidae		*Euparyphus* sp.		soldier midges
Arthropoda	Insecta	Diptera	Tabanidae		*Tabanus* sp.		horse flies
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	*Culicoides* sp.		biting midges
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	*Probezzia* sp.		biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae			non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae			non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae			non-biting midges
Arthropoda	Insecta	Diptera	Simuliidae	Simuliinae	*Simulium* sp.		black flies
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Baetis* sp.		small minnow mayflies
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Fallceon* sp.	*quilleri*	small minnow mayflies
Arthropoda	Insecta	Hemiptera	Gerridae				water striders
Arthropoda	Insecta	Lepidoptera	Crambidae	Nymphulinae	*Petrophila* sp.		crambid snout moths
Arthropoda	Insecta	Odonata	Libellulidae				skimmer dragonflies
Arthropoda	Insecta	Odonata	Coenagrionidae		*Argia* sp.		narrow winged damselflies
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Hydropsyche* sp.		netspinning caddisflies
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	*Oxyethira* sp.		microcaddisflies

Appendix D Channel characteristics at the HER01 monitoring site, Grand Canyon National Park, Arizona, 2009

Transect	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
	Mean	Std Dev	Mean	Std Dev	Value	Value
1	0.32	0.37	0.07	0.04	2.05	12.00
2	0.16	0.10	0.19	0.07	0.95	12.00
3	0.40	0.19	0.05	0.04	2.46	6.50
4	0.15	0.14	0.05	0.01	2.90	9.10
5	0.11	0.09	0.13	0.10	3.05	8.65
6	0.32	0.47	0.07	0.06	0.81	8.70
7	0.13	0.03	0.08	0.03	1.87	7.20
8	0.06	0.07	0.13	0.08	1.80	9.30
9	0.07	0.07	0.08	0.09	1.62	9.80
10	0.15	0.14	0.05	0.04	2.23	12.00
11	0.25	0.26	0.08	0.04	1.35	14.70