

Macroinvertebrate Monitoring Summary for the Smith River, Meagher and Cascade Co., MT: 2016-2018

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Smith River Macroinvertebrate Monitoring Station #6 out of the Canyon

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All photos in the report were taken by MBS, unless otherwise noted

Executive Summary

UMOWA has continued the Smith River Baseline Macroinvertebrate Monitoring program for its 3rd year. Eight long-term, baseline monitoring sites were established in 2016 for sampling benthic macroinvertebrates within the Smith River corridor between Fort Logan and Eden Bridge. Six sites had been previously sampled by MDEQ in 1999 and 2002-2005. Therefore, the goals of this study are: 1) to conduct standardized, replicated and quantitative macroinvertebrate surveys to serve as the baseline standards for future monitoring efforts within this Smith River section 2) to revisit and resample six Smith River sites previously sampled by MDEQ (1999-2005) to determine if significant changes have occurred over the last decade or longer, and 3) to understand and assess the Smith River aquatic biological integrity, as it relates to Sheep Creek and other tributary streamflow inputs.

In July of 2016, 2017 and 2018, we collected quantitative, replicated macroinvertebrate samples at the same eight Smith River sites. Streamflow inputs from Sheep, Rock, Tenderfoot, Hound Creek and other tributaries in the permit canyon have significant effects on the water quantity, quality and temperatures of the Smith River. Increased densities and diversity of insect communities, especially mayfly, stonefly and caddisfly taxa (EPT taxa), have been documented in the Smith River below these tributaries. Smith River sites upstream of Sheep Creek reported lower diversity, biological integrity and sensitivity of macroinvertebrates initially (2016), but have improved in 2018. The Smith River at Eden Bridge reported the lowest macroinvertebrate densities of all sites (2016 & 2017), consistent with the 2002-2005 MDEQ data. Eden Bridge reported low numbers of the salmonfly (*Pteronarcys californica*), golden stonefly (*Hesperoperla pacifica*) and populations of the sensitive mayflies, *Rhithrogena* & *Epeorus albertae* in 2005; these taxa were undetected in 2016 and 2017 samples, but *Rhithrogena* has returned again in good numbers in 2018.

EPT taxa diversity increases downstream of the Sheep Creek confluence and maintains these values through the canyon section and then declines downstream; although there were some individual site declines in EPT taxa richness between 1999 and 2016-2018; this was not significant overall (T-test, $p > 0.05$). EPT taxa increases in 2017 were due to more species of tolerant mayflies and caddisflies (micro-caddis) than previously reported. Twenty-three species of mayflies (E) were recorded throughout the study section: the dominant three were BWO's (*Baetis tricaudatus*), Tricos (*Tricorythodes explicatus*) and Pale Morning Duns (*Ephemerella excrucians*). Of the 21 total species of caddisflies that were collected between 2016 and 2018, the net-spinning caddisflies, *Hydropsyche occidentalis* and *Cheumatopsyche*, Mother's day caddis *Brachycentrus occidentalis* and long-horned caddis, *Oecetis avara* were collected across most sites. While stonefly taxa are not as common as reported in 1999-2005, 7 taxa were reported across the eight sites. Stonefly diversity and EPT taxa richness, in general, increase with increasing distance from Camp Baker until the Smith River exits the canyon. The Hound Creek and Eden Bridge sites contain unique benthic fauna reporting four mayfly species that were collected nowhere else in the study.

The northern crayfish (*Orconectes virilis*) had not been reported in any MDEQ samples between 1999 and 2005; in 2016, we reported crayfish densities of 1.5-20 individuals per m² at Smith River sites downstream of Sheep Creek to Eden Bridge, respectively. Northern crayfish upstream detections and abundance have further increased in 2017 and 2018; all the way to HWY 360 Bridge. This expansion of the northern crayfish upstream into increasingly warmer trout rivers is a pattern that we have been documenting across western Montana.

Overall, macroinvertebrate communities collected in 2016-2018 resembled those reported by MDEQ in 1999-2005 with a 50% average taxa similarity across sites; highest between-year taxa similarity was in the permit canyon (avg. 70.5%) and lowest at Hound Creek (32%) and Eden Bridge (35%). Along with shifting taxa composition at these downstream sites, there were some non-significant increases in % non-insect taxa and % Chronomidae (midges) comprising the samples at some sites. Substantial, but not significant reductions in mayflies, stoneflies and the percentage of EPT taxa in the samples were reported between 1999 and 2016-2018, especially from sites both upstream and downstream of the permit canyon section.

The biological integrity as measured with the MDEQ Low Valley MMI has significantly decreased across all sites between 1999 and 2016 (T-test, $p=0.012$), 2017 (T-test, $p=0.0004$) and 2018 (T-test, $p=0.0007$). Integrity declines in the canyon below Tenderfoot Creek (#5 HOE & #6 out of the canyon) are particularly troubling because macroinvertebrate metrics in the canyon have largely maintained similar biological health between 1999 and 2016 with some non-significant decreases in 2017. This community integrity shift likely reflects increase in water temperatures, nutrients, filamentous algae and possible sediment build-up in many gravel and cobble riffle areas of the stream channel. Upstream sites at HWY 360 and Camp Baker that received concentrated flushing flows have improved in integrity in 2018.

HBI Scores >4.0 at all Smith River sites between 2016 and 2018 indicate that the macroinvertebrate communities are experiencing some moderate nutrient enrichment, and three of the eight (38%) monitoring sites exhibited fairly significant organic pollution (scores >5.0); but these have all decreased to below 5.0 in 2018. The biological integrity as measured by the HBI has decreased, but not significantly across all sites from 1999 to 2016 (T-test, $p=0.08$) and 2017 (T-test, $p=0.07$). Smith River sites located below major tributaries reported improvements in the tolerance-level of benthic communities, especially downstream of Sheep Creek, although this was less apparent in 2017. We postulated that decreased biological health in sections upstream from the permit canyon (HWY 360 to Camp Baker) is substantially improved by Sheep Creek flows, while macroinvertebrate communities downstream of the canyon section quickly decline with some increase in biological health metrics corresponding to Hound Creek inputs.

The observed increases in macroinvertebrate densities, total taxa richness and EPT taxa (more tolerant species) across most sites between 2016 and 2017 were “reset” during the high flows of 2018. This is reflected in significant decreases in macroinvertebrate densities, taxa richness, decreased HBI scores (more sensitive taxa reappearing at some sites) and increases in the MMI (improved aquatic health at the uppermost sites). Filamentous algae (*Cladophora*) has remained abundant despite the high flushing flows of 2018, which can be directly correlated with increasing water temperatures and high nutrient inputs (reflected in the HBI scores of >4 at five of the 8 sites). Over the course of this study, more Smith River sites experienced declining macroinvertebrate integrity trends than positive ones, especially in the permit canyon in 2018. The maintenance of healthier macroinvertebrate communities in the canyon from 2016 to 2017 was attributed to tributaries entering the canyon (Rock, Trout, Tenderfoot Creeks, etc.) improving water temperatures and quality, but even these cannot seem to ameliorate some of the environmental stressors occurring in the Smith River.

1.0 Introduction

In 2018, UMOWA contracted Montana Biological Survey (MBS) to continue the sampling and analysis of macroinvertebrate communities in the Smith River. This is the 3rd year of macroinvertebrate data collection to rectify the lack of recent baseline data throughout the Smith River basin, but especially around the Sheep Creek confluence area near Camp Baker. In 2018, Sandfire Resources included the Smith River sites upstream and downstream of Sheep Creek into its aquatic monitoring program (using similar methods), and they have agreed to share this data for this project, rather than UMOWA duplicating these efforts. The Smith River has been included on the Montana Department of Environmental Quality's (MDEQ) 303(d) list of impaired waters since 2006, from the confluence of the North and South Fork Smith River near White Sulphur Springs downstream to Hound Creek, due to low flow alterations, *Escherichia coli* levels and high total Phosphorus (MDEQ 2016). In June of 2017 and 2018, total Nitrogen and Phosphorus levels exceeded the numeric nutrient standard set by MDEQ (Lewis 2018; Energy Labs, 2018 unpublished data).

A search of the MDEQ EDAS database (Jessup 2006, EDAS 2014) indicated that 6 sites in the Smith River basin have been previously sampled for macroinvertebrates (1999-2005), and this data is already well over a decade old (MDEQ 2007). There have been few quantitative macroinvertebrate samples taken in the Smith River basin since then, but see Stagliano 2010. This is surprising, given the popularity of the Smith River as a recreational and fishing destination for its permitted multi-day float. UMOWA has increased the amount of data in the Smith River basin and near the important Sheep Creek tributary by continuing the Smith River Baseline Monitoring program for benthic macroinvertebrates in 2018 with these objectives: **1)** Quantitatively sample the Smith River above and below the Sheep Creek confluence near Camp Baker to develop a baseline database designed to detect any future changes in macroinvertebrate communities due to proposed mine operations. **2)** Revisit and resample six Smith River sites previously sampled by MDEQ (1999-2005) to determine if changes in benthic communities have occurred over the last decade or longer. **3)** Report our findings on the UMOWA website www.umowa.org and as presentations at UMOWA's annual meeting and Trout Unlimited chapter meetings and **4)** Archive this information in EDAS and STORET formats, so that is available to future public, MDEQ or USEPA inquiries.

2.0 Methods

2.1 Sample Site Selection

MBS quantitatively sampled macroinvertebrates at six previously established (1999-2005) sites between Fort Logan Bridge (HWY 360) and Eden Bridge (MDEQ 2007). We added two sites

upstream and downstream of the Sheep Creek confluence near Camp Baker in 2016 that have not been quantitatively sampled previously (**Table 1**). We sampled macroinvertebrates during stable summer flows on July 18th and 19th, 2018 while floating the river when flows were 159 cfs at Fort Logan (HWY 360) Bridge, 210 cfs below Sheep Creek and 260 cfs at Eden Bridge (**Table 1, Figure 1, Photo 4**).

MTDEQ used the traveling kick-net technique at five of these six sites. Relative abundance taxa metrics from this sampling technique are comparable to Hess samples, but cannot be used for quantitative density estimates. Benthic macroinvertebrates had been sampled by MDEQ with the Hess at the Eden Bridge site (Smith River float take-out) for 4 years in a row (2002-2005) with 2004 reporting both a Hess and a kick-net sample taken (MDEQ 2007). The MDEQ stream classification of the Smith River sites is as a low valley stream with elevations throughout the basin <1700m in elevation, while having the majority of the upper watershed within the Middle Rockies Ecoregion (MDEQ 2012). Therefore, we used the low valley macroinvertebrate MMI (LVAL MMI) thresholds to determine impairment, but also present the mountain MMI as another useful comparison of the macroinvertebrate trends (**see Section 2.3**, MDEQ 2102).

Table 1. Smith River study sites, date sampled, 2018 water parameters measured and flows (Q) on that date. *Sites not sampled by MDEQ. D/S=downstream, U/S=upstream

SITE #	Site Name	MDEQ ID	Latitude	Longitude	Date Coll.	H ₂ O Temp °C	Cond. (µs/cm)	TDS (ppm)	pH	Q (cfs)
1	Smith River D/S HWY 360	BKK 129	46.6758	-111.1444	7/18/2018	16.2	377	156	8.2	159
*2	Smith U/S Sheep Creek Camp Baker		46.8041	-111.1824	7/18/2018	16.4	397	230	8.2	159
*3	Smith River D/S Sheep Creek		46.804	-111.1841	7/18/2018	15.8	260	159	7.9	210
4	Smith @ USGS D/S Camp Baker	BKK 130	46.8280	-111.1924	7/18/2018	17.1	342	169	8.0	210
5	Smith in canyon near HOE ranch	BKK 131	47.0122	-111.2924	7/18/2018	22.7	325	164	8.0	250
6	Smith River D/S out of canyon	BKK 132	47.1551	-111.3307	7/19/2018	21.4	327	156	8.0	250
7	Smith River D/S of Hound Creek	BKK 133	47.2154	-111.3866	7/19/2018	24.5	344	175	8.1	255
8	Smith River @ Eden Bridge	M10SMTHR01	47.2362	-111.3888	7/19/2018	25.5	327	165	8.1	260

2.2 Habitat and Physical Water Sampling

Temperature and basic physical water parameters (Total Dissolved Solids, pH and Conductivity) were recorded at each site prior to macroinvertebrate sampling using an Oakton 10 water quality multi-meter, calibrated for the lower conductivity range (**Table 1**). A suite of water samples was also collected by the Smith River Habitat Restoration Group, ~2 weeks prior to macroinvertebrate sampling, according to MDEQ protocols (MDEQ 2012b, Lewis 2018) (pers. comm. with Sherry Meador) and processed at the Energy Laboratories in Helena. A 30 m survey tape was staked from the green-line on the stream bank to record sampling distances to where samples were taken in the stream channel (**Photo 1, Table 2**). Stream channel depths at each Hess sample point (n=3) were recorded at the time of sampling (**Table 2**). Photo points, incidental aquatic species and visual estimates of the habitat were also noted during the field visits.

Figure 1. Smith River discharge data from the USGS Gauge below Eagle Creek downstream from Camp Baker for the 3 years of sampling. Red arrows are approximate dates of

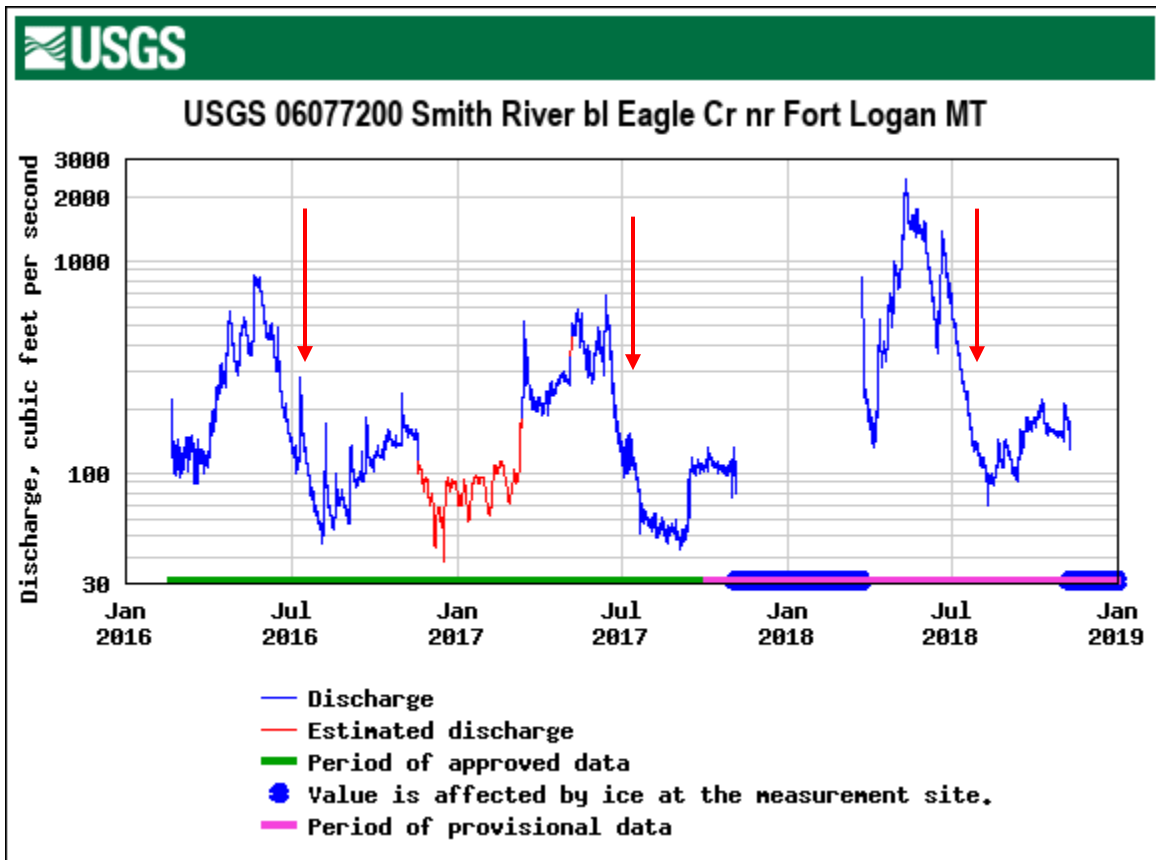


Table 2. Smith River Hess sample parameters measured in 2018 and incidental species captured, recorded and released: RMSC= Rocky mountain sculpin, LNDA= Longnose dace, ORVI=Northern crayfish. *Sites not sampled by MDEQ.

SITE #	Distance from Greenline (m)			Water Depth (cm)			Incidental Species		
	Hess 1	Hess 2	Hess 3	Hess 1	Hess 2	Hess 3	Hess 1	Hess 2	Hess 3
1	5	6	6	28	30	27			
*2	6	5	5	29	25	24	1 LNDA	1 ORVI	1 ORVI
*3	8	5	4	25	26	28			1 RMSC
4	6	4	8	30	25	33	2 ORVI	1 ORVI	
5	6	6	5	27	30	26	1 ORVI	1 RMSC	1 ORVI
6	5	4	6	25	24	30	1 ORVI		1 ORVI
7	12	13	12	25	30	27	1 ORVI	1 ORVI + LNDA	2 ORVI
8	4	5	4	25	28	27	1 ORVI	1 ORVI	3 ORVI

Photo 1. Hess sampling procedure at the Smith River site #6 out of the canyon 2018 showing abundant filamentous algae mats (l) and clean substrate after the sample is taken (r).



2.3 Macroinvertebrate Sampling

Three replicate Hess (33 cm diameter, 500 micron mesh) samples were taken within a designated riffle at each site to quantitatively collect macroinvertebrates at measured distances from the bank (**Photo 1 & 2**). Three Hess samples typically capture 90% of the total taxa present in a riffle (Vinson and Hawkins 1996). Each Hess sample constitutes a benthic area of 0.1 m², so a multiplier of 10 is applied to each sample to achieve a per meter squared estimate. At each sampling point, the Hess sampler was pushed into the stream bottom to form an effective seal and all cobbles (>64 mm) within the sampler were scrubbed clean of organisms and removed; then the entire area within the sampler frame was raked for one minute until all organic matter and macroinvertebrates were washed into the collection net of the Hess sampler (**Photo 1 & 2**). Macroinvertebrates, organic and inorganic matter were composited into a 40 liter bucket. By swirling the bucket with several water washes, organic material was elutriated from the inorganic (cobbles/gravels) portion onto a 500µm sieve, so that only macroinvertebrates and organic matter were transferred into 1 liter labeled sampling jars filled with 95% ethanol. The inorganic portion of the sample left in the bottom of the bucket was thoroughly examined for caddisfly cases before being discarded.

Photo 2. Hess sampling procedure in the Smith River near Hound Creek confluence (BKK133) in 2016 (l) and 2018 (r). Distance from the greenline to the sampler was measured (redline).



2.4 Taxonomic Analysis

Samples were processed and analyzed at the Montana Biological Survey laboratory in Helena. Macroinvertebrates were picked from the samples on a random grid pattern until 500-600 individuals were reached, placed in vials and then identified to the lowest taxonomic level possible (genus/species) with a dissecting microscope (10-40x) following MDEQ (2012) protocols.

MDEQ low valley (LVAL) and mountain (MTN) ecoregional multi-metric indices (MMIs) and other metrics were calculated from the data after it was entered into EDAS (Jessup 2006), including EPT taxa, % EPT, % Non-insect, % Chironomidae and the Hilsenhoff Biotic Index (HBI). The MMIs use different suites of these metrics: LVAL (5 metrics) and MTN (7 metrics) to give a composite score that impairment is judged; if below the threshold scores of 48 for LVAL and 63 for MTN then the community is considered impaired; MDEQ no longer uses the MMI to make site impairments (MDEQ 2012). The combined mayfly, caddisfly and stonefly species (EPT taxa) and the percentage of these in the sample (% EPT) are always informative metrics, as EPT taxa contain some of the more intolerant aquatic insects. Generally, 20 or more EPT taxa collected at a site in the mountain streams of Montana is considered an unimpaired and healthy community (Bukantis 1996). EPT richness metrics typically decrease with increasing sediment (Barbour et al. 1999); although, Tricos (*Tricorythodes* and *Caenis*) and burrowing mayflies (*Ephemera simulans*) are more silt tolerant and can increase in numbers with increasing siltation.

One informative stand-alone metric is the Hilsenhoff Biotic Index (HBI) which measures the tolerance of a macroinvertebrate community to organic enrichment (Hilsenhoff 1987), but has also been used as a surrogate for sediment tolerance (MTDEQ 2012). Tolerance values are based on a 0-10 scale, where zero-ranked taxa are most sensitive and 10-ranked taxa are most tolerant to pollutants. Values of 0.0-3.0 indicate no apparent organic pollution (excellent), 3.0-4.0 possible slight organic pollution (very good), 4.0-5.0 moderate pollution (good), 5.0-6.0 fairly significant (fair), 6.0-7.0 significant pollution (fairly poor), 7.0-8.0 very significant organic pollution 8.0-10 severe organic pollution. HBI scores are evaluated using a threshold value of 4.0 as a core indicator of organic or sediment impairment (MDEQ 2011).

Macroinvertebrate optimal and maximum thermal tolerances (Brandt 2001 and Ott and Maret 2003), categorical classifications (Apfelbeck 2007), and best professional judgment were used to categorize 225 taxa in the Madison and Missouri River systems (McGuire 2016). Community temperature metrics were calculated using pooled data (all replicates combined) where optimal and max. temperature values were applied to the abundance of each taxa (that values are available) for each site.

3.0 Results

Overall, 115 unique macroinvertebrate taxa were reported from the 72 macroinvertebrate assessment samples collected between Fort Logan and Eden Bridge from 2016 to 2018 (**Appendix A**). The cumulative mayfly, caddisfly and stonefly (EPT taxa) species richness across all sites was 51; 42 EPT species were reported in 2016 (**Table 3**); an additional 9 EPT taxa reported in 2017 were usually found below tributaries, no new EPT were added in 2018. Average total macroinvertebrate taxa richness was 33.3 taxa per site in 2016, 45 per site in 2017 and 34 per site in 2018 (**Figure 2a**); this elevated 2017 taxa richness was significantly different (increase) from samples collected from 1999-2005, 2016 and 2018 (T-test, $p < 0.001$) (**Table 4**). Macroinvertebrate communities collected in 2016-2018 had ~50% average taxa similarity across sites with those reported from MDEQ samples in 1999-2005; highest between-year taxa similarity was at sites in the permit canyon (avg. 79.5%) and the lowest at Hound Creek (30%) and Eden Bridge (34%) (**Appendix A**). Along with shifting taxa composition at these downstream sites, there were some substantial increases in % non-insect taxa and % Chronomidae (midges) comprising the samples at multiple sites. Increases in aquatic worms (Lumbricidae and Tubificidae), snails (*Physella*) or fingernail clams (*Pisidium*, *Sphaerium*) were the causes of higher % non-insects in some of the samples (**Figure 2b**, **Appendix A**). Loss of taxa from a site is not necessarily indicative of biological impairment, unless the species lost are all sensitive taxa. Between 2005 and 2016, Eden Bridge appeared to have lost salmonflies (*Pteronarcys*), the golden stonefly, *Hesperoperla* and the sensitive mayflies, *Epeorus albertae* and *Rhithrogena*. In their place, this site has added more tolerant taxa, such as the crayfish (*Orconectes virilis*), *Cricotopus* midges and Tubificidae worms (**Appendix A & D**). Likewise at the Hound Creek site in 2016, dominant benthic invertebrate taxa are, in order of abundance, *Hydropsyche morosa* gr., *Choroterpes albiannulata* and *Tricorythodes explicates*, whereas in 1999, BWOs (*Baetis tricaudatus*), the Heptageniid mayfly, *Ecdyonurus simplicioides*, PMD's (*Ephemerella excrucians*), and the mother's day caddis (*Brachycentrus occidentalis*) were dominant. These more-sensitive taxa were not completely lost, but have decreased substantially between 1999 and 2016 samples. Taxa shifts to more tolerant taxa are being documented across most sites and are reflected in higher HBI scores (**Figure 3**).

Smith River macroinvertebrate densities have significantly increased across all sites between 2016 and 2017, except for the two sites below Sheep Creek (**Figure 2a**). Densities of benthic macroinvertebrates averaged 9,944 individuals per m^2 (SE \pm 1,264) across all sites in 2016, while in 2017 densities averaged 10,381 individuals per m^2 (SE \pm 1,471) and varied significantly spatially with the overall trend of higher densities above Sheep Creek and through the permit canyon and then decreasing downstream to Eden Bridge (**Figure 2a**). The Smith River at Eden Bridge reported the lowest macroinvertebrate densities (~4,500 ind. per m^2) of all sites, consistent with

the 2002-2005 MDEQ data, while the highest average densities of 2017 were documented in the canyon (SM_HOE) at 17,220 ind. per m² and downstream of Sheep Creek (15,260 ind. per m²) in 2016 (Figure 1a). These are extremely high densities of macroinvertebrates, rivaling nutrient-rich aquatic environments, such as spring creeks or the Missouri River below Holter dam (Stagliano 2016). As a comparison, macroinvertebrate densities averaged 3,400 individuals per m² in Sheep Creek approximately 17 miles upstream from the Smith River (Stagliano, unpublished data). Macroinvertebrate densities at all sites reported in 2018 averaged 4,210 per m² and have been significantly reduced below Sheep Creek (**Figure 2a**), especially in the heart of the canyon downstream from Tenderfoot Creek. We could not compare benthic densities from 1999 across all sites because only Eden Bridge had comparable Hess samples taken (**see Section 3.8**).

Mayfly (E) and caddisfly (T) taxa were more diverse and abundant than stonefly (P) taxa at all sites (**Table 3, Figure 6**). Highest site EPT richness, 33 species, was reported at the Smith River in the Canyon (HOE) and downstream of Sheep Creek, respectively. While the lowest cumulative EPT richness (24 spp.) was reported at the HWY 360 site and out of the canyon (**Table 3**). There were 23 species of mayflies recorded throughout the study section with the dominant three, BWO's (*Baetis tricaudatus*), Tricos (*Tricorythodes explicatus*) and Pale Morning Duns (*Ephemerella excrucians*) often exchanging dominance at any one site depending on the silt coverage in the riffle sampling area (**Table 3**). The most sensitive mayflies, *Caudatella heterocaudata*, *Drunella coloradensis*, *Drunella grandis*, *Serratella tibialis* and *Epeorus albertae* are now restricted to the heart of the canyon below Sheep and Tenderfoot Creeks (**Table 3**)

Of the 21 total species of caddisflies that were collected in 2016-2018, the net spinning caddisfly, *Hydropsyche occidentalis*, Mother's day caddis *Brachycentrus occidentalis* and the long-horned caddis, *Oecetis avara* were collected across most sites and were dominant (**Table 3**). Populations of other net-spinning caddisflies (*Cheumatopsyche*, *Hydropsyche morosa* gr.), micro-caddis (*Hydroptila*) and snail-cased caddis (*Helicopsyche borealis*) were also common across most sites, but not as abundant (**Table 3**). High percentages of caddisflies comprising the %EPT were documented at sites below the tributaries, Sheep Creek and Hound Creek (Figure 1b). Stonefly (Plecoptera) taxa (5 species) were collected sporadically across the study reaches (**Table 3**).

The Golden Stoneflies, *Hesperoperla pacifica* and *Claassenia sabulosa* were the most widespread taxa found consistently and in higher numbers in the canyon and just downstream, with *C. sabulosa* still occurring in low numbers downstream to Eden Bridge (**Table 3, Appendix A**). In the 2016 samples, *Isoperla* (Green-winged Stoneflies), begin to disappear as you proceed downstream from Camp Baker into the canyon, but in 1999 and 2002-2003 *Isoperla* had been

previously collected by MDEQ at Hound Creek and Eden Bridge. Likewise in 2016, salmonfly (*Pteronarcys californica*) individuals are still reported at Camp Baker and into the canyon in decent numbers (**Photo 2**), and diminishing out of the canyon; whereas in 2004, they were collected all the way D/S to Eden Bridge. Surprisingly, only one stonefly taxa, *Skwala* was collected from the samples downstream of Sheep Creek in 2016 and 2018, while in 2017 there were 4 stonefly taxa (**Table 3**). In comparing macroinvertebrate communities sampled at the sites between 1999-2005 and 2016-2018, we can see some trends in decreasing number of EPT taxa and % EPT in 2016 in the samples across all sites, but these were not significant (T-test, $p=0.29$) and (T-test, $p=0.26$), respectively (Figure 1a). Additionally, these EPT metrics rebounded in 2017 (**Figure 2a**) and especially the % EPT in the Hound Creek and Eden Bridge samples in 2018 (**Figure 2b**). The tolerant, warmer water EPT taxa were less abundant in the 2018 samples downstream of Hound Creek and explains the significantly improved HBI scores at Eden Bridge (**Figure 3**).



Photo 3. Salmonfly nymphs in the Smith River D/S Sheep Creek sample.

Table 3. The cumulative mayfly, stonefly and caddisfly (EPT) taxa occurrences and dominance for the entire study reach 2016-2018. x=rare, X=common, XX=abundant, XXX=dominant at site

Order	Species	HWY 360	Camp Baker	DS_Sheep Cr	DS_CMBaker	Canyon (HOE)	Out of Canyon	DS_Hound	Eden Bridge
Mayflies	Ephemeroptera								
Baetidae	<i>Acerpenna pygmaea</i>	x			x			X	x
Baetidae	<i>Acentrella turbida</i>	X	x	x	x	X	x	X	X
Baetidae	<i>Baetis intercalaris</i>						x	x	x
Baetidae	<i>Baetis tricaudatus</i>	XX	x	XX	XX	X	X	X	x
Baetidae	<i>Dipheter hageni</i>		x	x	x	X	X	x	x
Baetidae	<i>Plauditus punctiventris</i>	x	x	x		x		X	
Baetidae	<i>Fallceon quilleri</i>	x						x	x
Leptophlebiidae	<i>Choroterpes albiannulata</i>						x	XX	X
Leptophlebiidae	<i>Paraleptophlebia bicornuta</i>						x	x	x
Leptophlebiidae	<i>Paraleptophlebia sp.</i>	x	X	X	X	X	x	x	x
Leptohyphidae	<i>Tricorythodes explicatus</i>	XX	XX	XX	XX	XX	X	X	x
Ephemerellidae	<i>Attenella margarita</i>		X	X	x		x	X	x
Ephemerellidae	<i>Ephemerella excrucians</i>	x	x	X	X	X			x
Ephemerellidae	<i>Caudatella heterocaudata</i>			x	x	X			
Ephemerellidae	<i>Drunella coloradensis</i>		x	X	x	X			
Ephemerellidae	<i>Drunella grandis</i>				x	X			
Ephemerellidae	<i>Serratella tibialis</i>			x	x	X			
Ephemeridae	<i>Ephemerella simulans</i>	X	x			x		x	
Heptageniidae	<i>Epeorus albertae</i>			x	x	X	x		
Heptageniidae	<i>Heptagenia</i>			x	x				
Heptageniidae	<i>Nixe / Ecdyonurus</i>	x		X	x	X	X	x	x
Heptageniidae	<i>Maccaffertium terminatum</i>					x			x
Heptageniidae	<i>Rhithrogena sp.</i>	X			x	x	x		X
Stoneflies	Plecoptera								
Perlodidae	<i>Isoperla mormona</i>	x	x	x	x				
Perlodidae	<i>Skwala</i>	x	X	x		x		X	x
Pteronarcidae	<i>Pteronarcys californica</i>		X	X	x	X			
Pteronarcidae	<i>Pteronarcella badia</i>		x	x	x				
Perlidae	<i>Hesperoperla pacifica</i>		x		x	x	X	x	
Perlidae	<i>Claassenia sabulosa</i>		x			x	X	x	x
Nemouridae	<i>Zapada cinctipes</i>		x				x		
Caddisflies	Trichoptera								
Brachycentridae	<i>Amiocentrus aspilus</i>			x	x	x			
Brachycentridae	<i>Brachycentrus americanus</i>			x	x				
Brachycentridae	<i>Brachycentrus occidentalis</i>	X	XX	XX	X	x	x	X	x
Hydropsychidae	<i>Arctotopsyche grandis</i>			x					
Hydropsychidae	<i>Cheumatopsyche</i>	X	X	X		X	XX	XX	X
Hydropsychidae	<i>Hydropsyche occidentalis</i>	X	X	X	X	X	X	x	x
Hydropsychidae	<i>Hydropsyche morosa gr.</i>	X		x		x		X	X
Hydropsychidae	<i>Hydropsyche slossonae</i>		x	x				X	X
Hydroptilidae	<i>Agraylea</i>		x				x	x	
Hydroptilidae	<i>Hydroptila</i>		X	X	X	X	X	X	x
Hydroptilidae	<i>Mayatrichia ayama</i>		x		x	x	X	X	X
Hydroptilidae	<i>Neotrichia</i>		x		x	x	x	x	x
Hydroptilidae	<i>Ochrotrichia</i>	x		x				x	
Lepidostomatidae	<i>Lepidostoma</i>	x		x	X	x			
Leptoceridae	<i>Ceraclea</i>	X							
Leptoceridae	<i>Oecetis avara</i>	X	X	X	X	X	X	x	x
Limnephilidae	<i>Dicosmoecus gilvipes</i>	x		x		x			
Limnephilidae	<i>Onocomoecus unicolor</i>	x	x	x					
Helicopsychidae	<i>Helicopsyche borealis</i>	X	x	XX	XX	X		X	
Philopotamidae	<i>Wormaldia</i>					x	X	X	
Psychomyiidae	<i>Psychomyia cf. flavida</i>							x	
	Total EPT per site	24	28	33	30	33	24	31	26

Figure 2a. Macroinvertebrate metric averages for 2016-2018 sample sites. Error bars are SE. Blue arrows are major tributaries entering the Smith River. Sites arranged in upstream (l) to downstream (r) orientation.

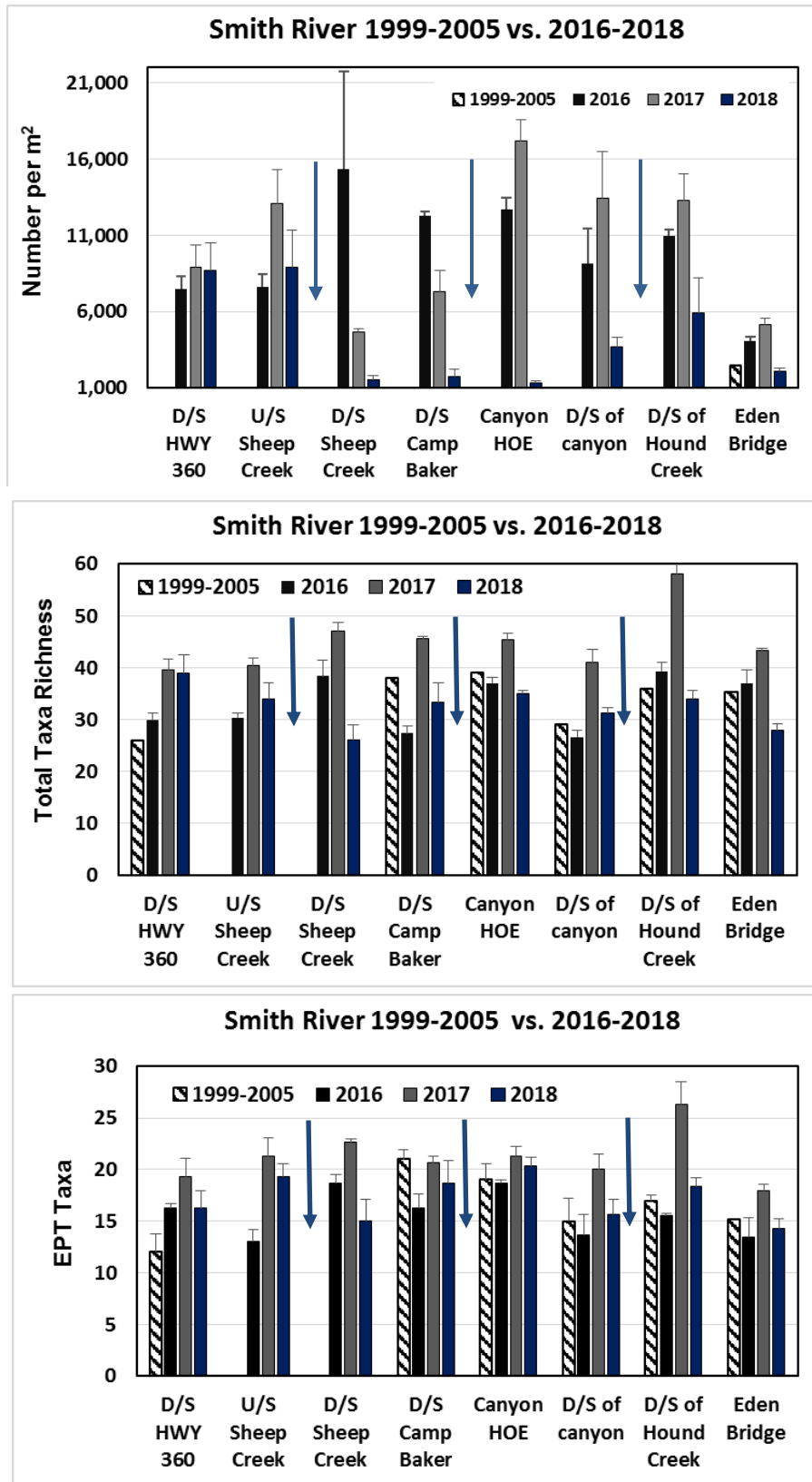


Figure 2b. Macroinvertebrate metric averages for 2016-2018 sample sites. Error bars are SE. Blue arrows are tributaries entering. Sites arranged in upstream (l) to downstream (r) orientation.

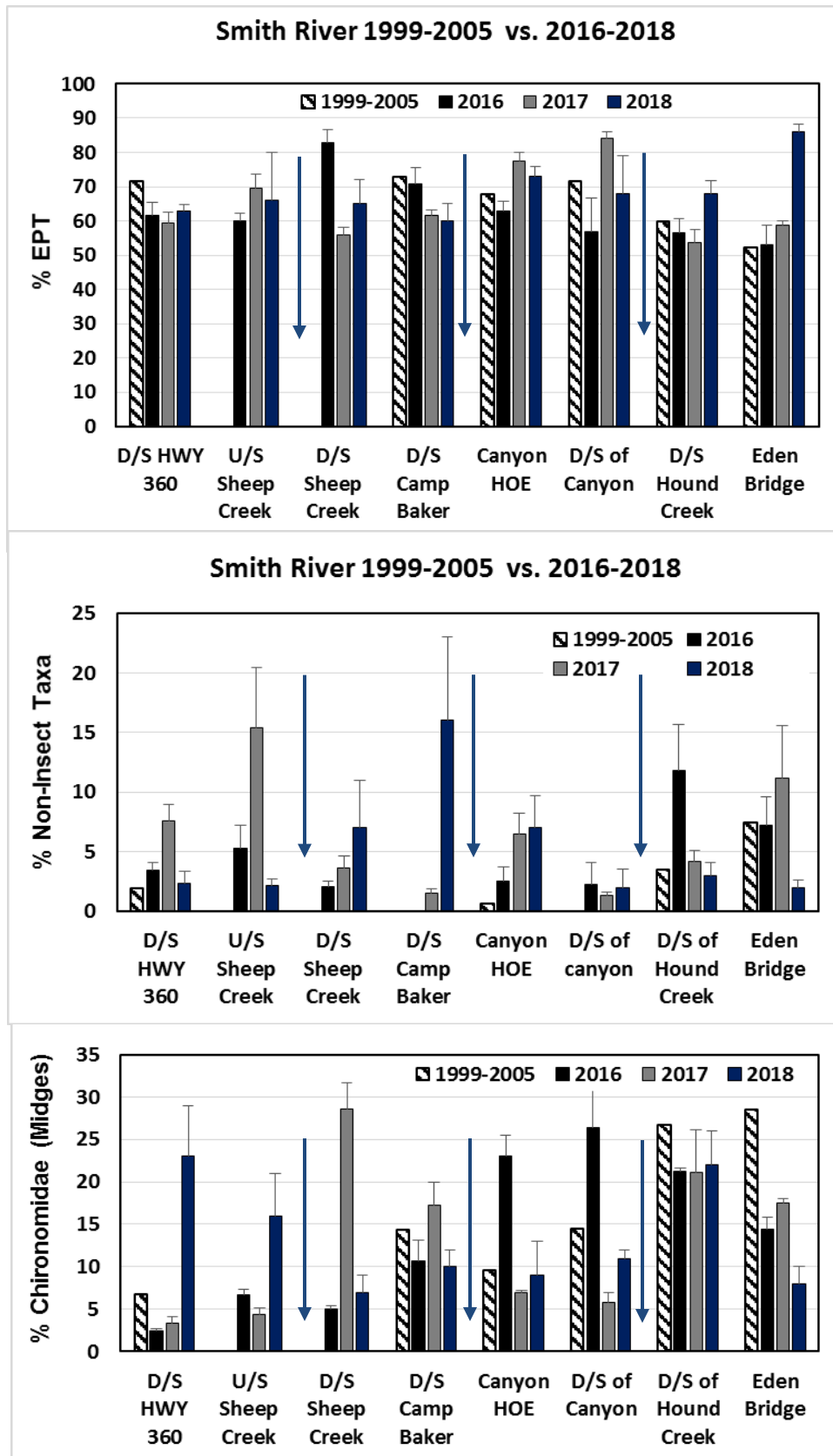
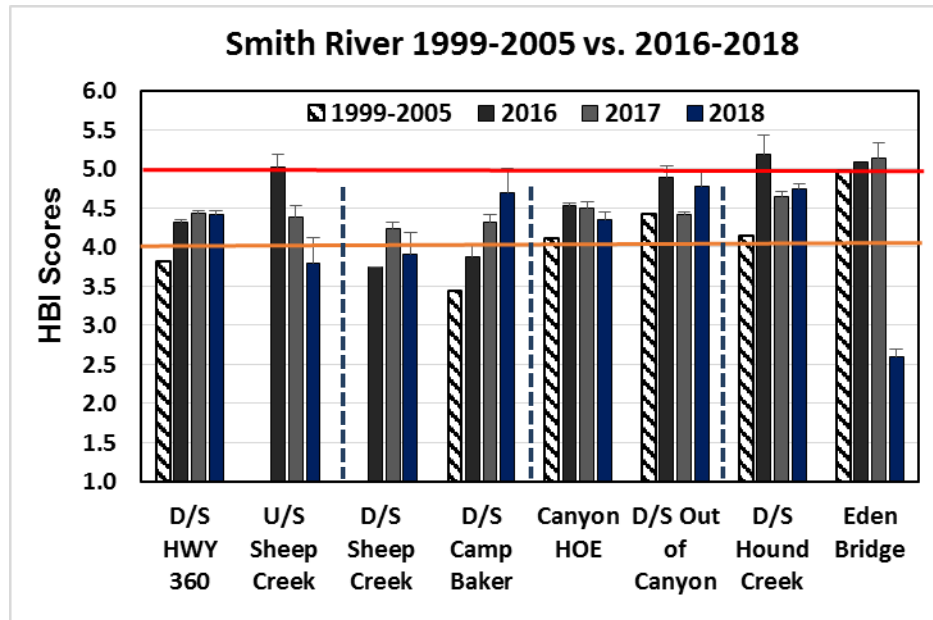


Figure 3. Macroinvertebrate HBI averages for the sample sites. Error bars are SE. Blue arrows are tributaries. Values above threshold lines are indicative of moderate (orange) to fairly significant (red) organic/sediment enrichment. Sites arranged upstream (l) to downstream (r).



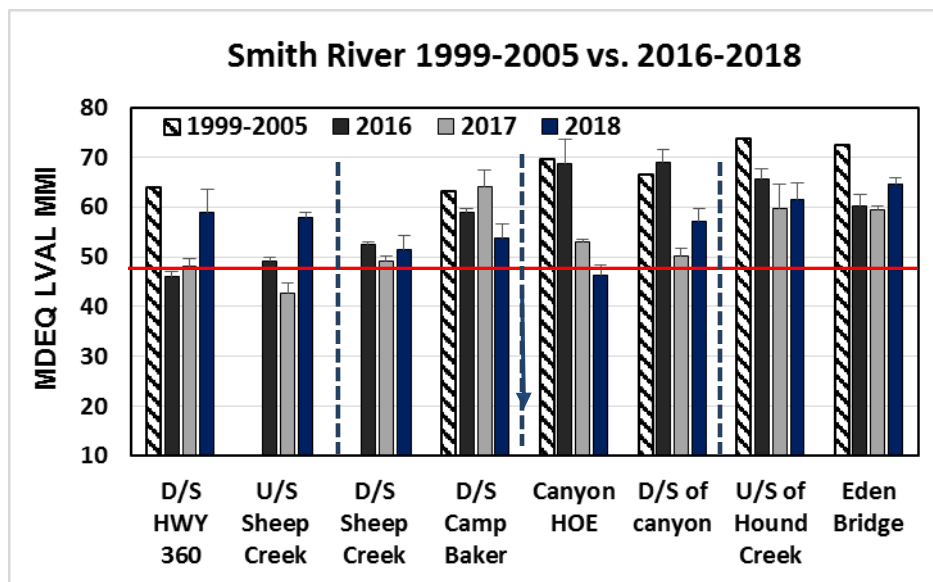
3.1 HBI Tolerance Scores

HBI scores >4.0 indicate that macroinvertebrate communities at all Smith River sites were experiencing some moderate organic enrichment, and three of the eight (38%) monitoring sites between 2016 and 2018 were exhibiting fairly significant organic pollution (scores >5.0); but these have all decreased to below 5.0 in 2018 (**Figure 3**). Only the Eden Bridge site had HBI scores in the 5.0 range from 1999-2005, but significant decreases in the tolerance scores between 2017 and 2018 have ranked this community non-impaired by nutrients (orange bar on **Figure 3**). Overall, the Smith River monitoring section HBI scores increased by 12.2% between 1999 and 2016; this was a significant shift (T-test, $p=0.011$) (**Table 4**) in the tolerance-level of benthic communities, indicating decreasing biological health. Largest cumulative site increases in the HBI scores between 1999 and 2018 were at HWY 360 (+21%) and downstream of Camp Baker at the USGS gauge (+41%), while the largest decreases (improvements) in HBI scores were at Camp Baker upstream of Sheep Creek (-24%) and at Eden Bridge (-48%) (**Table 4**). The Smith River site below Sheep Creek showed improvements in the tolerance-level of its benthic community compared to upstream in 2016, but this evened out in 2017, and by 2018, both were below the moderate nutrient impairment threshold; these were 2 of only 3 sites to achieve this status out of the total number in all years (**Figure 3**).

3.2 MDEQ MMI BIOASSESSMENT SCORES

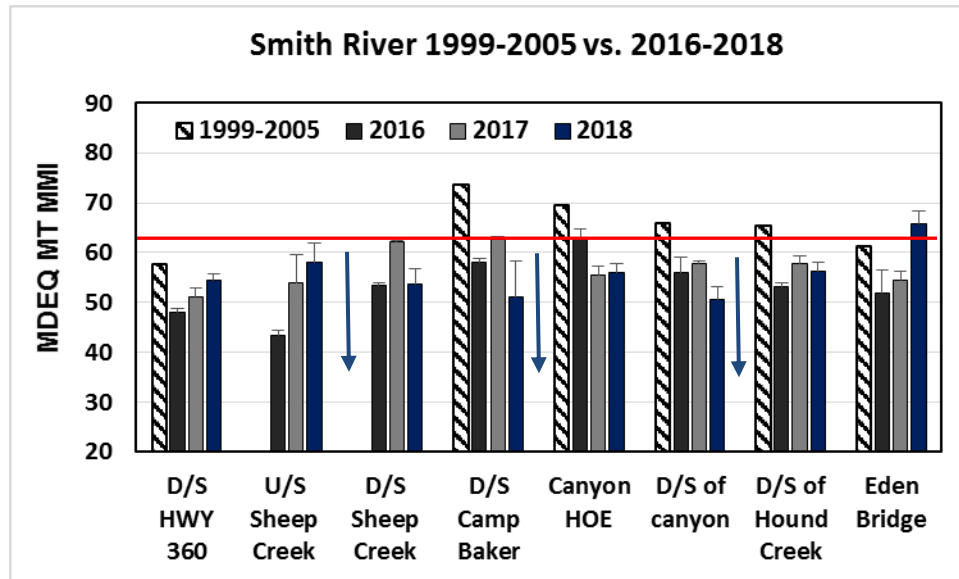
MDEQ LVAL MMI scores were most stable between 2016 and 2018 at the Smith River site below Sheep Creek, but these are barely above the 48 score impairment threshold (**Figure 4**). MDEQ Low Valley MMI scores have decreased overall by 10.1% between 1999 and 2016; this was a significant shift (T-test, $p=0.017$) with even more significant declines in 2017 ($p=0.0004$) and 2018 ($p=0.0007$) (**Table 4**). Largest site declines in the DEQ LVAL MMI scores between 1999 and 2018 were observed at HWY 360 (-28%, 2017, rebounding in 2018), downstream in the permit canyon HOE (-34%, 2018), out of the canyon (-24%) and Eden Bridge (-17%) (**Figure 4, Table 4**). These integrity declines in the canyon below Tenderfoot Creek (#5 HOE & #6 out of the canyon) are troubling because they had the highest scores in 2016, and may be caused by the dense filamentous algae documented in 2017 and 2018 (**Photo 4**).

Figure 4. Macroinvertebrate Low Valley MMI scores for 1999-2005 and 2016-2018 sample sites. Error bars are SE. Blue dashes are tributaries. Redline is the impairment threshold.



Using the MDEQ Mountain MMI, which calculates a different set of metrics, only one of the Smith River sites sampled between 2016 and 2018 ranked unimpaired (Eden Bridge in 2018); whereas, four of the permit canyon macroinvertebrate samples collected in 1999 ranked unimpaired (**Figure 5**). This was a significant improvement in benthic health at Eden Bridge. Smith River sites upstream and downstream of Sheep Creek remain impaired with this ecoregional MMI, but upstream has improved between 2016 and 2018 (**Figure 5**). Overall, MDEQ Mountain MMI scores decreased significantly (T-test, $p=0.0003$) on average by 13.1% between 1999 and 2017; only Eden Bridge experienced no significant change (**Figure 5**).

Figure 5. Macroinvertebrate Mountain DEQ MMI scores for 1999-2005 and 2016-2018 sample sites. Error bars are SE. Blue arrows are major tributaries. Redline is the impairment threshold.

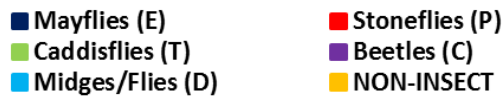
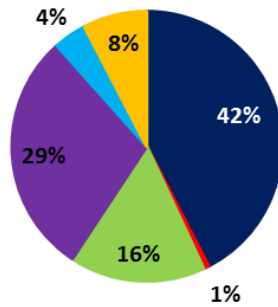


3.3 SMITH RIVER MACROINVERTEBRATE COMPOSITION

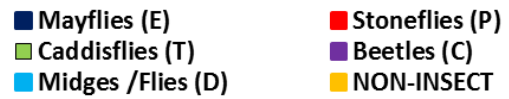
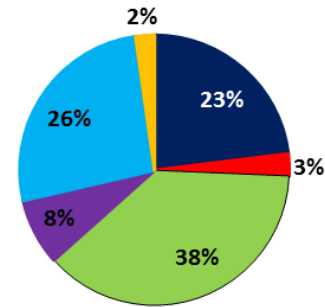
The cumulative relative abundance (RA) of mayfly, caddisfly and stonefly (% EPT) in the samples across all sites averaged 66% in 1999-2005; % EPT averaged 63% in 2016, and has increased to 65% in 2017, and 69% in 2018 (**Figure 2b**). It is fairly typical to see 10-20% shifts in dominant taxa groups from year to year based on the inherent variability and timing of benthic sampling. A large hatch of Tricos or PMD's two weeks before sampling occurs can certainly eschew mayfly RA lower, than if we captured the nymphs of that species prior to hatching (**Figure 6**). Significant increases in % EPT at particular sites has occurred at Hound Creek and Eden Bridge (**Figure 2b, Table 3**). Significant increases in the abundances of Chironomidae (Midges) were detected at particular sites since 1999, especially at HWY 360 (2018), upstream of Sheep Creek (2018), downstream of Sheep Creek (2017) and downstream of Tenderfoot Creek in the canyon (2016) and out of the canyon (2016), but this was not consistent or significant across all sites (T-test, $p > 0.05$) (**Figure 2b**). Most of the midge genera (*Cricotopus*, *Eukiefferiella*, *Nostococcladius*) that have caused these increases are associated with filamentous algae and *Nostoc* cyanobacteria which can be affected (reduced) by spring flushing flows.

Figure 6. Macroinvertebrate Ordinal Composition for 2017 and 2018 sites.

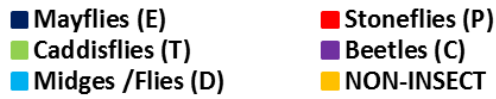
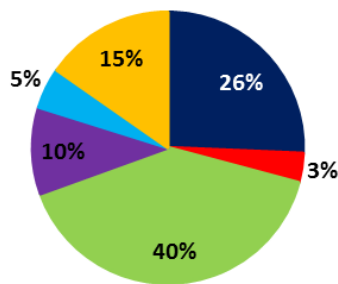
Smith River @ HWY 360 Bridge 2017



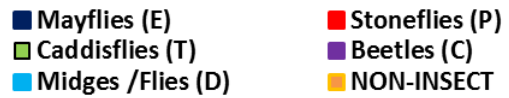
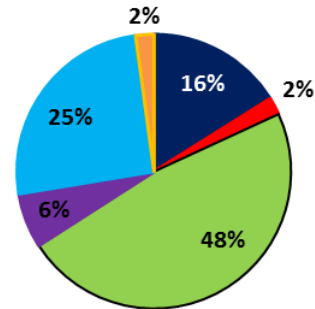
Smith River @ HWY 360 2018



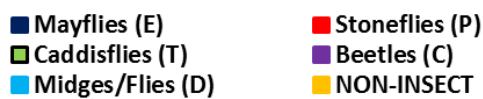
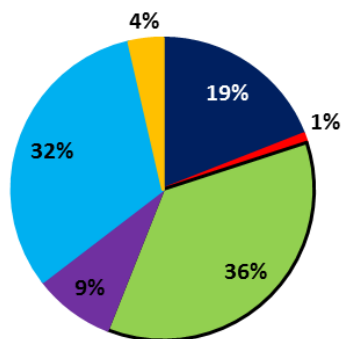
Smith River @ Camp Baker 2017



Smith River @ Camp Baker 2018



Smith River D/S Sheep Creek 2017



Smith River D/S Sheep Creek 2018

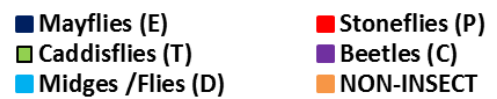
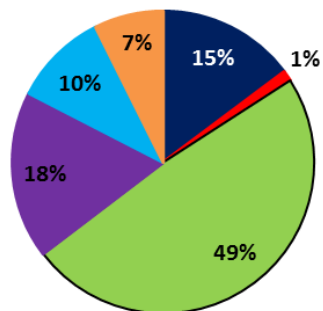


Figure 6. cont. Macroinvertebrate Ordinal Composition for 2017 and 2018 sample sites.

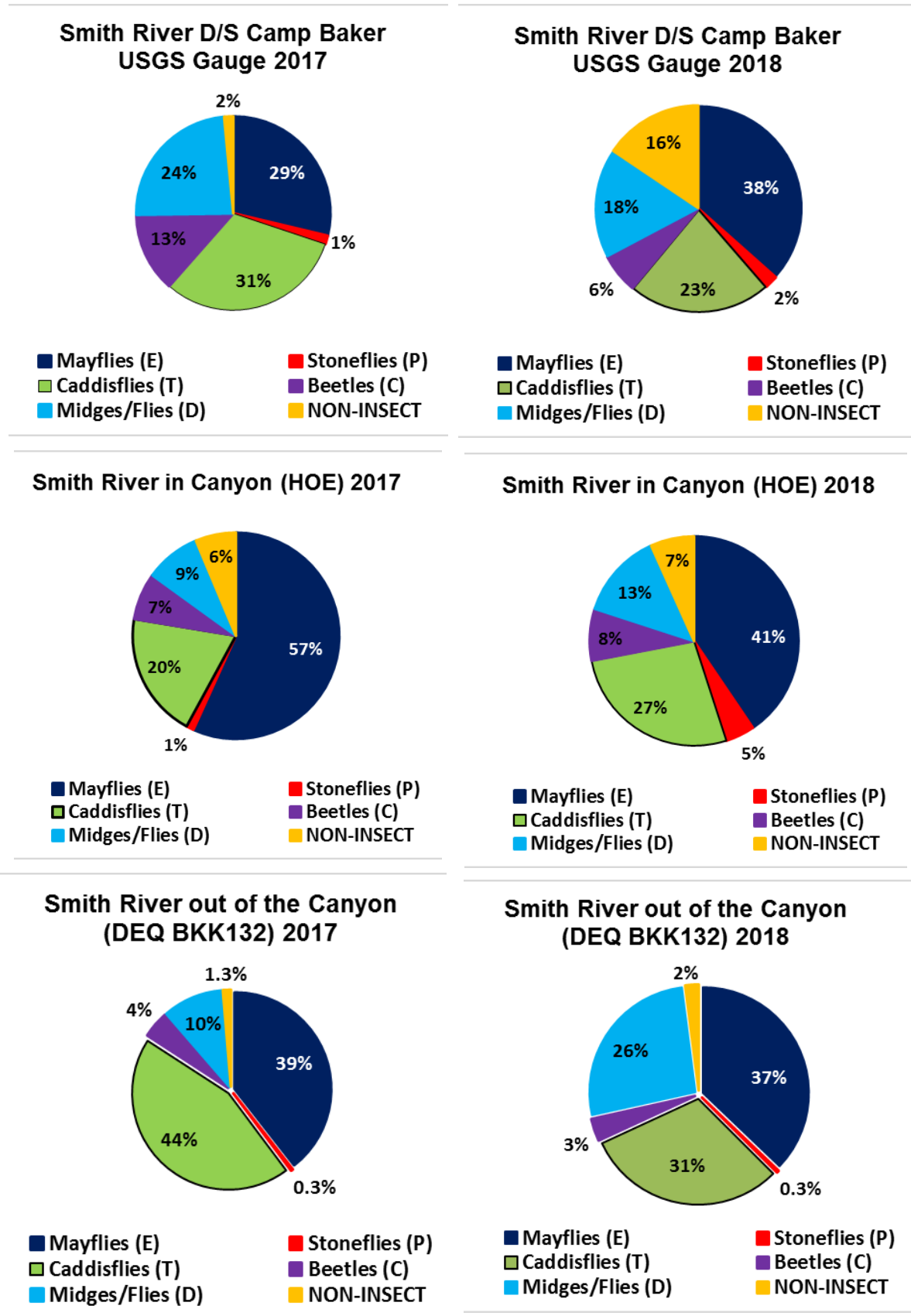
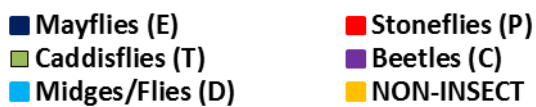
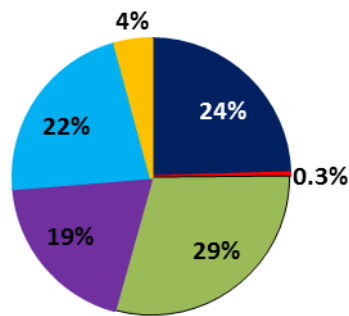
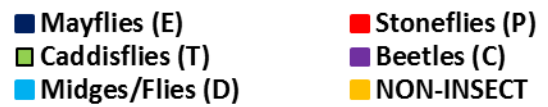
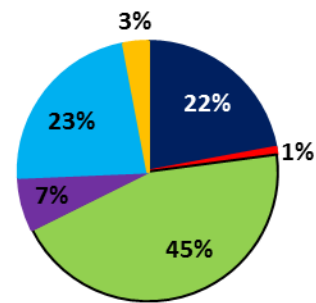


Figure 6. cont. Macroinvertebrate Ordinal Composition for 2017 and 2018 sample sites.

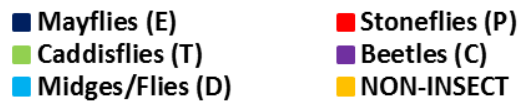
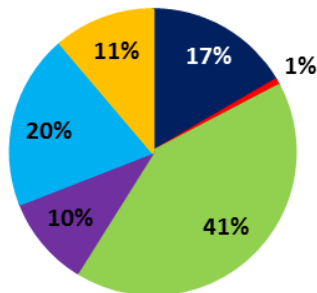
**Smith River D/S Hound Creek
 (DEQ BKK133) 2017**



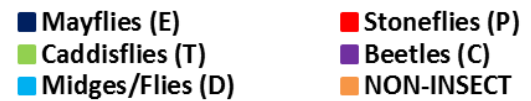
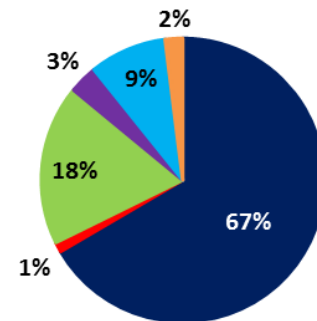
**Smith River D/S Hound Creek
 (DEQ BKK133) 2018**



Smith River @ Eden Bridge 2017



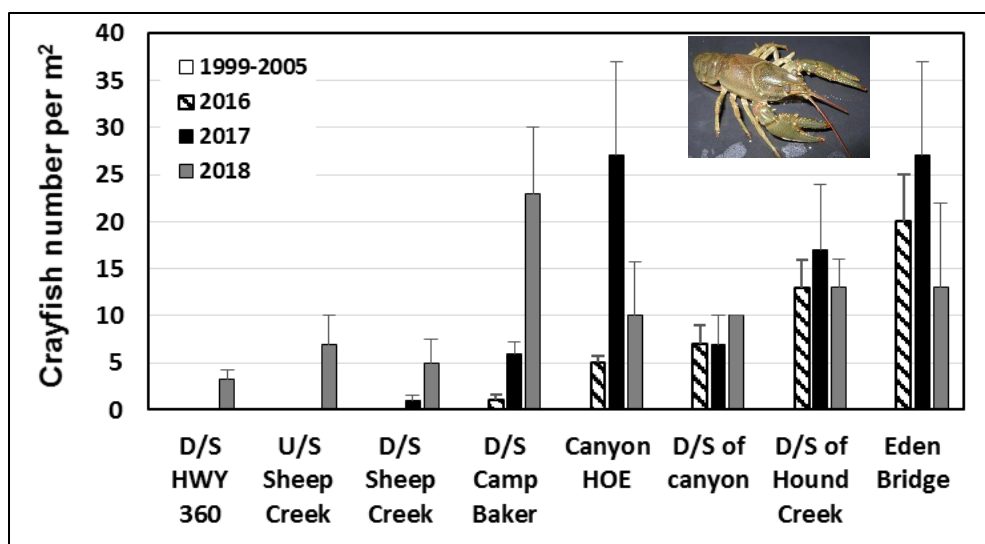
Smith River @ Eden Bridge 2018



Northern Crayfish

The northern crayfish (*Orconectes virilis*) had not been reported in any MDEQ samples between 1999 and 2005, but in 2016, we reported crayfish densities of 1.5, 5, 7, 13 and 20 individuals per m² at Smith River sites downstream of Camp Baker at the USGS gauge below Eagle Creek, near Heaven on Earth Ranch (HOE), out of the Canyon, Hound Creek and Eden Bridge, respectively (**Figure 7**). Crayfish have further increased their upstream detections as far as Highway 360 Bridge, as well as their abundances at occupied sites in 2017 and 2018 (**Figure 7**). Crayfish densities need to be at least ~1.5-3 individuals per m² at a site to be detected by the Hess sampler.

Figure 7. Crayfish densities reported for 1999-2018 Smith River sample sites.



Macroinvertebrate Community Temperatures

We evaluated the macroinvertebrate community tolerance to increasing temperatures for the 2017 and 2018 samples. Increasing maximum temperature tolerances up to ~25°C in 2017 at Smith River sites HWY 360 and D/S of the Canyon reflect a shift from more cool-water taxa to warmer water species (**Figure 8**). The Smith River downstream of Sheep Creek is maintaining a more cool-water macroinvertebrate community (avg. optimal temp. 17.0°C) because of the colder water influx of this tributary (**Figure 8**). Eden Bridge invertebrate communities reflected much lower temperatures in 2018, as much as 4°C less than in 2017 (**Figure 8**). Cooler temperatures reflecting higher discharge signals in 2018 were also seen at the HWY 360 Bridge, D/S of Camp Baker, D/S of the Canyon and at Hound Creek; the only site where communities reflected an increase is at the Camp Baker site U/S of Sheep Creek (**Figure 8**).

Figure 8. Macroinvertebrate Community Optimal (blue) and Maximum (red) Temperatures for 2017 and 2018.

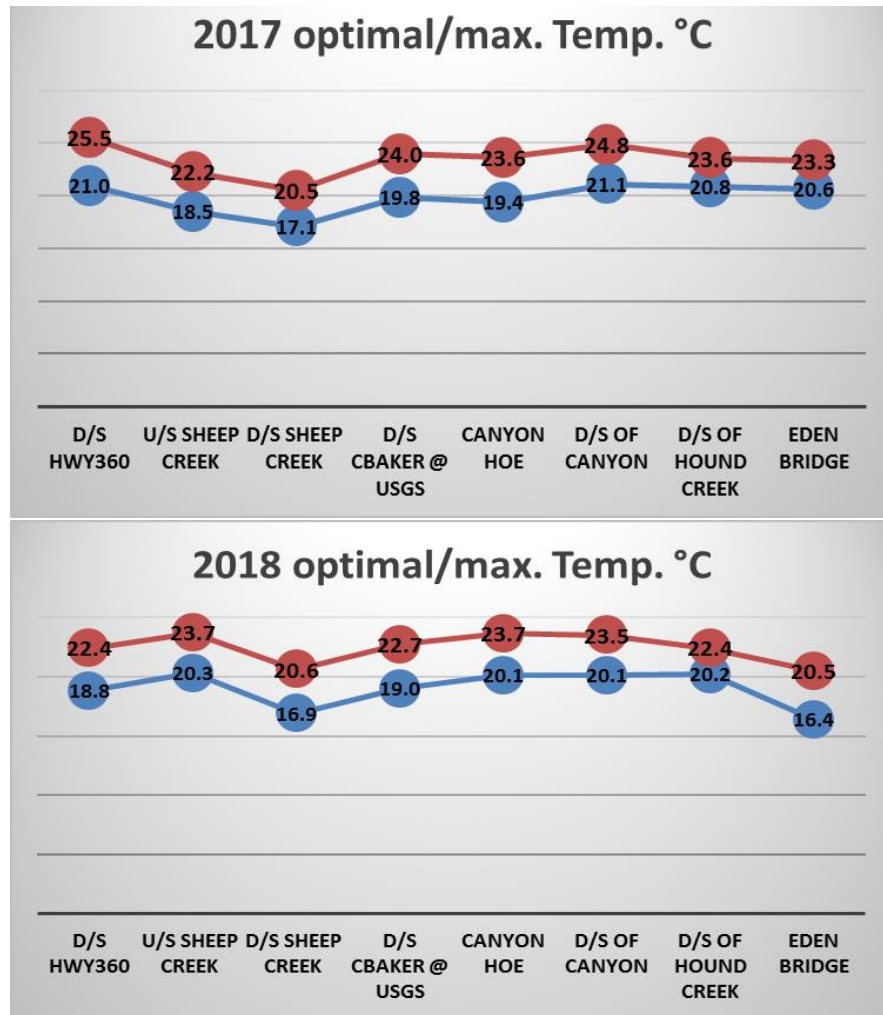


Photo 4. Smith River riffle downstream from HWY 360 (Fort Logan Bridge).



3.4 Smith River at HWY 360 Bridge (MDEQ site BKK129)

The macroinvertebrate community at the Smith River downstream of the HWY 360 (site code BKK129), reported the 2nd lowest benthic invertebrate density of all sites, averaging ~8,600 individuals per meter², which are still very abundant compared to other rivers (**Figure 2a**). Total taxa and EPT taxa richness has increased at this site since the 1999 sampling, but the % EPT in the samples has decreased (**Figure 2b**). Correspondingly, the HBI score has increased since 1999 indicating that the community is becoming more tolerant (**Figure 3**), and the benthic community at this site was the only that ranked impaired with the Low Valley MMI in 2016, a significant decline in biological integrity (28%) since 1999 (**Figure 4, Table 4**).

Dominant insect taxa at the HWY 360 Bridge site, in order of abundance, were the riffle beetle, *Optioservus quadrimaculatus* (avg. 1,933 per m²), the snail-cased caddis, *Helicopsyche borealis* (avg. 850 per m²), the net-spinning caddisflies, *Cheumatopsyche* spp. and *Hydropsyche occidentalis* and the Trico mayfly, *Tricorythodes explicates* (avg. 600 per m²). Mother's day caddisflies, *Brachycentrus occidentalis* also were represented in good numbers in the samples.

3.5 Smith River at Camp Baker upstream & downstream of Sheep Creek

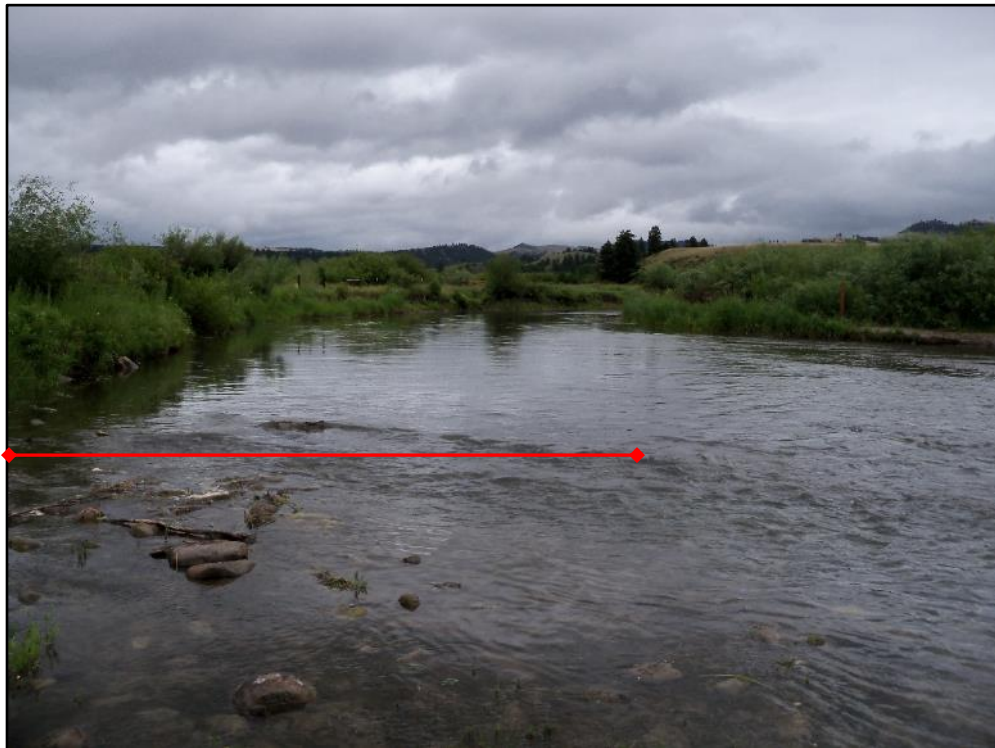
Smith River benthic macroinvertebrate densities downstream of the Sheep Creek confluence had significantly higher densities in 2016 compared to upstream (**Figure 2a, Appendix A**) and were the highest densities reported from all sites (15,260 ind. per m²) (**Figure 2a**). We do not have previously collected samples from this site, except salmonfly abundance reports compiled during the 1990's (Stagliano 2010), so we do not have long-term comparisons to compare. I do have documented reductions of the salmonfly, *Pteronarcys californica*. The sites above the Camp Baker put-in have shown a significant decreasing trend in habitat conditions and salmonfly populations for the 20 years of data examined (M. Canfield, unpublished, Stagliano pers. observation), while populations downriver in the canyon may be experiencing less of a decline because numerous tributaries below Camp Baker (Sheep, Spring, Rock and Tenderfoot Creek) add significant streamflows (Stagliano 2010). The benthic macroinvertebrate species richness, EPT taxa richness and %EPT comprising the samples were all significantly higher downstream of Sheep Creek then upstream (Figure 1a & 1b). Cumulative EPT richness for the Smith River D/S of Sheep Creek (32 spp.) was the 2nd highest reported of all sites in the study. Biological integrity as measured by the HBI, Low Valley and Mountain MMIs were also higher downstream of Sheep Creek (Figure 1b, 2 and 3), but still ranked impaired by the MDEQ MT MMI (Figure 4).

Dominant insect taxa at the Smith River Camp Baker site 2016, in order of abundance, were the Trico mayfly, *Tricorythodes explicatus* (avg. 1,290 per m²), blackfly larvae, *Simulium* (avg. 810 per m²), the net-spinning caddisflies, *Hydropsyche occidentalis* (avg. 1,004 per m²), and

Cheumatopsyche spp. (avg. 570 per m²) and the riffle beetle, *Optioservus quadrimaculatus* (avg. 710 per m²) (Appendix A). The Mother’s day caddisfly, *Brachycentrus occidentalis* was also well represented in the benthic samples.

Dominant insect taxa at the Smith River below Sheep Creek, in order of abundance, were the Trico mayfly, *Tricorythodes explicatus* (avg. 3,980 per m²), the PMD mayfly, *Attenella margarita* (avg. 1,320 per m²), the Mother’s day caddisfly, *Brachycentrus occidentalis* (1,810 per m²), the BWO mayfly, *Baetis tricaudatus* (920 per m²), the net-spinning caddisflies, *Hydropsyche occidentalis* (avg. 750 per m²), and the snail-cased caddisfly, *Helicopsyche borealis* (avg. 630 per m²). The dominance shift downstream of Sheep Creek to include the Ephemerellidae mayfly, *Attenella*, the caddisfly, *Brachycentrus* and BWOs indicates a significant improvement in the sensitivity of taxa in the benthic community. Subsequently, we observed a 26% decline in the HBI scores (Figure 2) and a 7% increase in the MDEQ Low Valley MMI score (Figure 3).

Photo 5. Smith River riffle downstream from Camp Baker. Distance from the greenline to the Hess sampler was measured.



3.6 Smith River in the Permit Canyon D/S Camp Baker (BKK 130,131,132)

The macroinvertebrate communities collected at the 3 sites downstream of Camp Baker were the most stable in terms biological integrity (Table 4), but the first site downstream (BKK130) did report substantial losses of total taxa and EPT richness compared to the 1999 samples collected there in 2016, but these rebounded in 2017 (Figure 2a, 2b). We documented very similar

macroinvertebrate communities in 2016 to those reported from 1999, averaging 80% taxa similarity (Stagliano 2017). Although, the % of EPT taxa comprising the samples has decreased across all canyon sites between 1999 and 2016, but increased in 2017 (**Figure 2b**). The % of Chironomidae (midges) comprising the samples has significantly increased at the Heaven on Earth reach (Canyon HOE) and just downstream from the canyon (**Figure 2b**). Macroinvertebrate community changes in the Low Valley MMI were the lowest reported for all sites, even increasing slightly (3.5%) at the downstream site out of the canyon (**Table 4**). The sites above the Camp Baker put-in have shown a significant decreasing trend in habitat conditions and salmonfly populations for the 20 years of data examined (M. Canfield, unpublished, Stagliano pers. observation), while populations downriver in the canyon may be experiencing less of a decline because numerous tributaries below Camp Baker (Sheep, Spring, Rock and Tenderfoot Creek) add significant cold-water flows (Stagliano 2010). This statement is true for this study as well, since salmonflies, golden stones and sensitive mayflies (*Epeorus* and *Rhithrogena*) have been reported in similar numbers in 2016 as they had been in 1999 (Stagliano 2017).

Photo 6. Smith River upstream from Heaven on Earth Ranch (BKK131). Huge blooms of filamentous algae were observed at this site in July 2017 and 2018.



3.7 Smith River near Hound Creek (BKK 133)

The macroinvertebrate community collected at this cobble riffle of the Smith River downstream of Hound Creek was highly influenced by abundant filamentous algae (**Photo 7, Appendix A**). Due to the larger cobble substrate in this riffle, crayfish (*Orconectes virilis*) and the benthic minnow, longnose dace (*Rhinichthys cataractae*) were consistently collected in the Hess samples and averaged 13.0 and 3.0 individuals per m², respectively (**Figure 7, Appendix A**). Dominant benthic invertebrate taxa at this site in 2016 were, in order of abundance, *Hydropsyche morosa gr.*, the mayflies, *Choroterpes albiannulata* and *Tricos* (**Table 3**); while in 2017, the *Cricotopus* midges, net-spinning caddis, *Hydropsyche morosa gr.* and riffle beetles were the dominant taxa (**Appendix A**). MDEQ's summer 1999 sample reported the dominant benthic taxa, in order of abundance, as BWOs (*Baetis tricaudatus*), the Heptageniid mayfly, *Ecdyonurus simplicioides*, PMD's (*Ephemerella excrucians*), and the mother's day caddis (*Brachycentrus occidentalis*). These silt-sensitive taxa have decreased substantially in the 2016 and 2017 samples, and thus the HBI scores increased since 1999 to reflect a moderately-impaired community (**Figure 3**). Cumulative total EPT for this site was the 3rd highest of the sites at 31 species (**Table 3**), and EPT species such as golden stones and salmonflies are persisting at this site probably due to a cooler flow from Hound Creek. Net-spinning and micro-caddisflies and *Tricos* were low in abundance and more tolerant to sediment. Benthic invertebrate abundance was in the high-range for this study section averaging ~10,500 individuals per m² in 2016, ~13,300 in 2017 declining to ~5,900 per m² in 2018 (**Figure 2a**).

Photo 7. Underwater view of the dense filamentous algae in the Smith River at the confluence of Hound Creek in July 2017.



3.8 Smith River near Eden Bridge (M10SMTHR01)

The macroinvertebrate communities collected at the Smith River Eden Bridge FAS site were the lowest in density, but the third most taxa rich (averaging 36.0 total taxa) (**Figure 2a**). This site reported one of the lowest average EPT taxa richness among the sites between 2016 and 2018 (avg. EPT taxa = 15 species). Average EPT richness increased from 14 taxa in 2016 to 18 taxa in 2017, but then back down to 14 species in 2018 (**Figure 2b**). The benthic community tolerance values (HBI) of >5.0 reported at this site in 2016 and 2017 indicates moderate organic pollution, and these were the highest values reported since 2002 (**Figure 8**), but in 2018, the HBI decreased to the lowest value ever reported (2.6) due to an increase in sensitive mayfly species, *Rhithrogena*. Between 2005 and 2016, Eden Bridge appeared to have lost salmonflies (*Pteronarcys*), the golden stonefly, *Hesperoperla* and the sensitive mayflies, *Epeorus albertae* and *Rhithrogena*. In their place, this site has added more tolerant taxa, such as the crayfish (*Orconectes virilis*), *Cricotopus* midges and Tubificidae worms (**Figure 8, Appendix A & D**). But, as previously mentioned, the mayfly *Rhithrogena* has reappeared and rebounded in numbers in 2018. Macroinvertebrate communities sampled at Eden Bridge in 2016 and 2017 are further declining towards “impaired” as calculated with the MDEQ Low Valley MMI (**Figure 8**). This was the first time at this site that the HBI scores and the MMI scores have diverged (Figure 8); this indicates that not only is the shift towards a more tolerant community, but also a loss of some of the more sensitive EPT taxa. High stream flows of 2018 have improved many of the macroinvertebrate metrics at this site with increased % of EPT and sensitive taxa (**Figure 2b**), and decrease in the HBI to levels lower than were ever reported (**Figure 8**).

Figure 8. Macroinvertebrate HBI scores for Eden Bridge samples. Error bars are SE. Yellow and redline are moderate and significant impairment thresholds.

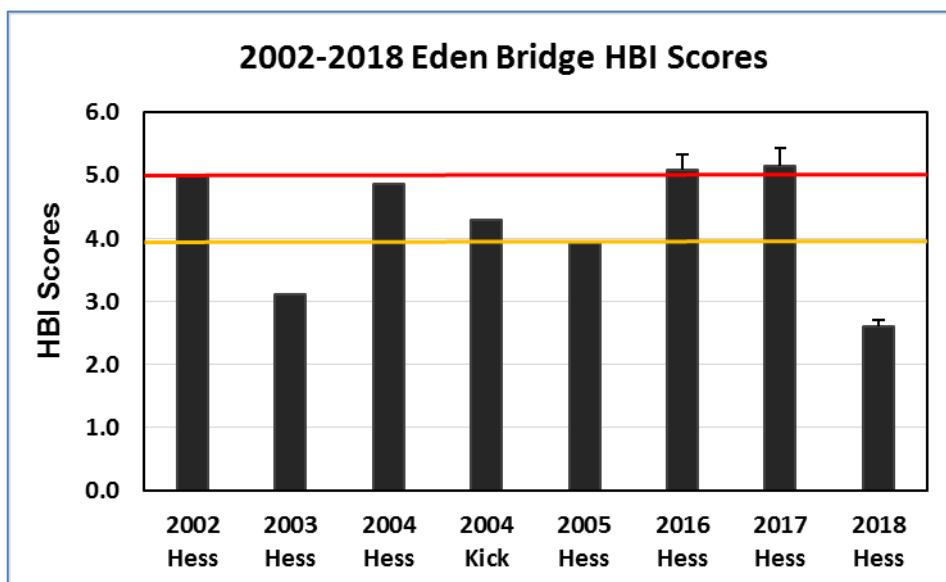
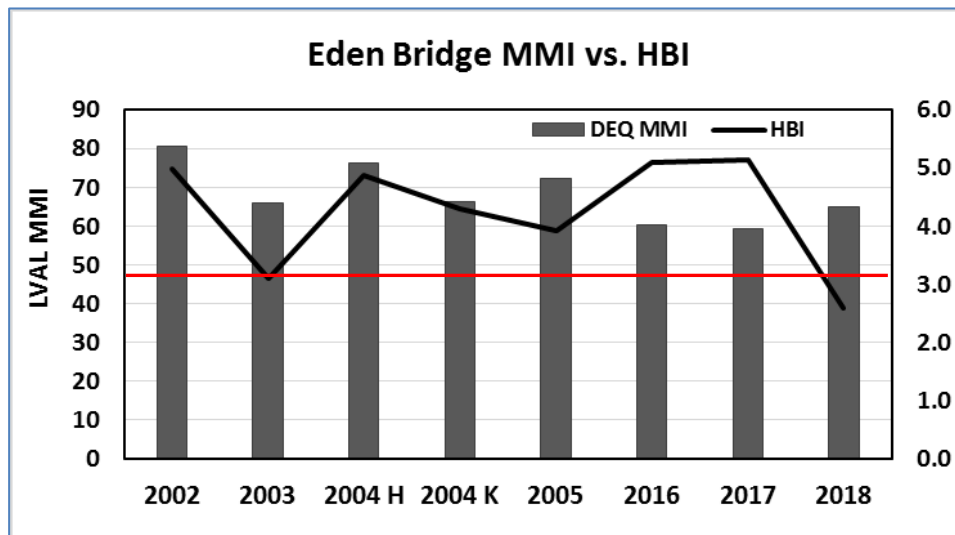


Figure 9. Relationship between the MDEQ Low Valley MMI and the HBI scores for Eden Bridge samples. Redline is the LVAL MMI impairment threshold.



Several mayfly taxa occurring here were specific to this site or the Hound Creek site (~4 miles upstream) including, *Ecdyonurus simpliciodes*, *Choroterpes albiannulata*, and *Acerpenna pygmaea* (**Appendix A**) which are more tolerant of warmer waters, but these were far less prevalent in 2018. Moderate densities (avg. 20 per m²) of the invading northern crayfish were collected here during the 2016 to 2018 sampling (**Figure 7**), but were never reported in samples collected by MDEQ from 2002-2005.

Photo 8. Riffle sampled at Eden Bridge during the summer sampling period 2016 (l) and 2018 (r) looking downstream.



Table 4. Macroinvertebrate percentage changes (Δ) for 1999-2005 versus 2016-2018 samples. Red shading reflects negative trends, green indicates positive invertebrate trends. *na* = no samples collected prior to 2016 for comparison. P-values significant at <0.05 .

		1999-2005 vs. 2016-2018					
		% Δ HBI Scores			% Δ LowVal MMI Scores		
SITE #	Site Name	2016	2017	2018	2016	2017	2018
1	HWY 360	13.0	16.0	15.0	-28.0	-24.9	-7.9
2*	U/S Sheep Creek	na	-13.0	-24.0	na	35.6	17.6
3*	D/S Sheep Creek	na	13.0	4.0	na	5.0	-2.0
4	D/S Camp Baker	12.5	25.3	41.0	-6.9	1.2	-15.1
5	In Canyon (HOE)	10.0	9.0	6.0	-1.5	-24.0	-33.6
6	D/S out of canyon	10.5	-0.2	8.0	3.5	-24.6	-14.3
7	D/S Hound Creek	25.0	16.1	14.0	-10.9	-18.8	-16.4
8	@ Eden Bridge	2.1	2.9	-48.0	-16.7	-17.8	-11.0
T-test, p-value		0.09	0.07	0.45	0.012	0.0004	0.0007

* Change calculated between 2016 and subsequent years

4.0 Conclusions

This 2016-2018 dataset represents three years of macroinvertebrate community sampling from monitoring sites on the Smith River since 1999-2005, and provides a significant baseline dataset for future monitoring efforts. This sampling was performed consistently each year with a Hess sampler during the summer season, and can be compared with previously collected MDEQ Kick-net and Hess samples (Eden Bridge) for most macroinvertebrate metrics. Very important spatial information concerning the macroinvertebrate communities of the Smith River has been documented, including quantitative benthic insect densities, diversity, temperature and nutrient sensitivity across multiple sites, and the important role that tributary streams and flushing spring flows have on the health of Smith River macroinvertebrate communities.

- 1) MTDEQ MMI values calculated using both the mountain and low valley scoring thresholds and the HBI have corroborated to document substantial widespread declines in the biological integrity of this Smith River section since 1999-2005 (**Table 4**). Declines and/or loss of sensitive insect taxa, especially stoneflies and mayflies continues to be documented, as well as the increased densities or expansion of non-insect taxa, such as aquatic worms and the northern crayfish. Only one site in the middle of the canyon section approached a non-impaired rank with the MDEQ Mountain MMI in 2016, but Eden Bridge

ranked non-impaired in 2018. All macroinvertebrate communities except at the Smith River u/s of HOE ranch were above the Low Valley MMI threshold impairment in 2018.

- 2) Tolerance scores of the benthic macroinvertebrate communities calculated with the HBI have increased on average by 12% since 1999, indicating moderate nutrient or sediment enrichment at all sites, and four of the eight (50%) sites' invertebrate communities exhibited responses to significant organic/sediment enrichment in 2016. Only the Eden Bridge site had HBI scores (>5.0) in this impairment level from MDEQ sampling in 1999-2005, but Eden and other sites have improved to below this level (<5.0) in 2018.
- 3) Tributary stream discharge from Sheep, Eagle, Rock, Tenderfoot, Hound Creek and others tend to increase the health of the Smith River insect communities below their confluences. Sampling sites in the heart of the permit canyon reported the most stable and biologically healthy insect communities since being sampled in 1999, but even these sites are exhibiting some declining trends in macroinvertebrates in 2017 and 2018, but these sites also experienced the largest disturbance effects from the high flows in 2018.
- 4) Despite observed increases in macroinvertebrate densities, total numbers of taxa and EPT taxa across most sites between 2016 and 2017, many of these taxa metrics were "re-set" due to the 2018 stream flows, especially at sites in the Canyon. While an upstream site (Camp Baker u/s of Sheep Creek) and Eden Bridge had decreases in HBI scores (to more sensitive taxa) and increases in the MMI (improved aquatic health).
- 5) The further expansion and increased abundance of the northern crayfish upstream in the Smith River basin (up to HWY 360 in 2018) is a pattern that we have been documenting across western Montana as once cold-water trout rivers are increasingly warming (Madison River: McGuire 2016, Yellowstone River: Stagliano, unpublished data). This expansion seemed unaffected by the high flows of 2018.
- 6) We conclude this analysis by indicating that multiple lines of evidence from the benthic macroinvertebrate communities are substantiating the declining biological health of the Smith River, especially upstream of Sheep Creek, in the permit canyon (in the last year) and as the river exits the canyon. Reasons for these ecological changes observed can be causally linked to increasing average water temperatures, high nutrient levels, sediment accumulations and low summer flows. These are some of the major factors why the Smith River was added to the MDEQ 303(d) list of Impaired Waters from White Sulphur Springs to Hound Creek in 2006 (MDEQ 2016). These abiotic factors are also likely linked to the massive increases in filamentous algae observed in the canyon from 2015 to 2018.

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Appendix A. Macroinvertebrate taxa list and abundance 2016-2018.

Appendix B. Macroinvertebrate MDEQ Low Valley MMI calculations 2016-2018

Appendix C. Macroinvertebrate MDEQ Mountain MMI calculations 2016-2018

Appendix D. MDEQ Macroinvertebrate Data Taxa list 1999-2005