

A look at the influence of taxonomic resolution on B-IBI scores and metrics:
Spotlight on Acari, Oligochaetes, and chironomids

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Summary/Take Home Message

Most agencies in the Puget Sound region are contracting with their taxonomic labs so that Acari and Oligochaetes are identified to subclass level and chironomids are identified to lowest practical level. The large number of agencies identifying chironomids to a fine resolution is higher than previously realized. Acari and Oligochaetes identified to lowest practical level average just over 3 taxa per sample; chironomids to lowest practical level average just over 11 taxa per sample compared to an average total taxa richness of 46 taxa.

As expected, the scoring of several B-IBI metrics shifts based on the taxonomic resolution of the macroinvertebrate data. At finer taxonomic resolution, overall taxa richness and clinger richness both increase compared to coarser taxonomic resolution. Percent dominance decreases at finer taxonomic resolution. These differences in individual metric scores are effectively corrected by applying different scoring criteria such that the overall B-IBI scores are comparable on the same scale. Even without the scoring correction factors, overall B-IBI scores often fall within the same condition classification regardless of taxonomic resolution.

In conclusion, taxonomic resolution does influence taxa richness metrics. However, stream impairment can be consistently assessed regardless of the taxonomic resolution used to identify benthic macroinvertebrates. Agencies have to weigh the purpose of their sampling (including whether they wish to have their data used by the Washington Department of Ecology (Ecology) for the state water quality assessment¹) and cost when determining what taxonomic resolution to specify.

¹ Benthic macroinvertebrate data can be submitted through the Environmental Information Management system to the Washington Department of Ecology for their water quality assessment. This assessment determines which streams are listed on the 303(d) list for impairment. All stream benthic macroinvertebrate data can be submitted, however only those waterbodies with taxa identified to the lowest practical level can be placed in category 5 "impaired". Streams with macroinvertebrate data at a coarser taxa resolution that have stream condition scores that imply impairment might get placed in category 2, which indicates that more data are required for a determination.

Taxonomic Resolution of data in the Puget Sound Stream Benthos system

The most typical resolution for Acari, Oligochaetes, and chironomids is subclass for Acari and Oligochaetes and lowest practical level (LPL) for chironomids (typically genus). Table 1 below shows the typical resolution used to identify organisms for each agency with data in the Puget Sound Stream Benthos data management system (PSSB). There are some small exceptions which are summarized in the table by reporting the percent of organisms identified to a coarse level of 'Acari', 'Oligochaeta', or 'Chironomidae'.

Table 1. Taxonomic resolution for stream benthic macroinvertebrate data stored in the PSSB by agency. Acari and Oligochaetes are commonly identified to subclass; chironomids to lowest practical level (LPL).

Agency	Acari	Oligochaeta	Chironomidae
Adopt-A-Stream	Subclass	Subclass	LPL
Bainbridge Island	Subclass	Subclass	LPL
Bellevue	Subclass	Subclass – 80.0%	Family - 66.5%
Bellingham	Subclass - 96.9%	Subclass - 98.8%	Family
Clallam Co	Subclass	Subclass	Family
Everett	Subclass	Subclass	LPL - 3.9%
Federal Way	Subclass	Subclass	LPL
Issaquah	Subclass	Subclass	LPL
EPA Benthos Grant	LPL	LPL	LPL
KC - DNRP	Subclass	Subclass	Family
KC - Roads	Subclass	Subclass	Family
KC - WRIA 8	LPL - 30.8%	Subclass	Subfamily - 39.1%
Kirkland	Subclass	Subclass	LPL
Kitsap	Subclass	Subclass	LPL - 5.0%
Lake Forest Park	Subclass	Subclass	Family
Pierce	Subclass	Subclass	Family
Redmond	Subclass - 98.5%	Subclass - 69.0%	LPL
Seattle	Subclass	Subclass	LPL - 15.8%
Skokomish Tribe	Subclass	LPL	LPL - 5.9%
Snohomish County	Subclass	Subclass	LPL
Thurston County	Subclass	Subclass	LPL - 3.6%
Ecology	LPL	LPL	LPL
Ecology - Boundary Ck & Muckleshoot	Subclass	LPL	LPL

When LPL resolution² is used for a given taxa group, an average sample has a total taxa resolution that includes approximately 3 Acari taxa, 3 Oligochaetes taxa, 11 chironomid taxa, 15 EPT taxa, and 13 'other' taxa (Figure 1).

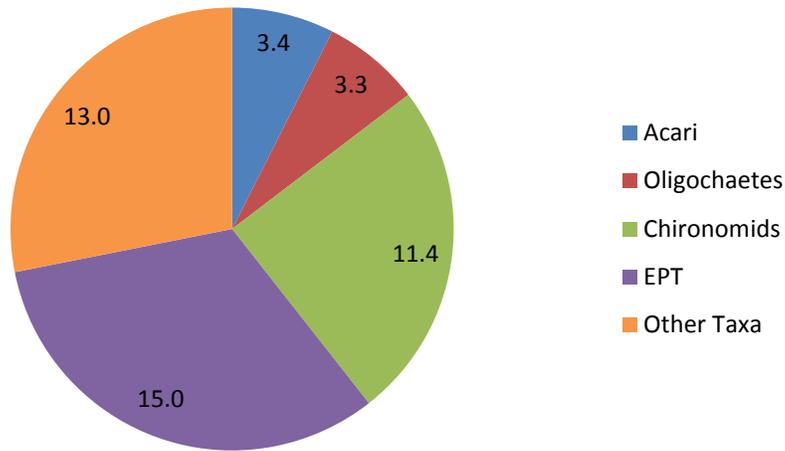


Figure 1. Relative contribution to overall taxa richness for different taxonomic groups. Values reported are the mean taxa richness (0 and 1 values were omitted to focus on LPL samples).

However, there is a lot of variability in overall taxa richness and within each taxa group between sites (Figure 2, Table 2).

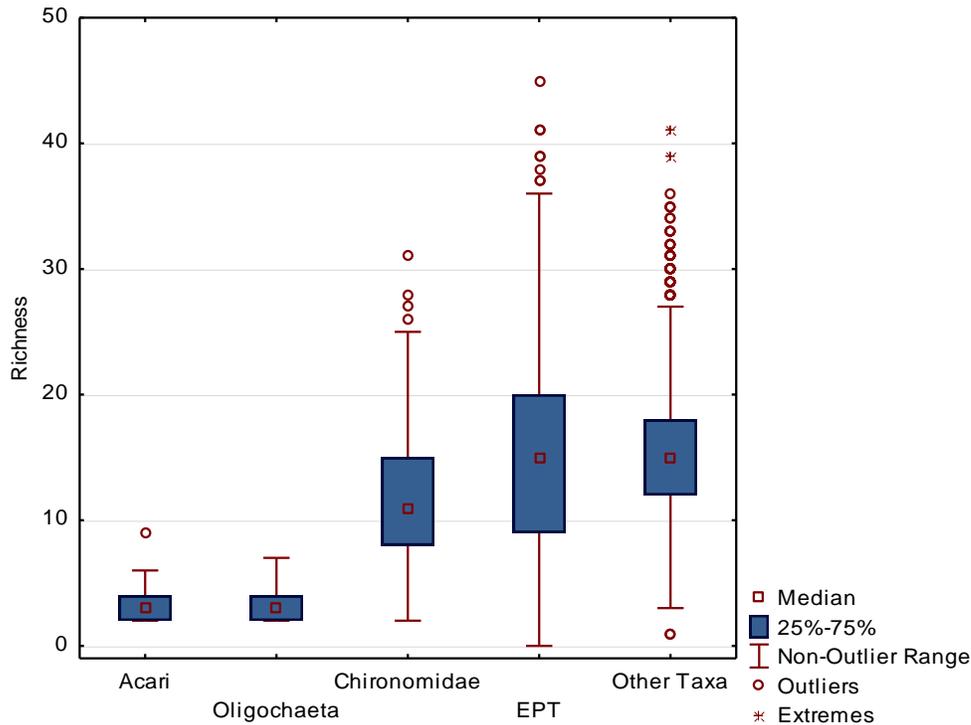


Figure 2. Distribution of taxa richness for various taxonomic groupings based on samples identified to LPL for the respective groups.

² The sample size for each taxa group is not the same. I eliminated all samples with taxa richness of zero (not present) or one (presumed to be coarse level resolution) for each taxa group to make calculations for mean, median, minimum, and maximum statistics. These calculations are used in the figures and summary tables.

Table 2. Summary statistics for taxa richness and abundance for three taxa groups.

Summary metric	Acari	Oligochaetes	Chironomids
# of taxa (min-max)	2-9	2-7	2-31
Mean # taxa	3.4	3.3	11.4
% of taxa richness (min-max)	3.2-16.7	2.7-40.0	4.2-58.8
Mean % taxa richness	7.4	9.1	28.8
% of abundance (min-max)	0-45	0-88	0-89
Mean % of abundance	1.7	9.2	18.4
Median % of abundance	0.9	5.2	14.1
# of taxa observed in PSSB	23	27	146

Analysis details: resolution levels, metadata

For subsequent analyses, I relied on the three standard taxonomic effort (STE) lists created Wease Bollman of Rhithron (Table 3). The three lists range from fine resolution with most taxonomic groups identified to lowest practical level representing the resolution used by Ecology (STE 1) to a coarser resolution representing the resolution used historically (pre-2012) by King County with Oligochaetes and Acari to subclass and dytiscids, simuliids, and chironomids to family (STE 3)³.

Table 3. Standard taxonomic resolution roll-up options implemented in the PSSB.

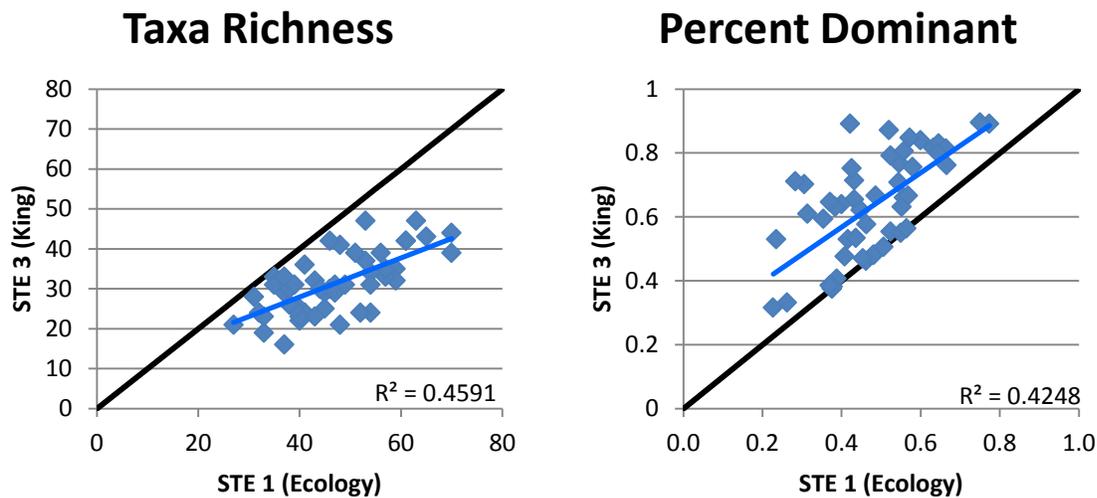
	STE 1: Finest resolution, closest to Ecology	STE 2: Mid-range resolution	STE 3: Coarsest resolution, closest to historical King County
	Oligochaetes at lowest possible, Acari at genus, Snails at genus, Dytiscidae larvae and adults to genus, Simuliidae larvae and pupae to genus, Chironomids at genus/species/species group, Trichoptera larvae to lowest possible and pupae to family	Oligochaetes at family, Acari at "Acari", Snails at genus, Dytiscidae adults to genus larvae to family, Simuliidae larvae to genus and pupae to family, Chironomids at subfamily/tribe, Trichoptera larvae to genus/species/species group and pupae to family	Oligochaetes at "Oligochaeta", Acari at "Acari", snails at family, Dytiscidae to family for adults and larvae, Simuliidae larvae and pupae at family, chironomids at family, Trichoptera larvae to genus/species/species group and pupae to "trichoptera" (order)
Oligochaetes	lowest possible	family	Subclass (Oligochaeta)
Acari (mites)	genus	subclass (Acari)	subclass (Acari)
Gastropoda (snails)	genus	genus	family
Dytiscidae - larvae	genus	genus	family
Dytiscidae - adults	genus	family	family
Simuliidae - larvae	genus	genus	family
Simuliidae - pupae	genus	family	family
Chironomids	genus/species/sp group	subfamily/tribe	family
Trichoptera - larvae	lowest possible	genus/species/sp group	genus/species/sp group
Trichoptera - pupae	family	family	order

³ In April 2013, on the Puget Sound Stream Benthos ([PSSB](#)), the definitions for STE 1 and STE 3 were switched to match the definitions in use by SAFIT and PNAMP standard taxonomic efforts so that level 1 represents the coarsest resolution and level 3 represents the finest resolution. However, these changes were not made to this memo.

For all analyses on the following pages, I downloaded Ecology's data that are in the PSSB. Ecology data were selected because their macroinvertebrate samples have consistently been identified to LPL across all taxonomic groups. I included only site visit data from streams within the Puget Sound basin and with ≥ 350 organisms in the sample⁴, which resulted in 51 site visits between 2002 and 2010 (the majority [32] are from 2009). For each of these samples, the data were downloaded so that each sample was subsampled to 500 organisms and the 1998 attributes were used. The MMI and Puget Lowland (PL) B-IBI scores and metrics were downloaded at five levels of taxonomic resolution: (1) STE 1, (2) STE 2, (3) STE 3, (4) taxonomic lab resolution, and (5) taxonomic lab resolution with chironomids to family level.

Coarse versus fine resolution (STE 1 vs. STE 3)

The taxa richness, clinger richness, and percent dominant metrics have different scoring criteria for the Puget Lowland B-IBI depending on whether chironomids were identified to family or genus level. These scoring adjustments were developed and applied to try to make the overall B-IBI scores comparable regardless of taxonomic resolution of chironomids. Because these three metrics are anticipated to change the most based on taxonomic resolution, I looked at these three and percent clingers (which replaces clinger richness in Ecology's MMI) (Figure 3). Mean taxa richness and percent dominant were significantly different between STE 1 and STE 3, clinger richness and clinger percent were not ($p < 0.05$).



⁴ 9 samples that were within the Puget Sound basin were excluded because there were fewer than 350 organisms.

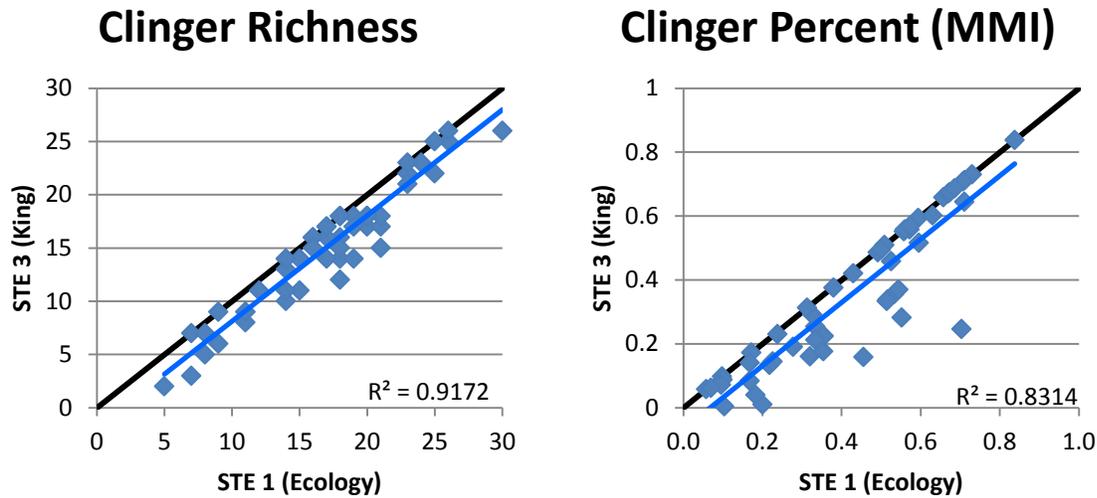


Figure 3. STE 1 is fine resolution, lowest practical. STE 3 is a coarser resolution. See Table 3 for details. Black line is the 1:1 line. Blue line is the best-fit line for the data.

I also looked at how taxonomic resolution influenced overall MMI or PL B-IBI scores by looking at regressions of STE 1 against STE 3 and the residuals of scores (STE 1 minus STE 3) (Figures 4-6). The residuals are significantly different from zero in all cases ($p < 0.05$)

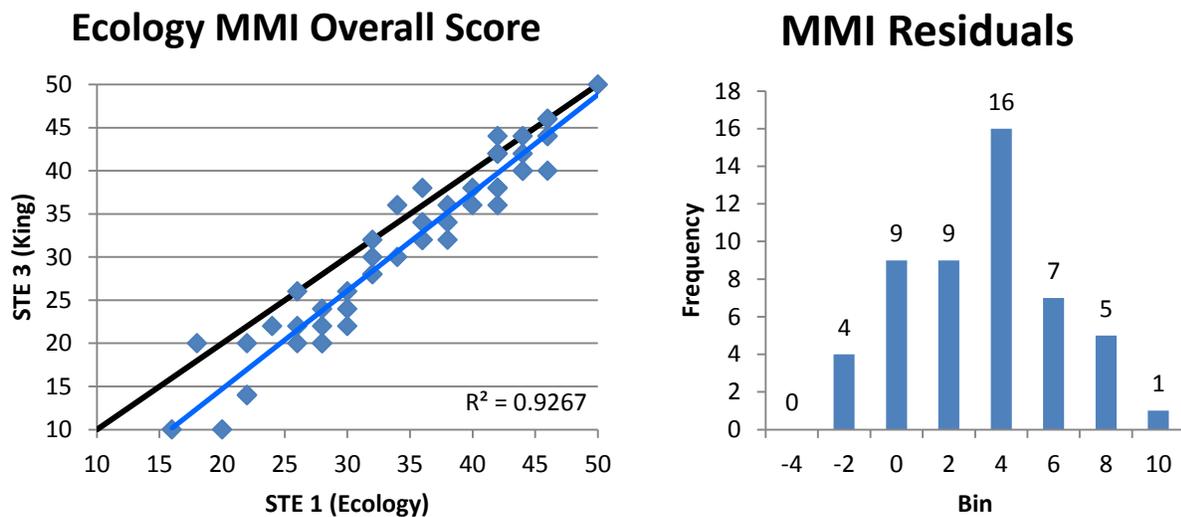


Figure 4. Influence of taxonomic resolution for Ecology's multimetric index (MMI): regression (left) and histogram of residuals (right) of STE 1 minus STE 3. Black line is the 1:1 line. Blue line is the best-fit line for the data. See table above for description of standard taxonomic effort (STE).

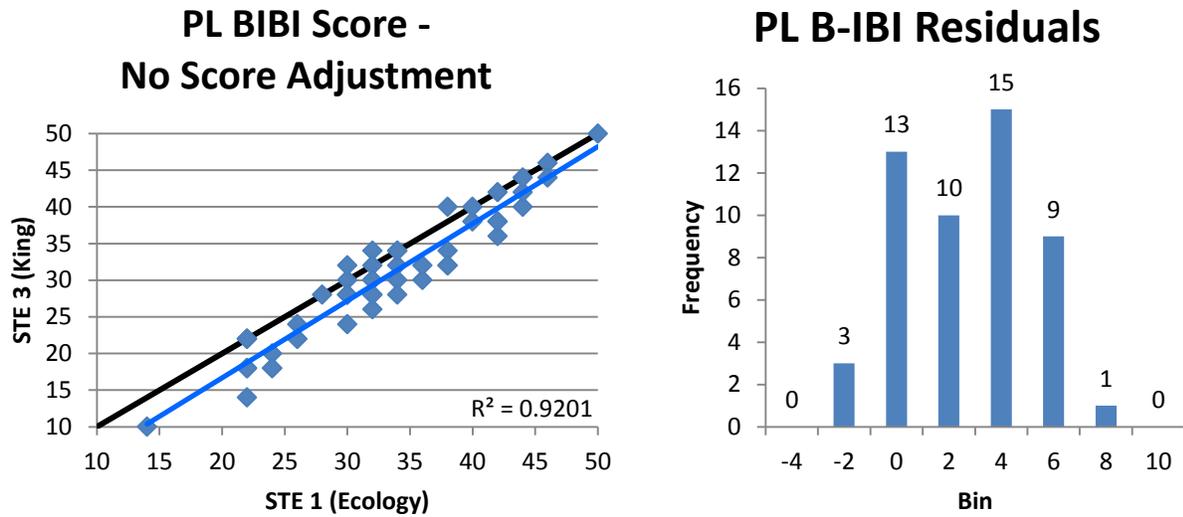


Figure 5. Influence of taxonomic resolution for the Puget Lowland (PL) B-IBI multimetric index, calculated using the scoring cut-offs for the species-genus B-IBI: regression (left) and histogram of residuals (right) of STE 1 minus STE 3. Blue line is the best-fit line for the data. See table above for description of standard taxonomic effort (STE).

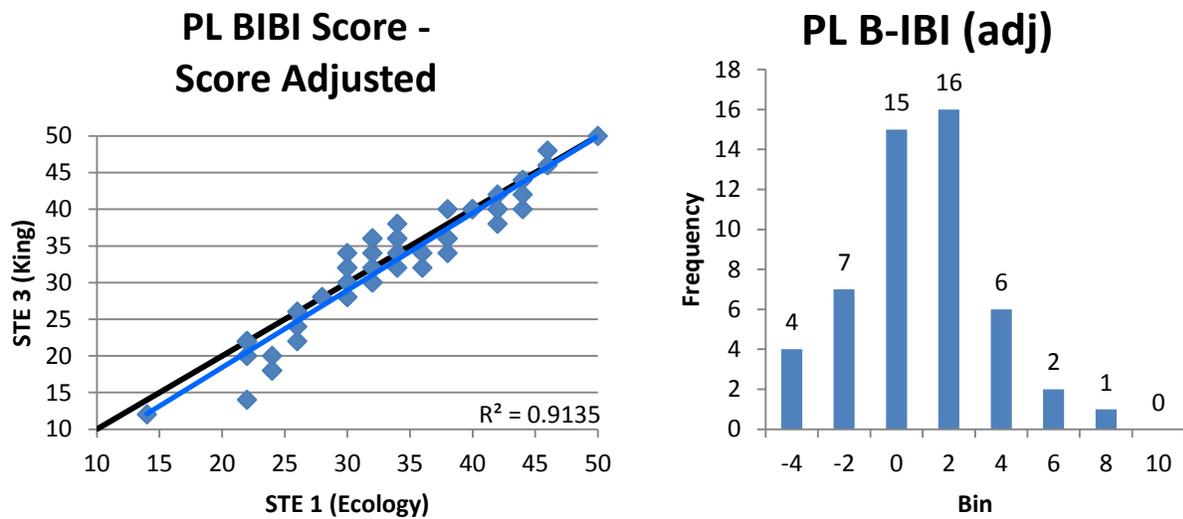


Figure 6. Influence of taxonomic resolution for the Puget Lowland (PL) B-IBI multimetric index where scores for three metrics (taxa and clinger richness and % dominance) were adjusted for STE 3 to compensate for differences in taxonomic resolution: regression (left) and histogram of residuals (right) of STE 1 minus STE 3. Black line is the 1:1 line, blue line is the best-fit line for the data. See table above for description of standard taxonomic effort (STE).

While the graphs above show that taxonomic resolution does have an impact on individual metrics and overall scores, shifts in biological condition categories are only observed at a small number of sites.

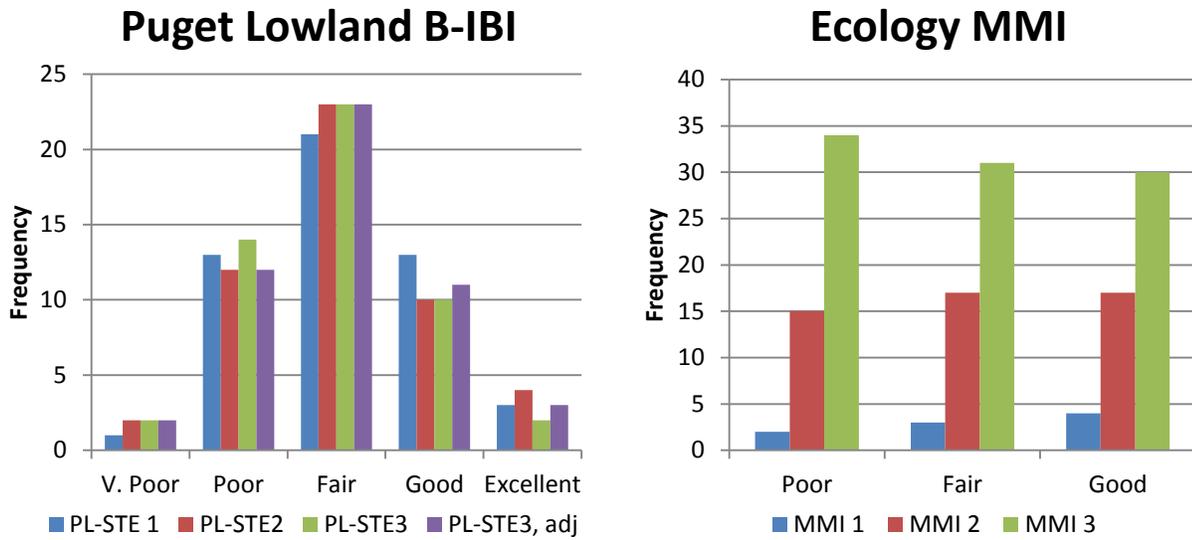


Figure 7. Histograms of qualitative biological condition categories based on taxonomid resolution.

The table on the following page conveys the same information on a site by site basis color coded by condition category (blue = excellent, green = good, yellow = fair, orange = poor, red = very poor). Each row represents a site visit. No color change indicates that the condition category stayed the same for a given index regardless of taxa resolution.

Table 4. Site by site changes in overall MMI or B-IBI scores. Color coded by qualitative condition category.

MMI			PL BIBI			
STE 1	STE 2	STE 3	STE 1	STE 2	STE 3	STE 3, adj
28	26	22	22	22	18	20
44	44	40	42	40	36	38
20	12	10	22	14	14	14
36	36	32	36	36	30	32
32	32	28	30	28	28	30
46	44	40	44	44	40	40
38	38	32	38	38	34	36
28	26	24	26	24	24	26
24	22	22	22	20	18	22
18	16	20	22	22	22	22
16	12	10	14	14	10	12
28	22	20	26	24	22	24
32	30	30	32	28	26	30
34	32	30	30	30	30	34
46	48	46	46	46	46	46
38	36	34	32	30	28	30
34	34	36	32	32	34	36
36	34	34	32	32	32	36
22	20	14	24	22	18	18
32	28	28	30	28	28	32
42	42	38	42	40	38	40
30	28	26	32	28	28	32
26	26	26	28	28	28	28
26	24	20	22	22	22	22
30	26	24	22	24	22	22
22	20	20	24	22	20	20
40	38	36	38	34	32	34
36	34	32	34	32	30	34
42	42	42	34	34	34	36
36	38	38	30	32	32	32
46	46	46	46	48	44	48
44	44	44	44	46	42	42
42	42	38	34	34	32	36
44	44	42	34	34	34	38
32	30	32	32	32	30	30
42	40	36	36	36	32	34
50	50	50	50	50	50	50
28	24	20	30	28	24	28
44	42	40	38	34	32	36
42	42	42	40	38	38	40
42	42	42	42	42	42	42
46	46	44	44	44	44	44
30	26	22	26	24	22	22
26	22	22	22	20	18	20
36	34	32	30	32	28	28
38	36	36	32	30	30	34
46	44	44	42	40	38	40
36	34	32	34	30	28	32
42	42	44	38	38	40	40
40	40	38	40	40	40	40
22	22	14	24	24	18	18

Isolating impact of chironomids

My initial analysis on 5/23/12 included a comparison of STE 1 and 3, which incorporates taxonomic resolution differences across taxa groups including Acari, Oligochaetes, and chironomids, but also things like dytiscidae and simuliidae (see Table 3). In addition, it doesn't allow analysis isolating any one group. However, the PSSB also has the option to calculate the Species-Family and Species-Genus B-IBIs, which rolls only chironomids to either family or genus level. Therefore, I took a look at the influence of only chironomids on three individual B-IBI metrics (taxa richness, clinger richness, percent dominance) and overall B-IBI scores in the following graphs (Figures 8-12). The mean taxa richness and percent dominance were significantly different ($p < 0.05$) between taxonomic resolution (chironomids at genus vs. family), but overall B-IBI and clinger richness were *not* significantly different ($p < 0.05$) between resolutions.

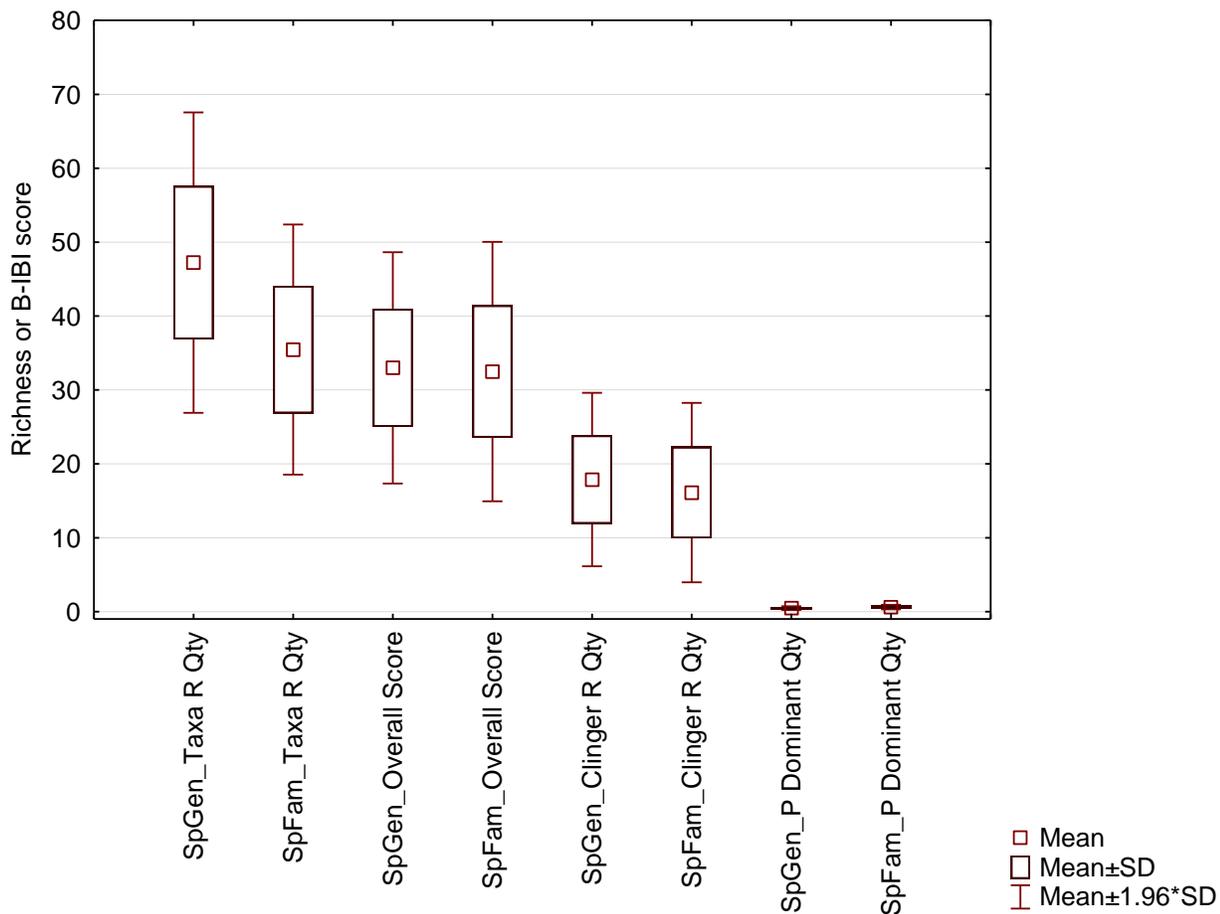


Figure 8. Box plots of three B-IBI metrics and overall B-IBI score at different taxonomic resolutions (chironomids at genus = SpGen; chironomids at family = SpFam). Mean taxa richness and percent dominance were significantly different between chironomid resolutions ($p < 0.05$), overall B-IBI score and clinger richness were not significantly different.

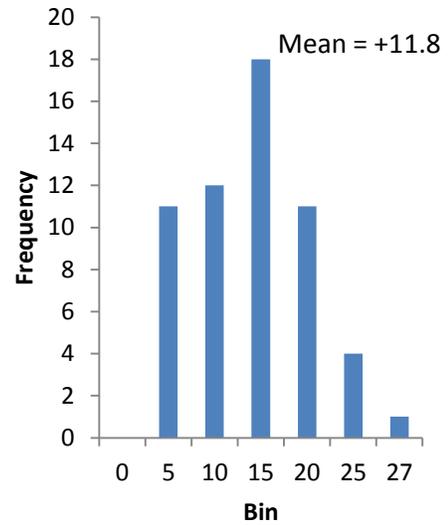
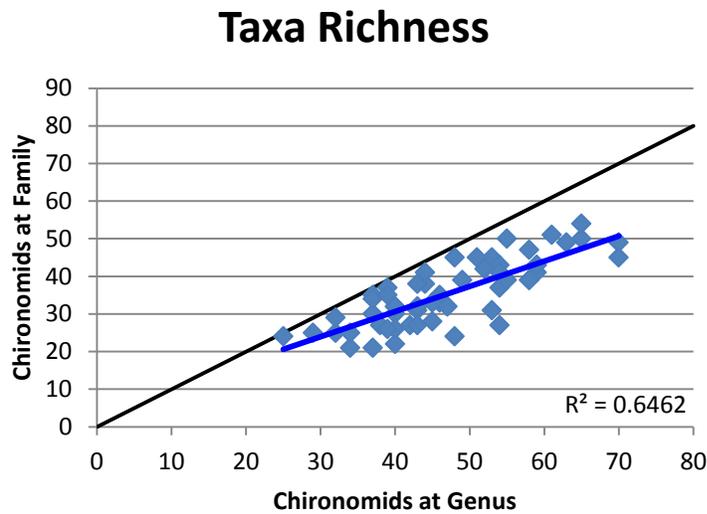


Figure 9. Regression (left) and residuals (right) of taxa richness with chironomids at family and genus resolutions, all other taxa at LPL. Black line is the 1:1 line, blue line is the best-fit line for the data. The mean residuals are significantly different than zero ($p < 0.05$).

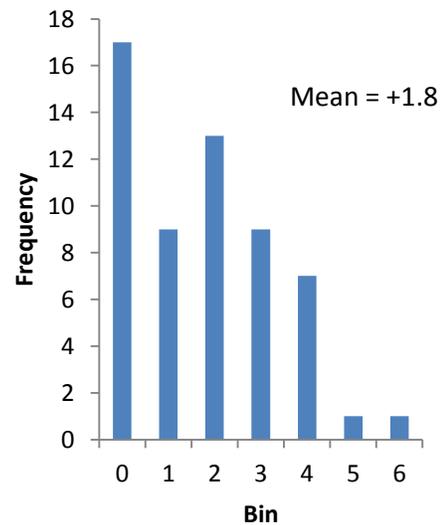
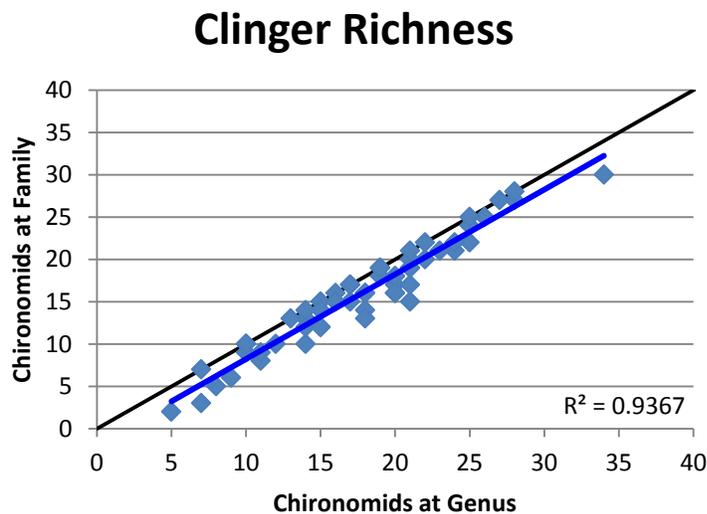


Figure 10. Regression (left) and residuals (right) of clinger richness with chironomids at family and genus resolutions, all other taxa at LPL. Black line is the 1:1 line, blue line is the best-fit line for the data. The mean residuals are significantly different than zero ($p < 0.05$).

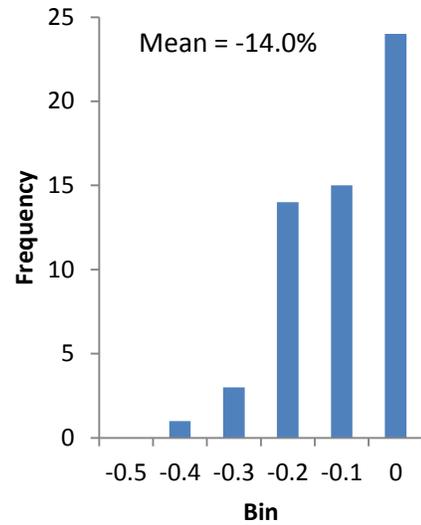
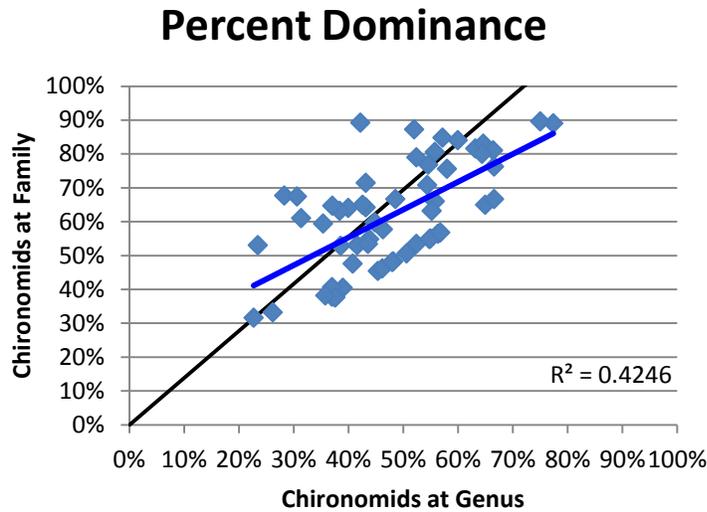


Figure 11. Regression (left) and residuals (right) of the percent dominance metric with chironomids at family and genus resolutions, all other taxa at LPL. Black line is the 1:1 line, blue line is the best-fit line for the data. The mean residuals are significantly different than zero ($p < 0.05$).

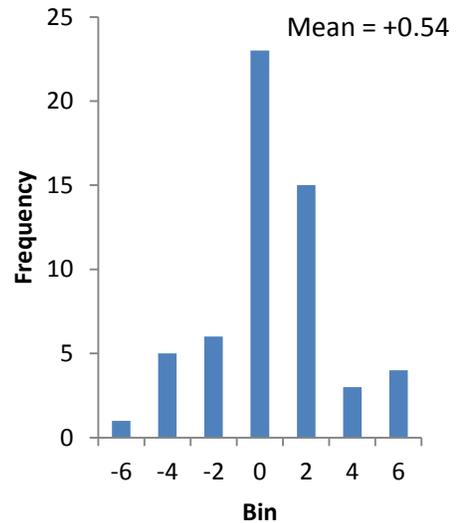
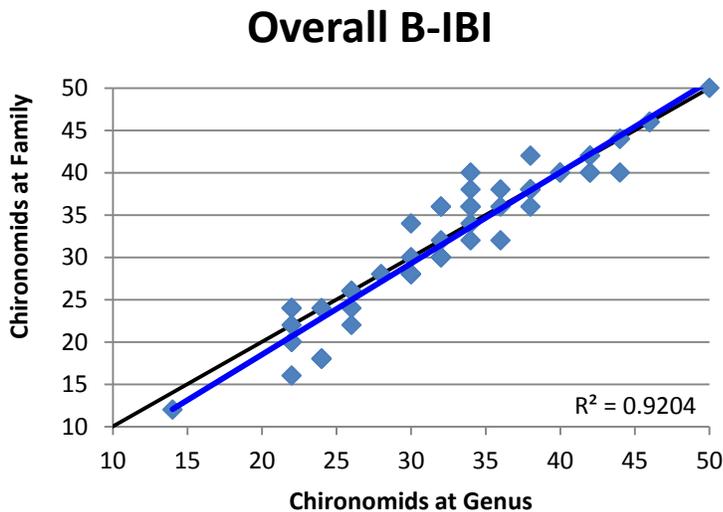


Figure 12. Regression (left) and residuals (right) of overall B-IBI with chironomids at family and genus resolutions, all other taxa at LPL. The Species-Family and Species-Genus B-IBI's use different scoring criteria for three metrics to adjust for the different chironomid resolution. Results are comparable to those in Figure 6. Black line is the 1:1 line, blue line is the best-fit line for the data. The mean residuals are *not* significantly different than zero ($p < 0.05$).