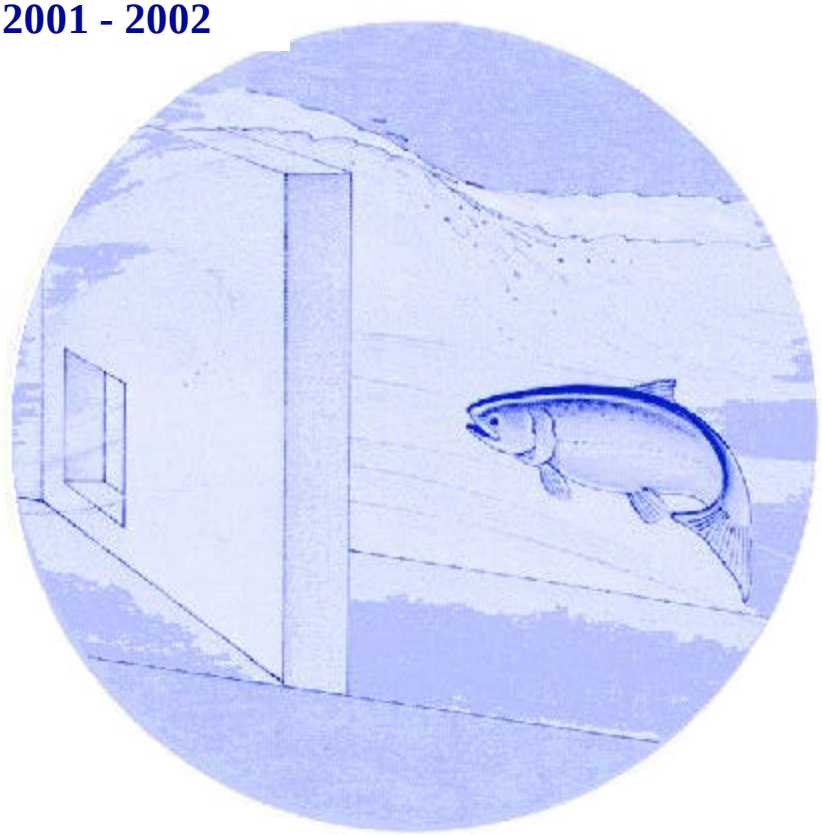
Yakima Benthic Index of Biotic Integrity

Progress Report
2001 - 2002



DOE/BP-00006305-1

September 2002

This Document should be cited as follows:

Gayeski, Nick, "Yakima Benthic Index of Biotic Integrity", Project No. 2000-04800, 10 electronic pages, (BPA Report DOE/BP-00006305-1)

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

Yakima Benthic Index of Biotic Integrity
Project # 2000-048-00

Interim Progress Report for
Sampling Conducted in FY 2001 & 2002

By
Nick Gayeski, Project Director

September 25, 2002

Sample Collection

Sample collections in project-years two and three (2001 & 2002) proceeded as planned. Twenty-eight (28) sites were sampled in 2001 between August 14 and September 12. Sites included two (2) mainstem Yakima River sites between Selah Gap and Union Gap, three (3)Yakima river sites upstream of Roza Dam, and three (3) mainstem Naches River sites between Cliffdell and the Wapatox Canal. The other twenty sites were tributary sites, including the Cle Elum River below Cle Elum Lake, lower Bumping river, and the American River at Pleasant Valley. Six (6) tributaries of second to fourth order were sampled at or near the same location at which they were sampled in 2000, as were two sites on the upper mainstem Yakima and one on the mainstem Naches.

Thirty-three (33) sites were sampled in 2002 between August 12 and September 13. These included one (1) mainstem Yakima River site between Selah Gap and Union Gap, four (4) sites in the mainstem Yakima upstream of Roza Dam, and two (2) sites on the mainstem Naches between Naches and Cliffdell. The other twenty-six (26) sites were tributary sites, including one (1) site on the lower Tieton river, three (3) sites on the Bumping River (two downstream of Bumping Reservoir and one upstream), and two sites on the American River. Four (4) other sites were on smaller tributaries to the mainstem Naches, three (3) of which had been sampled in one (1) of the two preceding years, and one (1) (upper Rattlesnake Creek) that has been sampled in all three (3) years. Two (2) tributary sites in the upper Ahtanum subbasin were sampled, one (1) of which was sampled in 2000 and the other of which has been sampled in all three (3) years.

One tributary (lower Wenas Creek) to the mainstem Yakima upstream of Selah Gap and downstream of Roza Dam was sampled. This was also sampled in 2001. Thirteen (13) sites were sampled in tributaries to the upper Yakima River, including two in the Teanaway subbasin one of which was sampled in 2000 and the other of which was sampled in 2001.

Over the three (3) years of sample collection under the project to date, a total of 93 site-years have been sampled from 59 distinct sites. Of these 31 have been sampled once, 22 have been sampled twice, and 6 have been sampled three times. Of the 93 site-years, 23

are mainstem Yakima and Naches River sites, 31 are mainstem and tributary sites within the Naches River subbasin, and 46 are mainstem and tributary sites within the Yakima River subbasin upstream of Roza Dam.

The majority of tributary and mainstem sites occur between elevations of 1400 and 2900 feet above mean sea level. Eight (8) distinct sites (ten (10) site-years) occur at elevations above 3000 feet. Two (South Fork of Manastash Creek at Buck Meadows and North Fork of Ahtanum Creek) occur at elevations above 4000 feet.

Sample Processing

As described in the annual Progress Report for sampling conducted in FY 2000, all samples were processed (counted and identified) in Dr, James Karr's Bug Lab at the University of Washington by Kris Rein, who has also assisted with the majority of field collections. As discussed in that Report approximately half (45) of the 96 total replicate samples collected in FY 2000 were processed by counting subsamples of approximately 700 individuals. All 84 replicate samples collected in FY 2001 were similarly subsampled. As noted in the preceding annual report, subsampling has facilitated the timely and accurate processing of samples. We have begun processing samples collected during the recent (2002) field season. As discussed below under metric development subsampling at the 700 count level appears to be clearly sufficient for the development of a sensitive multi-metric capable of distinguishing 5 or more classes of site condition.

Metric Development

Processing of all samples collected during FY2000 and 2001 (a total of 60 site-years) was completed by July 2002 providing a reasonably rich data set with which to evaluate candidate metrics. With this expanded data set we have refined the preliminary evaluation of candidate metrics on which we reported in the annual Report for FY 2000. Provisionally we have focused on the same set of ten (10) metrics that have been employed and validated in Benthic Indices of Biotic Integrity developed for streams in the Puget Sound lowlands and the Clackamas River basin in northwestern Oregon:

- Cumulative number of long-lived taxa within a site;
- Cumulative number of intolerant taxa within a site;
- Average number of total taxa within a site;
- Average number of mayfly taxa within a site;
- Average number of stonefly taxa within a site;
- Average number of caddisfly taxa within a site;
- Average number of clinger taxa within a site;
- Dominance: average percentage of individuals in the three most abundant taxa within a site;
- Average percentage of tolerant individuals within a site; and
- Average percentage of predator individuals within a site.

Criteria for assigning scores (1, 3, or 5) to each metric (e.g., the average total number of taxa among the three replicates at a site-year) were based primarily upon visual inspection of scatter plots of the absolute values at all site-years. These scatter plots indicated that scoring criteria differed little from the criteria employed in the Puget Sound B-IBI, except for the Percent Tolerants metric. For this metric, results indicate that a more stringent set of scoring standards should apply in the Yakima/Naches basins than in the Puget Sound lowlands. In the Puget Sound, a site scores a 5 for Percent Tolerants if fewer than 27% of the total taxa among the sample collected at the site are classified as "tolerant"; a 3 if Percent Tolerants is less than or equal to 44% but greater than 27%, and a 1 if greater than 44%. Scoring criteria for the Yakima/Naches differs from this as follows: 5 = (less than 10%), 3 = (less than or equal to 25% but equal to or greater than 10%), and 1 = (greater than 25%). The ten provisional metrics and their associated scoring criteria are listed in Table 1.

Table 1

Metric/Score	Total Taxa	Total Ephem.	Total Trichopt.	Total Plecopt.	Total Long-Lived	Total Intol-erant	Total Clinger	Percent Predators	Percent Tolerants	Dominance
5	>=28	>=7	>=5.3	>=5.3	>=8	>=4	>=16	>=9	<10	<55
3	(14-28)	(3.5-7.0)	(2.7-5.3)	(2.7-5.3)	[4-8]	[2-4]	(8-16)	(4.5-9)	[10-25]	[55-75]
1	<=14	<=3.5	<=2.7	<=2.7	<4	<2	<=8	<4.5	>25	>75

With ten (10) metrics, the lowest possible site score is 10 and the highest possible score is 50. Individual site-year scores for the full two years of data obtained to date range from a low of 12 (lower Wide Hollow Creek) to a high of 48 (South Fork Ahtanum Creek above Tampico).

Statistical analyses of previous IBIs conducted by Dr. James Karr and associates in recent years indicate that IBIs obtained using 10 to 12 metrics can reliably detect differences in site condition when mean scores differ by more than about 8.5 for standard values of alpha (0.05) and beta (0.20, power = 0.80). For a 10 metric IBI the total range in possible site scores is 40 (50 - 10). If the standard error of the mean proves to be 4 (or lower), we would be able to distinguish 5 site conditions at the 95% confidence level.

Assuming the standard error of the mean to be equal among all categories of site condition and to have an absolute value of 4, the five site conditions would score as follows:
A (Very Good): >42-50
B (Good): >34-42
C(Fair): >26-34
D(Poor): >18-26
F(Very Poor): <=18.

In general, it is more difficult for a site to obtain a high score than to obtain a mid-range score. Correspondingly, to be considered very poor or severely degraded a site should be expected to fail across a substantial proportion of the entire range of aspects of biotic

integrity measured by the entire suite of metrics. This suggests that one might consider being more lenient in classifying sites at the high end and more conservative in assigning sites to the worst category than results from applying the 8-point interval criteria uniformly across the range of possible scores. Inspection of the entire data set suggests that the following site-classification criteria may be more appropriate:

A: >40
B: >32-40
C: >24-32
D: .16-24
F: <16.

References to site condition in the remainder of this report will be based upon this second set of suggested site-classification criteria.

Three (3) sites score in the "F" range: Moxee Drain (12), lower Wide Hollow Creek (16), and lower Wenas Creek on the property newly acquired by the Bureau of Reclamation (14). Twelve (12) sites score in the "A" range: one (1) in the Ahtanum basin, four (4) in tributaries to the Naches River and seven (7) in tributaries to the upper Yakima River.

Mainstem Naches and Yakima River sites score in the "D", "C", and "B" ranges. In the mainstem Naches, one (1) site scored a "B", and three (3) sites scored "C". In the upper Yakima mainstem, one (1) site scored a "B", two (2) scored a "C", and two (2) scored a "D". In the mainstem Yakima below Selah Gap, one (1) site scored a "C", and three (3) scored a "D".

The eight (8) tributary sites above 3000 feet scored in the "A" through "C" range. These 8 sites contained ten site-years of data, only one of which scored a "C". This site-year was on the North Fork of Taneum Creek in year 2000 and was located approximately 150 meters downstream of a broad well-maintained logging road culvert. The riparian area is a dense mixture of understory shrubs, alder, and mature evergreens of several species and large wood forms several channel-spanning debris jams throughout the stream reach between the road crossing and the culvert. This site-year scored a 32 and had an unexpectedly high dominance (76.5%; score: 1) due to the presence of a relatively large number of Oligochaetes and a modest number of total taxa (24; score: 3).

Accordingly, in year 2001 we chose a site upstream of the culvert. This site-year scored 42, an "A" (dominance 54.1%, score: 5; total taxa 31, score: 5). In view of this difference in site-year score both sites were sampled in 2002 to see if the difference persists.

Consistency of between-year site scores

As noted previously, 22 sites have been sampled in two of the three years of sampling. Of these, nine (9) were sampled in both 2000 and 2001. Three of these nine sites were mainstem sites (one on the Naches near Cliffdell, and two on the upper Yakima River. Another two were tributaries at elevations above 3000 feet. The remaining four sites were

tributaries below 3000 feet in the Ahtanum, Naches, and upper Yakima subbasins. Scores at seven of these nine sites were significantly consistent between years. The other two were somewhat anomalous. These sites and their corresponding year-scores are listed in Table 2. (* indicates anomalous between-year scores.)

Table 2

Site	Year 2000 B-IBI Score	Year 2001 B-IBI Score
Big Creek (3600 feet)	34	36
Cooke Creek (3500 feet)	44	46
SF Manastash Cr.* (2800 ft)	34	44
Upper Rattlesnake Cr. (2700 feet)	36	40
Lower Ahtanum Cr. (1000 feet)	20	18
SF Ahtanum Cr. (2500 feet)	48	42
Yakima at Ringer Rd. (1400 feet)	22	20
Yakima at River Raft Rentals (1700 feet)	24	22
Naches at Cottonwood Campground* (2200 feet)	34	22

The scores for the Naches site at Cottonwood Campground near Cliffdell are the most surprising. The same riffle was sampled in both years and discharge as measured at the Bureau of Reclamation Hydromet station at Cliffdell did not differ by more than 20 cfs between the two years (421 cfs on 22-Aug 2000 and 403 cfs on 27-Aug 2001). This site was sampled again in 2002 and results from this sampling will provide additional information on variability at this site.

The scores for the site at the lower South Fork of Manastash Creek raise a different issue. In this case different riffles located not more than 50 meters apart from one another were sampled. The riffle sampled in 2001 was located downstream of the riffle sampled in 2000 and was chosen because it was somewhat easier to access and was of moderately slower velocity. Otherwise it appeared qualitatively identical to the upstream riffle. We believe that it is unlikely that conditions affecting macroinvertebrate community composition were markedly different between years. Rather, it is likely that the riffle chosen in 2000 was not the best one locally available and had fewer niches than the one chosen in 2001. The 2001 site was the last to be processed in 2002 and we obtained this result too late to make the decision to include one of these sites in our 2002 sampling. One or both of these sites will therefore likely be sampled in 2003.

High Elevation Sites

As we noted in the Annual Report for FY 2000, elevation is a potential confounding factor in the determination of reference-based environmental monitoring criteria such as the B-IBI. This arises for two principal reasons: first, above some threshold elevation(s) within subbasins annual thermal regime and ecological variables such as the relative importance and magnitude of allochthonous food inputs change in significant ways that affect the abundance, diversity, and composition of the macroinvertebrate community in comparison to similarly (un)disturbed sites at lower elevations and higher stream orders; second, sites at high elevations are often the only ones in a near-pristine condition that may provide an indication of the general features of the macroinvertebrate community in the absence of human disturbance. This requires that one can reliably extrapolate from properties of the macroinvertebrate community measured obtained at high elevation, undisturbed sites to characterize expected condition at disturbed sites at lower elevations lacking undisturbed or minimally disturbed reference sites.

A total of 8 sites (10 site-years) at elevations greater than 3000 feet were sampled during the 2000 and 2001 field seasons. The upper Cooke Creek site was sampled in 2002 and the results from the processing of this sample are also available, making 11 site-years of data for high elevation sites. These site-years are listed together with elevation, total number of taxa and B-IBI score in Table 3. For comparison a selection of ten (10) of the better-scoring tributary sites between 2000 and 2800 feet elevation are shown in Table 4.

Table 3. **Tributary Site-Years at Elevations Above 3000 Feet.**

Site/Year	Elevation (ft amsl)	Total # Taxa (metric score)	B-IBI Score
NF Ahtanum Cr./2000	4600	28 (5)	34
American R. at Pleasant Valley/2001	3300	21.3 (3)	36
Big Creek/2000	3600	22.3 (3)	34
Big Creek/2001	3600	23.7 (3)	36
SF Manastash Cr. at Buck Meadows/2000	4300	26 (3)	40
NF Taneum Cr./2000	3600	24 (3)	32
NF Taneum Cr./2001	3600	31 (5)	42
Naneum Cr. above High Cr./2000	3500	31 (5)	44
Upper Cooke Creek/2000	3500	35 (5)	44
Upper Cooke Creek/2001	3500	36 (5)	46
Upper Cooke Creek/2002	3500	36 (5)	46

Table 4. Selected Tributary Sites Between 2000 and 3000 Feet Elevation

Site/Year	Elevation	Total # Taxa (metric score)	B-IBI Score
Lower Cabin Creek/2001	2300	34.7 (5)	40
NF Teanaway/2000	2400	31.3 (5)	44
Lower SF Manastash Cr./2000	2800	26.7 (3)	34
Lower SF Manastash Cr./2001	2800	37 (5)	44
Taneum Creek, BurRec/Rcky Mtn Elk property/20001	2000	38.3 (5)	36
SF Ahtanum/2000	2600	37.3 (5)	48
SF Ahtanum/2001	2600	34 (5)	42
Oak Creek/2000	2500	33.3 (5)	44
Upper Rattlesnake Cr./2001	2700	32.3 (5)	40
Nile Creek/2000	2400	30 (5)	42

While an examination of all ten (10) metrics and related indices of community composition are required to adequately compare sites and evaluate site differences, the Total Taxa metric is a significant one to focus on in the present context because high elevation sites are often comparatively depauperate in taxa due to restricted thermal regime alone. Quite apart from elevational differences in basin topography, nutrient sources, and stream order and gradient, restricted thermal regime is expected to result in a reduction of niche space and, an attendant reduction in both number and kinds of taxa potentially available at undisturbed high elevation sites compared to undisturbed lower elevation and/or higher stream order sites.

The data for many of the sites above 3000 feet compare reasonably well in numbers of total taxa with lower elevation tributary sites subject to moderate levels and varying kinds of disturbance. Given not-too-different numbers of taxa across the elevation range between 2000 and 3600 feet, we can turn our attention toward examining differences among the individual taxa that make up the site community at different elevations and different levels of disturbance to refine our choice of metrics and the associated scoring criteria. It is less likely that it would prove fruitful to examine differences among taxa between moderately disturbed sites below 3000 feet and less disturbed sites above 3000 feet if total taxa numbers were consistently and significantly lower at these high elevation sites.

In addition to the value of a robust, reliable B-IBI applicable to tributaries in the Yakima/Naches basin, data from these high and mid-elevation tributary sites are important for the development and refinement of metrics applicable to mainstem Yakima and Naches rivers and larger regulated tributaries, such as the Cle Elum, Tieton, and Bumping rivers. This issue will form a major part of our analytic work in the final year-and-a-half of the project.

Mainstem Sites and IBI Scores

Table 5 lists mainstem Naches and Yakima site-years, elevations, total taxa numbers, and B-IBI site score.

Table 5. Selected Mainstem Site Data for FY 2000 and 2001

Site/Year	Elevation	Total # Taxa (metric score)	B-IBI Score
Naches at Cottonwood Campground/2000	2200	32.3 (5)	34
Naches at Cottonwood Campground/2001	2200	22.3 (3)	22
Naches at Naches/2000	1400	26.3 (3)	32
Naches at Horseshoe Bend/2001	1700	25.3 (3)	26
Naches above Wapatox Canal/2001	1600	24.3 (3)	26
Yakima at Parker/2000	900	22 (3)	22
Yakima above Moxee Drain confluence/2000	1000	22.3 (3)	20
Yakima downstream of Hwy 24 bridge/2001	1000	26 (3)	22
Yakima upstream of Hwy 24 bridge/2001	1000	29 (5)	26
Yakima at Big Horn/2000	1400	26.3 (3)	32
Yakima at Ringer Road/2000	1400	22 (3)	22
Yakima at Ringer Road/2001	1400	21.3 (3)	20
Yakima at River Raft Rentals/2000	1700	19.3 (3)	24
Yakima at River Raft Rentals/2001	1700	24 (3)	22
Yakima at Golf Course Road/2000	2100	27.3 (3)	34
Yakima at WDFW Easton/2001	2100	25.3 (3)	28

Compared to the majority of mid- and high-elevation tributary sites (Tables 3 and 4), the majority of mainstem sites have fewer total taxa and score lower. *Prima facie* it does not appear unreasonable to expect that sites in the upper mainstem Yakima and Naches above approximately 1400 feet should have at least as many taxa as third (3^{rd}) and fourth (4^{th}) order tributaries at similar elevations.[1] It is particularly striking that high elevation sites in the Kolockum Hills east of Kittitas Valley in the upper Yakima subbasin have markedly

[1] We do not provide the argument for this expectation here, but only note that it is one of the working hypotheses that will guide further analysis and development of the metrics for mainstem sites.

greater numbers of taxa and higher site scores than any mainstem site in the upper Yakima basin.

It would thus appear that some anthropogenic impact or combination of impacts on mainstem site condition (biotic integrity) is being detected by the suite of metrics we have evaluated to date.

Evaluation of Landuse Impacts on Site Condition

During spring of 2002 GAP Analysis data for most of the subbasins where sampling occurred in 2000 and 2001 was obtained from Washington Department of Natural Resources. Maps of basin area upstream of sample site locations incorporating GAP landuse data have been produced and preliminary analyses have begun to examine the correlations between gross landuse/condition measures and individual metric values and overall B-IBI scores at individual sites. There is, for example, an expected correlation between site score and percentage of forested land cover in the catchment upstream of sample sites (R-square = 0.29 for the entire data set) and an evident reduction in the variance of scores among catchments with similar percentage of forest cover as percentage of forest cover increases.

Gross road density *per se* (kilometers of road per square kilometer of catchment area, km/km^2), however, shows a weak correlation with B-IBI site score. Taking the quality of the GAP data at face value, this result appears to be due to the majority of site-years being located in catchments with road densities less than 1/2 km/km^2. However, no site scores higher than 34 at road densities greater than or equal to 2 km/km^2.

Paved road density shows a stronger signal with a negative correlation between density and site score (R-square = 0.16), but with surprisingly low road densities (tens of meters per square kilometer. This data is likely an artifact of the majority of paved roads in the upper Yakima and Naches basins being located at low elevations, primarily along mainstem corridors, while the majority of catchment areas are either unroaded or roaded only by unpaved roads. We expect to discover a stronger signal for both unpaved and paved roads when densities are measured within a narrower area adjacent to the wetted channel (hundreds of meters, for example) and when road crossing data is obtained.

Next steps

Overall, the important result at this point just past the midpoint in the project timeline is the development of a set of candidate metrics that broadly characterize site condition in expected ways that appear to reflect the impacts of several kinds of anthropogenic impacts on the biotic integrity of lotic aquatic conditions in the upper Yakima and Naches basins. This is principally the result of having acquired a diverse, representative set of sample data across the full range of scales and conditions present in the study area. Sampling during the third field season this summer has increased both the diversity of sites sampled and the replication across years within the data set.

In addition to continued processing of samples obtained in 2002, during the winter and spring of 2002/03 we will continue analyzing landuse data related to forest cover and road densities and will acquire additional sources on agricultural landuse. We will also begin characterizing mainstem river sites with respect to distance from points of regulation and confluences of large (regulated and unregulated) tributaries.

We believe that the current data set (93 site-years) is rich and representative enough for most purposes of metric development and evaluation. Sampling during the final field in summer 2003 will not need to be as extensive as during the first three (3) years. Our primary focus in sampling in 2003 will be sampling a select set of upstream/downstream sites within tributaries and along mainstems to further evaluate and refine the sensitivity of the metrics to measure local impacts and recovery-with-distance. Secondarily, we will sample in order to increase replication at specific sites where analyses of data obtained during the first three years indicate a need for additional replication. We expect to sample between ten (10) and twenty (20) sites. Remaining time and budget will be devoted to a thorough review and a detailed statistical analysis of the full data set with consulting statistician Leska Fore, who has worked extensively with the statistical properties of multi-metric indices of biotic integrity.