Appendix D: Background and Detailed Information about the Index of Biotic Integrity (IBI)

The original IBI was created as an assessment tool for fish communities [1], but was subsequently adapted for benthic macroinvertebrates (BMI) communities.[2] In recent years, with increasing bioassessment data and the use of more sophisticated analytical techniques, IBI development in California has improved in quality and application. The first demonstration of a California regional IBI was applied to the Russian River watershed in 1999.[3] In 2005, an IBI was developed for southern California (SoCal IBI) coastal streams, based on 88 regional reference sites and 187 test or non-reference sites.[4] Quantitative criteria were used to define reference sites using a set of parameters that quantified human disturbance.

To determine biotic condition of streams and rivers, the BMI communities at a particular site need to be described in meaningful terms called biological metrics. These biological metrics define characteristics of the BMI assemblage that changes in some predictable way with increased human disturbance.

Biological metrics are categorized into four types:

>**Richness Measures -** These metrics reflect the diversity of the aquatic assemblage where **increasing diversity correlates with increasing health** of the assemblage and suggests that niche space, habitat, and food sources are adequate to support survival and propagation of a variety of species.

>**Composition Measures -** These metrics reflect the **relative contribution of the population of individual taxa to the total fauna.** Choice of a relevant taxon is based on knowledge of the individual taxa and their associated ecological patterns and environmental requirements such as those that are environmentally sensitive or a nuisance species.

>**Tolerance/Intolerance Measures -** These metrics reflect the relative sensitivity of the community to aquatic disturbances. The taxa used are usually pollution tolerant and intolerant, but are generally nonspecific to the type of stressors. Percent Hydropsychidae and Baetidae (tolerant families) are regional metrics that have evolved to be particularly useful in California. The metric values usually increase as the effects of pollution in the form of fine particulate organic matter and sedimentation increase.

>**Functional Feeding Groups -** These metrics provide information on the balance of feeding strategies in the aquatic assemblage. The functional feeding group composition is a surrogate for complex processes of trophic interaction, production, and food source availability. An imbalance of the functional feeding groups reflects unstable food dynamics and indicates a stressed condition.

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[1] Karr, J.R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6:21-26.

[2] Kerans, B.L. & Karr, J.R. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. *Ecological Applications* 4: 768-785.

[3] Harrington, J.M. 1999. An index of biological integrity for first to third order Russian River tributary streams. A Water Quality Inventory Series, California Department of Fish and Game.

[4] Ode, P.R. et al. 2005. A quantitative tool for assessing the integrity of southern coastal California streams. *Environmental Management* 35(4): 493-504.

Seven biological metrics were eventually chosen from a total of 61 metrics as the best to discriminate reference from non-reference streams. They are:

1. **EPT Taxa:** The number of different species present from the mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) families.
2. **% Tolerant Taxa:** The percent of the community that is considered "tolerant" of degraded conditions, e.g. most of the midge fly (Chironomidae) and black fly (Simuliidae) larvae.
3. **% Intolerant Individuals:** The percent of individuals in the community that are considered sensitive, or "intolerant" of even moderate environmental degradation, i.e. members of the stonefly (Plecoptera) family.
4. **Coleoptera Taxa:** The number of different beetle species present (i.e. Coleoptera richness).
5. **% Non-insect Taxa:** The percent of the community that are not insects, e.g. the snail and worm species present.
6. **% Collector Individuals:** The percent of the community that are "collectors", i.e. that feed by gathering detritus off of rocks or by filtering detritus out of the water.
7. **Predator Taxa:** The number of different species that are predators, i.e. insects that hunt and feed on other animals. Dragonfly (Odonata) larvae are predatorial macroinvertebrates.

These metrics are then scored from between 0 and 10 based on Table D-1, and multiplied by 1.43 to give a score out of 100.

Table D-1. Scoring ranges for seven biological metrics in the SoCal B-IBI (from Ode et al. 2005).

Metric Score	Coleoptera Taxa	EPT Taxa		Predator Taxa	% Collector Individuals		% Intolerant Individuals		% Non-Insect Taxa	% Tolerant Taxa
	All Sites	6	8	All Sites	6	8	6	8	All Sites	All Sites
10	>5	>17	>18	>12	0-59	0-39	25-100	42-100	0-8	0-4
9		16-17	17-18	12	60-63	40-46	23-24	37-41	9-12	5-8
8	5	15	16	11	64-67	47-52	21-22	32-36	13-17	9-12
7	4	13-14	14-15	10	68-71	53-58	19-20	27-31	18-21	13-16
6		11-12	13	9	72-75	59-64	16-18	23-26	22-25	17-19
5	3	9-10	11-12	8	76-80	65-70	13-15	19-22	26-29	20-22
4	2	7-8	10	7	81-84	71-76	10-12	14-18	30-34	23-25
3		5-6	8-9	6	85-88	77-82	7-9	10-13	35-38	26-29
2	1	4	7	5	89-92	83-88	4-6	6-9	39-42	30-33
1		2-3	5-6	4	93-96	89-94	1-3	2-5	43-46	34-37
0	0	0-1	0-4	0-3	97-100	95-100	0	0-1	47-100	38-100

The SoCal IBI was used to evaluate the biotic integrity of the sites in the HTB Bioassessment Program. Three of the seven metrics in the SoCal IBI have separate scoring ranges for the two Omernik Level III Ecoregions in southern coastal California region (6 = Chaparral and Oak Woodlands, 8 = Southern California Mountains). Although all the sites are in the Santa Monica Mountains, Omernik's map shows the entire area in Ecoregion 6; therefore the values in the column titled 6 were used to determine the metric scores. The scores were summed from all seven metrics, multiplied by 1.43 to adjust the scoring range to a 100 point scale, and then categorized as "very good" (100-81), "good" (80-61), "fair" (60-41), "poor" (40-21) and "very poor" (20-0).