Bay Area Macroinvertebrate Bioassessment Information Network
San Francisco Bay Area Creeks Benthic Index of Biotic Integrity (IBI)
Draft IBI Workplan – v.4

Introduction:

The following describes a series of tasks that will support the development of an Index of Biological Integrity (IBI) for benthic macroinvertebrates (BMIs) in the San Francisco Bay Area. This workplan is a follow-up to the Proposed 2004 Workplan (BAMBI Agenda Planning Committee 2004) that outlined options for resolving key technical and methodological issues related to the development of bioassessment methods and tools in the Bay Area.

The Bay Area Bioassessment Information Network (BAMBI), established in February, 2002, was created to bring together individuals and organizations involved in aquatic bioassessment in the San Francisco Bay Area (Bay Area). Interest in bioassessment has grown significantly in the Bay Area during the past five years, as evidenced by the increasing number of organizations that collect and use bioassessment data. Although some biomonitoring has been performed in bays and wetlands, the primarily focus of BAMBI is aquatic bioassessment in lotic freshwater environments (creeks and rivers) using benthic macroinvertebrates (BMI). The goal of BAMBI is to maximize the utility of aquatic bioassessment in the Bay Area by developing a programmatic and analytical framework for the collection, sharing, analysis, and use of bioassessment data.

The objective of this work plan is to document the tasks which will be completed during the development of a Benthic Macroinvertebrate Index of Biotic Integrity (B-IBI) for creeks and rivers in the San Francisco Bay Area.

Background:

Bioassessment is the use of biological organisms for environmental assessment. It is based upon the idea that organisms have specific habitat requirements and the presence of a taxon indicates certain environmental conditions. Interest in aquatic bioassessment has increased substantially in the United States since the 1980s, when the focus of water quality regulation began to shift from point sources to non-point sources of pollution. Recognizing that chemical analyses were often inappropriate to evaluate the biological integrity goal of the Clean Water Act (CWA), the U.S. Environmental Protection Agency (EPA) developed and promoted a Rapid Bioassessment Protocol (RBP) (Plafkin et al., 1989). The purpose of the RBP was to provide a standard methodology to assess the biological condition of water bodies using aquatic organisms. Ohio was one of the first states to implement a comprehensive biological monitoring program, adopting numeric biological criteria for fish and macroinvertebrates in 1990. Throughout the 1990s, practically every state in the nation has adopted a rapid bioassessment methodology as an essential component of their water quality monitoring program.

Bioassessment data in the United States is most frequently analyzed using a multimetric approach. A metric is a measure of the biota that changes in a predictable way with increased human influence. To be most effective, a metric must distinguish between known reference condition sites and sites known to exhibit a range of impaired conditions. In a multimetric approach*,* metrics are integrated into an index of biological condition, commonly referred to as an Index of Biological Integrity (IBI) (Karr 1981). The IBI approach is designed to maximize detection of degradation by controlling for natural variation (Karr and Chu, 1999; Ode et al., 2002).

In California, IBIs have been developed for San Diego (Ode et al., 2002) and Coastal Southern California (Ode et al., 2003). The California Department of Fish and Game is planning to develop similar IBIs for the North Coast and the Central Valley.

Tasks:

1.0 Form Technical Advisory Group

Rationale: Technical oversight is needed to ensure the proper development of the IBI.

- 1.1 Identify Technical Advisory Group (TAG) members and level of participation.
- 1.2 Select potential peer reviewers.

2.0 Compile Existing BMI Data from Participating Agencies/Organizations

Rationale: IBIs are developed using data sets that describe the region of interest.

- 2.1. Review extent of data obtained to date.
- 2.2. Contact participants and request additional data sets, field forms and supporting information using a *Data Request Form*.
- 2.3. Inventory compiled data sets, e.g., enter metadata into a metadata database, for example, that developed by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP).

Deliverables:

1. Contact information for participants
2. Draft and Final Data Request Forms.
3. Metadata Database

3.0 Standardize the Format of Data Received and Import into the California Ecological Data Application System (CalEDAS) Database.

Rationale: The CalEDAS Database (CDFG 2000) is an adaptation of USEPA's EDAS database (USEPA 1999) which was designed to manage biological data, calculate metrics, and export data to various formats. Using a common relational database structure will facilitate data exchange between participants.

- 3.1 Evaluate metadata collected in Task 2.0 screen/qualify data to ensure sampling/laboratory methodologies were consistent among all data and quality control/assurance procedures were in place and followed. Discard all data not consistent with established methodologies and/or no quality assurance procedures.

- 3.2 Standardize format of all data received from BAMBI participants which was not discarded in 3.1.

3.2 Import, or to extent necessary, enter participant data into CalEDAS.

3.3 Conduct quality control procedures to ensure data was imported/entered correctly.

Deliverable: CalEDAS database populated with participants data.

4.0 Develop Reference Conditions

Rationale: Reference conditions represent the desired state of health, in this case of BMI communities, for a region of interest. They are used to provide a benchmark, or point of reference, against which to compare monitoring data, thereby measuring the existing state of health, or condition.

4.1. **Identify the scale of interest for classifying watersheds as units of analysis**. Watersheds are commonly used as units of analysis because they integrate all upstream land use activities. Determine what size of drainages participants are interested in, e.g., drainages that reach the Bay, or smaller units based on criteria such as drainage size or stream order? Is there an existing data set that could be used for the entire Bay Area, or would several existing ones that describe portions of the Bay Area be used?

4.2. **Develop and populate reference and test group pools** .

4.2.1 Identify criteria and obtain associated data sets (ideally those that cover the entire geographic region) that may be used to classify streams in terms of both natural variation in their watersheds (e.g., ecoregion subsections, elevation, susceptibility to landslides, flow status) and human disturbance (e.g., land use or land cover, roads, water management structures, historic natural resource extraction such as mining, forestry).

4.2.2 Establish thresholds for eliminating sites from the potential reference pool based on criteria identified and available data sets. Screen sites from the reference pool on the basis of human disturbance at the reach-scale, riparian-scale and watershed-scale. It is assumed that the above classifications and thresholds will be developed in a GIS. This may be done by creating composite data sets manually or by using a piece of software such as USEPA's Analytical Tools for Landscape Analysis (ATtILA) extension(http://www.epa.gov/nerlesd1/land-sci/attila/pdf/011factsheet.pdf).

4.3 Establish IBI development and validation data sets.
Randomly divide the full data set established in task 3.1 into a development set that will be used to screen metrics and develop scoring ranges and a validation set that will be used for an independent evaluation of IBI performance.

4.4 **Groundtruth reference sites**. Groundtruth the candidate list of reference sites. Consider implementing the method employed by San Diego, which includes examining flow status, access, habitat conditions, biotic sampling (CDFG 2002).

Deliverable: A set of reference conditions that provide a benchmark against which monitoring data may be compared, thereby measuring the existing state of health, or condition.

5.0 Screen to Select the Most Robust "Core" Metrics

Rationale: A metric is a measure of the biota that changes in a predictable way with increased human influence. To be most effective, a metric must be able to distinguish between known reference condition sites and sites known to exhibit a range of impaired conditions.

5.1 **Establish Expanded List of Metrics for all Data**
Develop approximately 61 metrics for each data set passing criteria established in Task 3.1 through CalEDAS output functions.

5.2 **Screen Metrics.**
Select metrics from all of the metric categories (richness, composition, tolerance, and trophic/habitat) that have the highest discriminatory power (e.g., clear dose-response curves) and that are not redundant (e.g., not highly correlated). Pearson correlation disturbance gradients will likely be used to define the smallest suite of independent disturbance variables against which to test metric response.

Deliverable: A set of robust Core metrics that may be used in an IBI to measure BMI health and indicate watershed health.

6.0 Assemble the IBI:

Rationale: In order to understand the state of health, or condition that existing BMI data indicate, it is necessary to devise a method for measuring them against the reference condition.

6.1 **Define scoring ranges of core metrics**.
Examine statistical properties of metrics to assign scores to ranges in metric values that capture their range of variability. The scoring range described in Hughes et al. (1998) and McCormick et al. (2001) were used recently to develop the San Diego IBI (CDFG 2002).

6.2 **Calculate IBI scores for each site.**
Score the metrics using the scoring index developed in subtask 5.1 and sum the core metric scores for each site.

6.3 **Define method of ranking IBI scores**.
Define the range of IBI scores that will constitute ranks. Some quantification of percentile is typically used to define ranks, e.g., quartiles, quintiles, etc. For example, quintiles could be defined as the following 5 categories: "very good", "good", "fair", "poor", and "very poor". The number of ranks and their labels, however, may vary from the above example.

Deliverable: A development-stage IBI to measure BMI health as an indicator of watershed health. *Note: this IBI needs to be tested and refined as outlined in Task 7.0 before being used as a routine monitoring tool.*

7.0 Validate and Refine the IBI

Rationale: Once developed, and IBI must be validated to determine whether it has the necessary power to discriminate between site conditions and subsequently refined based on testing results.

7.1 **Compare Test and Validation Data Sets.** Compare IBI score distributions to the validation data set to test is the IBI scoring range is repeatable. Depending on the results of the comparision, some sites designated as "reference" or non-reference" may need to be reassigned to the appropriate class. Reasons for eliminating reference sites based on data include: 1) unusually high degrees of natural variability at a site; 2) evidence of impairment from stressors not measured in the reference site selection phase; 3) evidence that a site is not representative of its class.

7.2 **Evaluate the need to create more than one IBI for the Bay Area**. It may be useful to partition natural variation and stratify on an environmental variable in order to increase the discriminatory power of an IBI. Two methods may be employed: multimetric or multivariate. The multimetric method for classifying natural variation using a GIS approach was discussed in 3.3. Multivariate statistical techniques are commonly used to examine the influence of environmental variables on community composition.

Deliverable: A preliminary IBI that may be used by participants to measure BMI health as an indicator of watershed health.

8.0 Continued Testing and Refining of IBI with subsequent monitoring.

Rationale: IBI development is an iterative process that should be revisited as regional databases and biological knowledge expand (Karr and Chu 1999).

8.1 External Review of IBI

8.2 Tasks 4 – 6 will result in a preliminary IBI that should be tested and refined with monitoring data collected in subsequent years.

8.3 Identify potential reference sites in units where they are absent or underrepresented, and identify a mechanism for how such data may be gathered, e.g., through in-kind participant contributions, or through BAMBI monitoring.

Deliverable: Documentation of external review of the preliminary Bay Area IBI.

Placeholder for Summary of Key Issues to be Addressed

8.0 References:

Bay Area Bioassessment Information Network Agenda Planning Committee. 2004. Proposed 2004 Workplan, Options for Resolving Key Issues. 10 pp.

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