IP 4

Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI)

Issue Paper #4

I. Topic: Improving physical habitat assessments associated with macroinvertebrate community data.

II. Background Information

In the context of bioassessment, physical habitat assessment collects information about the structure of the stream and riparian corridor in association with bioassessment sampling at each site. It involves a suite of qualitative or quantitative descriptions of attributes (parameters), with emphasis on those that best reflect functional influences on the organisms that are used as response indicators of stream condition. The California Stream Bioassessment Procedure (CSBP, 1999) has adopted a particular approach developed by USEPA for its Rapid Bioassessment Procedures (RBP; Barbour et al 1999), called a Visual-Based Habitat Assessment ("VBHab" in the rest of this paper). VBHab involves observer scoring of 10 parameters, each on a scale of 1-20. In the most basic application, the individual parameter scores are summed to create a habitat score specific to one sampling location and time. Two versions of the VBHab worksheet are provided, one for high-gradient reaches dominated by a riffle-run structure, and one for low-gradient or glide-pool dominated reaches. Although the May 1999 and earlier versions of the CSBP only included the high-gradient version as its Physical Habitat Quality Form, the low-gradient VBHab is incorporated into the training manual developed by the Sustainable Land Stewardship Institute (SLSI; Harrington and Born, 2000) and used where appropriate by some projects.

The CSBP worksheet also requires measurements or qualitative estimates of other physical parameters and basic water quality chemistry. The CDFG Aquatic Bioassessment Laboratory (ABL) is reviewing the possibility of adding recommendations for other quantitative measurements.

Why is it important? Physical habitat features are empirically correlated with community characteristics of benthic macroinvertebrates (BMIs). Physical parameters can be related to processes operating at different spatial and temporal scales. Landscape level parameters like climate, geology and topography are usually involved in classification of sites or stream segments. VBHab focuses on instream or reach-level features as indicators of relative impact, but may not capture all aspects of physical habitat that are important for understanding of biological data. However, the scale and resolution of the management questions involved should underlie the decision about what to measure, and there is no "one-size fits all" solution.

What is the current status in the Bay Area? CSBP is the standard minimum effort for most organizations, although the level of comparability among datasets is unknown. Anecdotal information suggests that many agencies collect other chemical or physical data along with BMI sampling but actual practices have not been surveyed. Alternative recommendations have been discussed including the presentation by Jim Carter and Steve Fend at the February 2002 initial meeting of BAMBI.

III. Objectives of issue paper:

This section reviews some of the history and rationale of the VBHab, and its relation to the larger context of habitat assessments in general. The following section looks at issues and concerns in relating physical habitat assessments to BMI data in the Bay Area, and suggests some possible strategies for addressing these issues. Since selection of strategies depends on clarifying objectives and endpoints, these questions should be addressed among BAMBI participants.

History and rationale of the Visual-Based Habitat Assessment worksheets

The earliest version of VBHab was derived primarily from a stream classification system for the early stages of Wisconsin's statewide water quality assessments. This "habitat assessment matrix" was intended as a "holistic habitat assessment to enhance the interpretation of biological data". The basic format and parameters remained relatively unchanged following the initial RBP publication in 1989 but there was ongoing discussion, refinement and elaboration during the 1990's including:

- Expanded narrative descriptions characterizing the varying score levels ("Poor, Fair, Good, Optimal")
- Development of alternative parameter definitions for high-vs. low gradient streams
- addition of photographs and citations in the second edition, illustrating "optimal" vs "poor" scoring conditions for individual parameters.

The basic rationale is that multiple physical parameters are needed to capture three categories of habitat influence:

Category (per Plafkin et al 1989)	Parameters included in VBHab
Primary, "microscale" (instream habitat)	Epifaunal substrate/ cover; embeddedness; velocity and depth regime
Secondary "macroscale" (reach level) channel morphology	Sediment deposition; flow status; channel alteration; riffle frequency or sinuosity
Tertiary riparian and bank structure	Bank stability; vegetative protection; riparian zone width

Extensive national guidance on physical habitat assessment for bioassessment (Plafkin et al 1989, Gibson 1994, Rankin 1995, Barbour et al 1999) is mainly in the context of a developing a comprehensive bioassessment program involving:

a. systematic selection of habitat parameters that is integrated with stream classification and further refined for the targeted taxonomic assemblage (e.g. BMIs)
b. large numbers of sites for statistical review and validation of phab system as a correlate of biological response
c. establishment of local reference conditions and expected ranges of "optimal" habitat scores for each stream class
d. professional biologists or ecologists interpretation and field judgment in performing VBHab or "Level 1" assessments.

However regional adaptations may be needed, such as:

- rewriting the scoring descriptions for individual parameters to reflect observable conditions that distinguish a site in relation to regional reference conditions (i.e. "optimal, fair, good, poor")
- changing the weighting of individual parameters in calculating the overall score per site.

Specific parameter lists

Table 1 lists additional parameters required on the CSBP worksheet, with method suggestions from the SLSII manual (directed at volunteer monitors). CSBP guidance does not otherwise specify detailed methods or techniques for calibrating subjective estimates. These data may or may not be incorporated in analysis by the project manager. The table also includes parameters required on the RBP Physical Characterization/Water Quality Field Data Sheet, or suggested by Carter and Fend (USGS 2002). Their preliminary suite of alternative habitat metrics, including both chemical and physical parameters, are shown in Figure 1.

Various management or resource agencies have also promulgated assessment approaches with a variety of physical habitat measurements. These range from qualitative menus of checkboxes on data sheets to quantitative measurements. The Environmental Monitoring and Assessment Program (EMAP) is a national program implemented by USEPA, which surveys BMIs and also fish and periphyton assemblages at randomly selected sites, as well as performing chemical and toxicity sampling. EMAP's physical assessment involves use of high-or low-gradient rapid habitat assessment forms similar to VPHab, but also includes quantitative protocols that are presented as a "level II" habitat option for the revised RBPs:

- thalweg profile at 11 stations equally spaced along the reach
- tally of large woody debris
- channel and riparian cross-section measurements at 11 transects and estimation of substrate, vegetation and cover features at each
- measurement of discharge

This level II suggestion is being reviewed for potential incorporation in the CSBP

The role of physical habitat assessments in general watershed assessment.

Bioassessment projects in the Bay Area have many objectives, but most of the questions about physical habitat assessments arise in relation to evaluation of nonpoint source impacts. Of 10 managers of existing or planned projects surveyed for the February 2002 BAMBI meeting, ambient water quality monitoring was the most frequently named primary objective (6 respondents) followed by watershed characterization, assessment, or trend monitoring (5). Only two respondents listed identification of reference conditions as a primary objective but 5 others considered it a secondary objective. Most responses were from the RWQCB or stormwater programs and reflect concerns with Clean Water Act reporting provisions.

In the context of watershed assessment, a variety of methods may be applied but usually include consideration of landscape-level parameters (reviews include Rankin 1995, Stein 1995). The RBP field sheets assume availability of basic mapping information for the overall watershed, and knowledge of stream type. VBHab scoring is based on a series of assumptions about ecosystem

processes that underlie the selection of appropriate indicators. In a heavily urbanized context, many of these assumptions break down because systems no longer behave as envisioned in the guidance. There may also be constraints specific to California or the Bay Area (e.g. Mediterranean climate, frequency of medium or large scale disturbances, prevalence of bedrock confinement in many headwater areas).

Habitat assessment also may be needed for regulatory reasons separate from bioassessment (e.g. CEQA, wetlands delineation). Results of VBHab may serve as a cross-check but are not substitutes for these detailed specific-purpose assessments. The proposed Stream Protection Policy may also generate specific information needs for habitat assessment in water quality permitting.

There is a spectrum of cost vs. benefit trade-offs for including new assessment parameters to accommodate different data objectives and in different system types. This operates at the decision-making level for individual projects, but also as a question of regional standardization. Analysis of detailed physical habitat data may be important for development of benchmarks such as an Index of Biotic Integrity (IBI) or other biocriteria, even if the parameters are discontinued at a later implementation phase. Standardization would be important in this process if pooling datasets from different sources is needed.

IV. Current Issues

Local experiences and issues with VBHab

Judging by perennial interest in this topic, the VBHab's usefulness is questionable for many Bay Area users. Possible reasons include:

1. Stream classification is needed to factor out landscape level effects. The linkage between VBHab parameters and biological response is based on an implicit model of channel forming processes. Landscape-scale changes like impervious percentage, dams, and corridor fragmentation are only indirectly represented in the parameters, but may be dominating the system response. An example is the dominating effect of dams on BMI communities from 85 sites in Santa Clara County (Carter & Fend, 2000)
2. Sampling sites may not be representative of the reach or section of watershed in question. One ACCWP site has localized impacts from recent bank erosion and a relatively low VBHab score, but supported a diverse community through continual recolonization of sensitive taxa from upstream; another with good habitat scores but low taxon richness may be dominated by a long culverted section upstream.
3. The shape of the biological response curve may be sigmoidal with a long "tail", so that scores in the lower ranges correlate poorly with biological response. Plafkin et al (1989) also suggest that for this type of response curve, BMI results from sites at the high end of the habitat quality scale will also be relatively insensitive to small degradations. The extent and subregional variability of such "tails" is still undetermined.
4. Methodology for the RBP's was designed with an implicit assumption that there would be large datasets. This is only true for a few projects in the Bay Area, notably the SWAMP.

5. Some projects are interested in BMI data for specific management questions and "snapshot" visual assessments don't provide enough information. Geomorphic processes respond to major land use changes over periods of years to decades, but VBHab may not capture differences between position on this timescale or other historical effects. VBHab is not a substitute for reach-level assessments of fish habitat and biological resources that would be needed to effectively manage them.[1]
6. Individual parameters have ambiguous interpretations in terms of the "optimal…poor" scale, when applied in the Bay Area. Examples include:
   - Sediment deposition
   - Channel flow status, which may be artificially augmented by urban runoff during dry periods, instead of connected to subsurface flow.
   - Riffle frequency and bank stability, which may reflect artificial effects (e.g. dumped construction rubble, concrete or gabions) rather than a channel-floodplain relationship shaped by flow.
7. Scoring is inaccurate or inconsistent, or the wrong version of the worksheet is being used. Hannaford and Resh (1995) observed relatively consistent scoring among student observers for some parameters (e.g. canopy cover) but more variability where geomorphological or biological judgement is involved (e.g. bank stability, riparian zone. Reach-scale or riparian corridor parameters, as well as instream ones like substrate or cover, may look different from different positions within the reach and be hard to integrate over the entire reach.

Potential uses of VBHab

Reasonable applications for the existing VBHab include:

- Support selection of sampling sites, such as where matching control vs. impact pairs is desired for point-source monitoring design.
- Eliminate inappropriate candidates as part of the reference site identification process
- Support approximate ranking of sites in relation to reference conditions
- Identify obvious constraints on site potential, and assist interpretation of biological data
- Preliminary reality check on the range of expected variation, supporting the stream classification process.
- Prioritizing sites for follow-up (in conjunction with other information).
- Educational, as a vehicle for discussing habitat concepts with volunteer groups or other non-technical audiences (dedicating this task to staff or specifically trained volunteers may be needed if the data is to be used by others)

Supplements or alternatives to VBHab parameters

Existing habitat assessment approaches usually include the same general parameter categories as Table 1, but differ in the number of parameters, relative emphasis among categories, and the

[1] Although BAMBI's scope does not include fish, it should be noted that the RBP methodology for fish assemblages was primarily developed for systems with a diverse, locally shifting assemblage of multiple small species of native fish (e.g. darters) and is not readily transferred to California's fish fauna.

choice of precise measurements vs. rapid, integrative evaluations or check-offs. When considering addition of parameters to the a proposed assessment, several questions should be asked:

1. Does the parameter or parameter group reflect local limiting factors on biological communities?
2. Do they show a good dose-response curve that distinguishes sites over the range of disturbance
3. Can they be applied consistently in a cost-effective way by available personnel?

Two additional questions need to be asked both at the scale of individual program managers and also for the region:

4. Does the information help support useful decision making?
5. Are the parameters to be used for exploratory analyses or are they intended to test specific hypotheses or validate existing conceptual models?

The second edition of USEPA's RBP (Barbour et al 1999) identifies two approaches to managing variability of data: standardization and Performance Based Methods System (PBMS). The RBPs are intended as a framework for development of local Standard Operating Procedures (SOPs), but complete standardization is not likely to be satisfactory for all purposes. The PBMS approach instead permits the use of different methods, but in a framework where they are matched to explicit data quality objectives and supported by tests of their performance. While a full PBMS approach may not be practical for small agencies or programs, it can serve as a model for developing region-specific standards in the context of the statewide effort to promote bioassessment.

BAMBI participants should ask whether the expected improvement in assessment information will justify the effort and cost of developing, testing and implementing new habitat standards to supplement or replace VBHab. There may be a few good candidate parameters that can be identified but other gaps may be better addressed by guidelines or examples of integrating field work and factors during program design and data analysis. For example, flow regime, either from ongoing level sensors or inferred from other data sources, would be a useful complement to either the snapshot view of flow condition in the VBHab or more precise one-time measurements.

Efforts to develop alternative or supplemental habitat measures should be coordinated with the related topic of protocol standardization, but also would be related to reference condition development and discussion of QA/QC practices

V. Options for improvement

Potential improvement actions are suggested below, mainly for Bay Area practioners in a collective sense. Ideally these would be complementary:

1. support stream classification efforts for the region, and clarify hierarchy of landscape vs site-specific influences for major stream types

2. Identify/confirm useful indicators, which may or may not be same as the VBHab parameters. Alternative suggestions include EMAP,
3. address cost-benefit tradeoffs for different types of data interpretation, identify priorities for using or testing supplemental parameters.
4. Develop general guidelines, models or discussion resources for interpretation of local phab data.
5. Share SOPs and sponsor cross-agency trainings to improve standardization for parameters that are subjective/ highly variable. Hannaford and Resh (1995) found that training greatly reduced the variability among observers and also improved consistency when reinforced before moving to a new watershed. Supporting activities might include development of a library of photo or video clips for calibration discussions.
6. Use results of trainings, field QA/QC tests and other feedback to refine guidance on the variability and application of habitat parameters in Bay Area conditions.

Some actions such as 4 and 5 can be initiated by individual groups or agencies and include others as partners. Input and experiences from diverse projects is also needed for tasks 1, 2 and 6. Regional cooperation would facilitate all of the actions but seems especially necessary for tasks 1 and 3

VI. Suggested next steps

1. Review current practices and biggest needs for specific interpretation in the short run.
2. Share experiences and disseminate useful studies from other regions.
3. Identify levels of action for priority needs that are appropriate and reasonable for the Bay Area, which may include:
   - networking and information sharing,
   - developing more formal guidance
   - selection and field testing of candidate parameters.

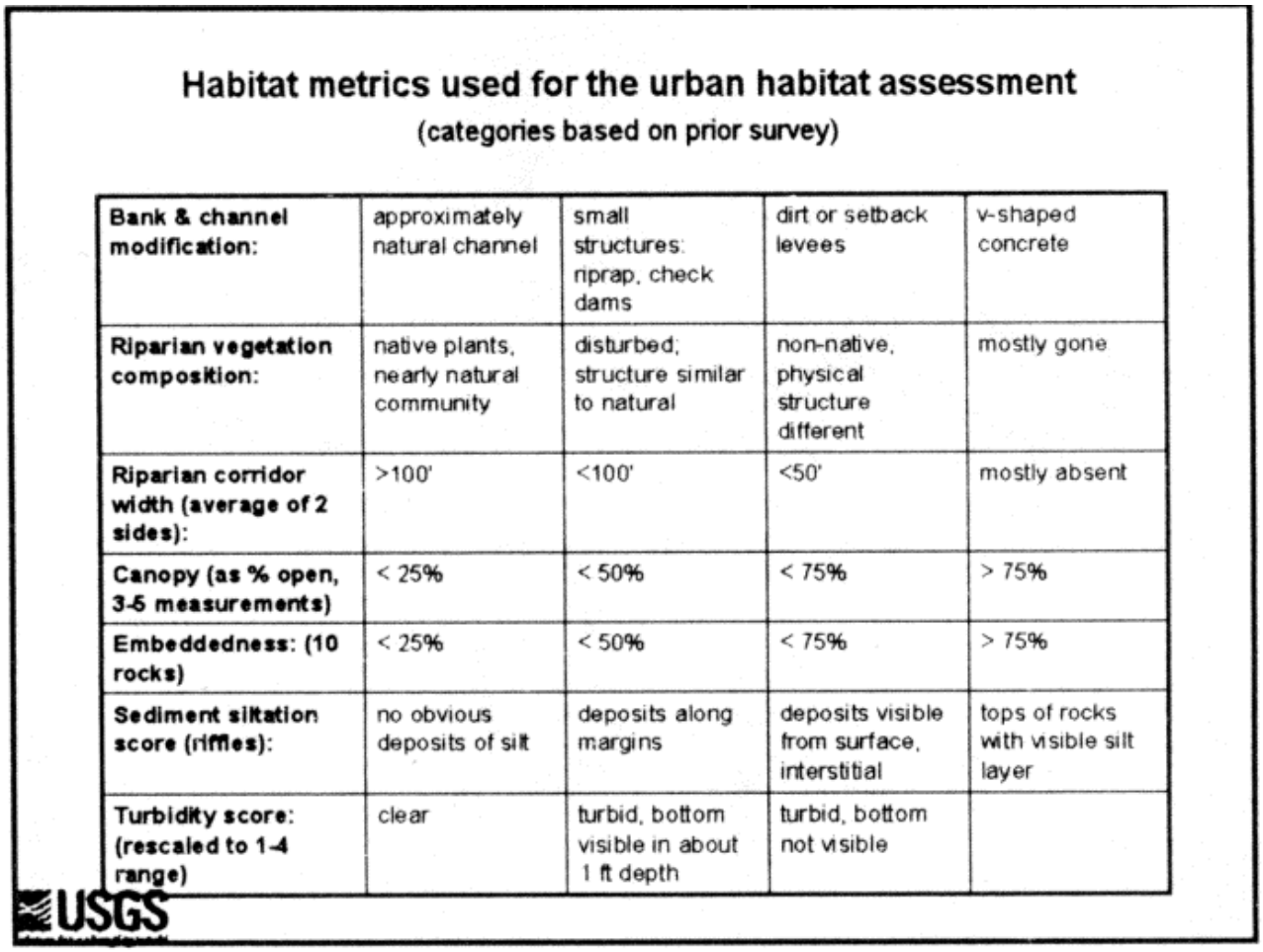
3. Consider resources available for leading the next steps and for funding support. This may involve forming a workgroup and/or advisory panel for continued email discussion.

Table 1. Site-specific physical parameters associated with BMI sample protocols.

Parameter	CSBP field worksheet	SLSI guidance	RBP 1999 required	USGS 2002
Reach Length	measure		Yes	
Stream Width			estimate	
Reach Area			estimate	
Stream Depth			estimate	Ea. Point (a)
Riffle Length	Ea. riffle		.	
Avg. Riffle Width	Ea. riffle		.	
Avg. Riffle Depth	Ea. riffle			
Riffle Velocity	Ea. riffle	Estimate with float; prefer measure with meter	representative run –measure at thalweg	Ea. Point (a)
% Canopy Cover	Ea. riffle	Visual estimate; prefer measure w/ densiometer		
Substrate Complexity	Ea. riffle			
Embeddedness	Ea. riffle			Ea. Point (a)
Substrate Composition (inorganic)	Ea. Riffle (% by class)		Reach % by class	
Substrate Composition (organic)			Reach % by class	100-count, ea. Riffle
Substrate Consolidation:	Ea. riffle			
Percent Gradient:	Ea. riffle			Measure at riffle, reach
Surrounding landuse			checkboxes	
NPS pollution present			checkboxes	
Riparian vegetation type, dominant species			Yes	
Large Woody Debris			Area, density over reach	
Aquatic Vegetation: Dominant type, species, area of reach			Yes	
Substrate odors, oils, color			checkboxes	
Bankfull depth				Measure at riffle, reach

(a) each sampling point out of 5 composited from a sampled riffle

Figure 1. Preliminary habitat assessment used for Santa Clara data analysis (Carter and Fend, presentation at 2002 BAMBI meeting).



Habitat metrics used for the urban habitat assessment

(categories based on prior survey)

Bank & channel modification:	approximately natural channel	small structures: riprap, check dams	dirt or setback levees	v-shaped concrete
Riparian vegetation composition:	native plants, nearly natural community	disturbed; structure similar to natural	non-native, physical structure different	mostly gone
Riparian corridor width (average of 2 sides):	>100'	<100'	<50'	mostly absent
Canopy (as % open, 3-5 measurements)	< 25%	< 50%	< 75%	> 75%
Embeddedness: (10 rocks)	< 25%	< 50%	< 75%	> 75%
Sediment siltation score (riffles):	no obvious deposits of silt	deposits along margins	deposits visible from surface, interstitial	tops of rocks with visible silt layer
Turbidity score: (rescaled to 1-4 range)	clear	turbid, bottom visible in about 1 ft depth	turbid, bottom not visible	

USGS

VII.References

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The Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI) includes scientists, watershed managers and regulators interested in local applications of *bioassessment* --the use of biological community data for assessing the condition of waterbodies and watersheds. BAMBI's focus is on *benthic macroinvertebrates* (bottom-dwelling animals without backbones, visible to the naked eye) which are present in most aquatic environments and are useful indicators of ecosystem function because their community composition responds to a wide range of ecosystem variables. BAMBI Issue Papers provide background and discussion of technical areas important to the development and improvement of bioassessment in the Bay Area. These are provisional workproducts for BAMBI discussion in January 2003, contributed by members of the Bay Area Stormwater Management Agencies Association (BASMAA), and the SFBay RWQCB. Forward comments or questions to BAMBI c/o watersheds@acpwa.org