Scope of Work

2015/2016 Update and Refinement of the "Chessie BIBI" Indicator of Stream Health

December 10, 2014
Revised September 9, 2015

Objectives

- Update and refine the existing Chesapeake basin-wide index of biotic integrity for stream macroinvertebrates, or "Chessie BIBI;"
- Incorporate genus-level metrics into the index if warranted;
- Make the procedure for calculating the index simpler and more accessible to users; and
- Develop a "2008 baseline" against which the progress in restoring stream health (trends) can be measured.

Background

In March 2008, Chesapeake Bay Program (CBP) partners combined state agency stream assessments in a map of benthic macroinvertebrate impairment[1] and concluded the result could not adequately represent stream condition on a basin-wide scale. An approach used earlier to develop an interstate stream index for the Potomac River basin[2,3] was then applied to the underlying monitoring data. The result was a Chesapeake basin-wide index of biotic integrity for stream macroinvertebrates, or "Chessie BIBI," completed in late 2008[4] and refined with additional data and analysis in 2011.[5] The index is comprised of highly discriminatory family-level biometrics, some of which are already used by state and local agencies in their own stream assessments. Biometrics in the index are scored uniformly across state boundaries according values observed at minimally disturbed "reference" (REF) sites in each of the basin's physiographic regions ("bioregions"). The index classifies REF sites and degraded (DEG) sites equally well, and index classification efficiencies range from 77.8% in the under-represented North Central Appalachian bioregion to 91.7% in the well-represented Piedmont bioregion. Twenty-eight monitoring programs have now contributed data, and a relational database of most of these data and their associated family-level metrics is currently on-line at www.chesapeakebay.net. Spatial coverage in most HUC8 watersheds of the Chesapeake basin between 2000 and 2011 is good. The index has proven to be sensitive to conductivity gradients and nutrient enrichment[6] and to streamflow alteration.[7]

CBP uses the Chessie BIBI as a "stream health indicator" on its website.[8] Index results were included in CBP *Bay Barometer* reports between 2008 and 2012. The index is mentioned specifically as a measure of stream restoration progress in the 2009 Executive Order 13508, Draft Strategy for Protecting and Restoring the Chesapeake Bay.[9] It is a biological endpoint that will reflect the improvements in stream health and function called for in the 2014 Chesapeake Watershed Agreement.[10] At this time, the index needs to be updated with the most recent macroinvertebrate data. It is now possible to develop and test genus-level metrics to incorporate into the index, and further test the index's sensitivity to various stressors (e.g., water quality, physical habitat). Finally, a 2008 baseline needs to be established against which progress can be measured.

Activities

The Interstate Commission on the Potomac River Basin (ICPRB) proposes to update and refine the Chessie BIBI index. Staff will perform the following activities with funds available through ICPRB's Clean Water Act, Section 117 grant:

1) Update Database The existing CBP relational database of stream macroinvertebrates raw data and metrics, habitat scores, and water quality data extends only to 2010 (Table 1). The data were originally submitted to CBP and processed by ICPRB staff located at CBPO. The database needs to be updated with more recent data for CBP reporting purposes. ICPRB will partner with the CBP Scientific, Technical Assessment and Reporting (STAR) team and Habitat GIT team Stream Health workgroup to request recent data sets from stream monitoring programs in 2015. The raw data will be quality assured, reformatted, and incorporated into the existing stream database structure by ICPRB staff using established CBPO procedures.[11] Processing data is time intensive and also dependent on when monitoring programs submit the data.

Table 1. Agencies that have provided stream data.

Agency	Monitoring Program Name	Start	End	# Samples
AAC_DPW	AACO-Watershed, Ecosystem, and Restoration Service	3/8/2004	4/14/2008	239
BAL_DPW	City of Baltimore- Stream Monitoring Program	4/3/2002	5/6/2010	277
BC_DEP	Baltimore Co. Watershed Management and Monitoring	4/1/2003	4/29/2008	607
DC_DDOE	District of Columbia-Stream Monitoring Program	6/19/2003	5/21/2009	44
DNREC	Delaware Biological Monitoring Program	10/16/2001	11/8/2010	87
FC-DPW	Frederick County Watershed Management Program	4/23/2001	9/18/2009	351
FC-SPS	Fairfax County Stream Quality Assessment Program	7/31/2001	4/10/2008	239
HC_DPW	Howard Co Bio-Monitoring and Assessment Program	3/7/2001	3/30/2009	266
LC-DBD	Loudoun County Stream Quality Assessment Program	3/27/2009	10/12/2010	201
MC-SPS	Montgomery Co Dept. of Environmental Protection	3/22/1993	5/7/2008	1651
MDDNR	Maryland Biological Stream Survey	5/10/1994	11/18/2010	7472
MDDNR	Maryland Core/Trend Monitoring Network	5/10/1994	11/18/2010	7472
NYDEC	New York Routine Statewide Monitoring Program	7/29/2002	8/7/2008	346
PADEP	Pennsylvania Other Water Quality Assessments	3/12/1999	12/22/2010	1652
PADEP	Pennsylvania Surface Water Monitoring Program	3/12/1999	12/22/2010	1652
PADEP	Pennsylvania Unassessed Watersheds	3/12/1999	12/22/2010	1652
PADEP	Pennsylvania USGS	3/12/1999	12/22/2010	1652
PGC-DER	Prince Georges Co Programs and Planning Division	3/11/1996	4/7/2008	501
SRBC	SRBC-Watershed Assessment and Protection-TMDL	7/6/1998	10/19/2009	1167
SRBC	SRBC-Watershed Assessment Program	7/6/1998	10/19/2009	1167
USEPA	EPA-EMAP Wadeable Streams Assessment	4/27/1993	11/10/2004	500
USEPA	EPA-Mid-Atlantic Highlands Assessment	4/27/1993	11/10/2004	500
USEPA	EPA-Wadeable Stream Assessment Program	4/27/1993	11/10/2004	500
USFS	National Forest Service Stream Assessment	5/18/2000	5/8/2003	7
USGS	USGS-National Water Quality Assessment Program	6/2/1993	8/27/2008	243
VADEQ	Virginia DEQ Non-Tidal Stream Monitoring Program	10/18/1993	12/22/2010	3335
VCU	INteractive STream Assessment Resource	6/11/1999	11/24/2010	729
WVDEP	West Virginia Div. of Water and Waste Management	8/19/1996	8/31/2010	918

2) Metric and Index Calculations In-house computer programs at CBPO were used previously to calculate the Chessie BIBI from macroinvertebrate metrics in the database.[11] The procedure is embedded in the CBPO information management system and not readily performed by persons outside that office. Currently, CBPO staff are not available to perform the work. ICPRB staff will modify the procedure and original programming code so that both ICPRB and contributing monitoring programs can calculate and track the Chessie BIBI outside of the CBPO system. It is anticipated that new biological metrics will be added over the course of this project.

3) Index Sensitivity The sensitivity of the established family-level index could be improved at this time because more information is available about the environmental stressors in individual watersheds and the pollution tolerances of different macroinvertebrate taxa. ICPRB will perform the following steps:

- Update tolerance score assignments for family-level taxa and confirm feeding and habit assignments.
- Identify reference and degraded sites using stricter water quality and habitat selection criteria and additional watershed criteria; if sufficient data are available, explore a karst-specific scoring approach for Valley bioregion.
- Use RPART (recursive partitioning) to re-test the influence of Ecoregion IV landscape categories on reference site habitat and water quality features, and confirm necessity of bioregion-specific versions of the index.
- Calculate discrimination efficiencies for a suite of family-level macroinvertebrate metrics.
- Reassess the discrimination efficiencies of the macroinvertebrate metrics used in the existing Chessie BIBI index and refine if needed.
- Confirm consistency of the narrative rating thresholds across bioregions (e.g., excellent is BIBI $\geq$ 67; good is BIBI 50 - <67; etc.).
- Compare with state qualitative ratings.
- Revisit approach describe inICPRB report 11-02 to Maryland Dept. of the Environment (2011). Identify metrics that are sensitive to nutrient enrichment and determine if they can be incorporated into revised Chessie BIBI.

4) Bioregion Under-Representation Reference sites in the North Central Appalachian (NCA) and Northern Appalachian Plateau and Uplands (NAPU) bioregions in Pennsylvania and New York were under-represented when the index was originally developed. Additional reference-quality data in these bioregions are now available (Ellyn Campbell SRBC, per. comm.). The sensitivity of the index in these bioregions will be tested with more confidence and probably improved.

5) Genus-Level Metrics The use of family-level macroinvertebrate metrics in the index was necessary in 2008 because some agencies only identified taxa to family-level. Since then, most agencies have moved to genus-level identifications. It is thought that an index with some genus-level metrics will have more discriminatory power than an index based solely on family-level metrics, and individual genus-level metrics may prove more sensitive to specific stressors. The possibility of incorporating genus-level metrics into the basin-wide index will be explored for the more recent time period. ICPRB expects to perform the following steps:

- Assign tolerance scores and feeding and habit categories to genus-level taxa.
- Calculate discrimination efficiencies for a suite of genus-level macroinvertebrate metrics and select a set of highly discriminating metrics for each bioregion.
    - Attempt to include at least one metric that is sensitive to flow alteration, one that is sensitive to elevated nutrients, and possibly one that is sensitive to elevated conductivity. Select biometrics that yield the highest index classification efficiencies.
- Determine if incorporating genus-level metrics improves the performance of the Chessie BIBI index or if a separate, genus-level index is warranted.
- Perform jackknife validation of metrics and index.
- Compare with state qualitative ratings.

6) 2008 Baseline The 2014 Chesapeake Watershed Agreement calls for an improvement in stream health and function in *"…ten percent of stream miles above the 2008 baseline for the Chesapeake Bay*

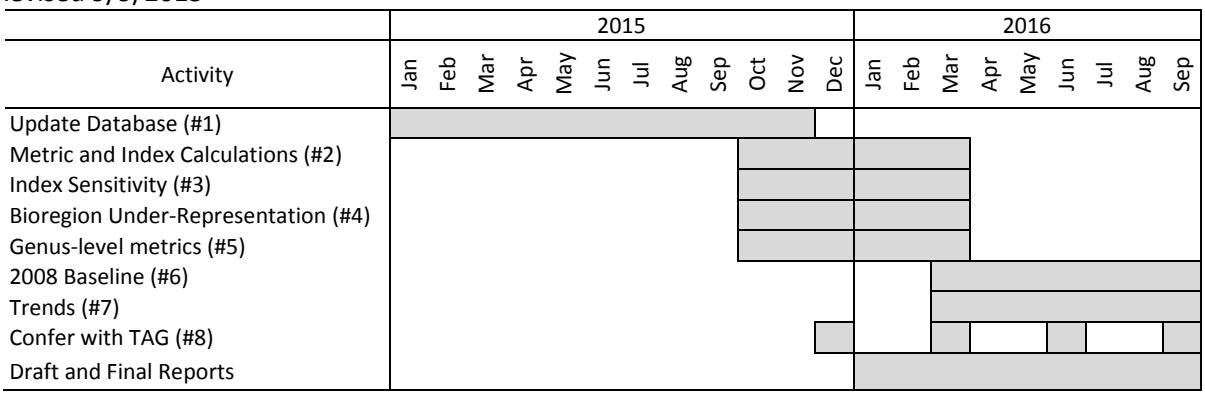
watershed." Stream macroinvertebrates are an important biological component of stream ecosystems and a 2008 baseline for this component can be established using the Chessie BIBI index. ICPRB will explore different approaches for developing a 2008 baseline and present them to STAR and the Stream Health Workgroup for discussion.

7) Trends A method for detecting changes (trends) in stream health over time is needed by CBP partners to measure progress in restoring streams. While trends can be determined straightforwardly from data collected at fixed monitoring stations, the random stratified sampling designs of many monitoring programs in the Chesapeake basin make it difficult to measure trends using those data. Several trend analysis approaches were explored by Adam Griggs (ICPRB) and presented to the Non-Tidal Water Quality Workgroup in a November 9, 2011 conference call. One possibility is to use averaged index values for different time increments and identify step-trends in stream health by watershed units (HUC8 or HUC10). In this project, ICPRB will continue to explore different approaches for determining trends in the Chessie BIBI on a watershed basis.

8) Technical Advisory Group A group of knowledgeable and interested individuals, including representatives from the Habitat GIT team Stream Health Workgroup and Science and Technical Analysis and Reporting [STAR] team Non-Tidal Water Quality Workgroup, will be formed to guide this effort. Quarterly reports and conference calls to discuss the results will be done. Important decisions, milestones and products will be submitted as well to the full workgroups for review.

Activities Timeline

Revised 9/9/2015



Key Project Personnel

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Michael Selckmann, Aquatic Ecologist, ICPRB, 30 West Gude Dr, Suite 450, Rockville, MD 20850
1-year Research Fellow (tentatively 1 Oct 2015 – 30 Sept 2016) at ICPRB

Deliverables

Updated databases of raw count data
Expanded data set of macroinvertebrate metrics and Chessie BIBI index values
Revised Standard Operating Procedure for processing data and calculating metrics and index
Computerized procedure for calculating metrics and index

Progress reports to Technical Advisory Group
Draft and Final reports

Citations

[1] Map prepared by John Wolf, Chesapeake Bay Program GIS team, March 2008. "Benthic macroinvertebrate impairments, freshwater streams and rivers health assessment." Available online at: http://www.chesapeakebay.net/maps/map/benthic_macroinvertebrate_impairments

[2] Astin, L.E. 2006. Data synthesis and bioindicator development for nontidal streams in the interstate Potomac River basin, USA. Ecological Indicators 6: 664-685.

[3] Astin, L. E. 2007. Developing biological indicators from diverse data: The Potomac Basin-wide Index of Benthic Integrity (B-IBI). Ecological Indicators 7: 895-908.

[4] Foreman, K., A. Nagel, and C. Buchanan. 2008. Development of ecosystem health indexes for non-tidal wadeable streams and rivers in the Chesapeake Bay basin. Progress report prepared for the CBP Non-Tidal Water Quality Workgroup by the Chesapeake Bay Program Office and the Interstate Commission on the Potomac River Basin.

[5] Buchanan, C., K. Foreman, J. Johnson, and A. Griggs. 2011. Development of a basin-wide benthic index of integrity for non-tidal streams and wadeable rivers in the Chesapeake Bay watershed: final report to the Chesapeake Bay Program Non-Tidal Water Quality Workgroup. ICPRB Report 11-1. Available online at: www.potomacriver.org/pubs/pubs.

[6] Mandel, R., C. Buchanan, A. Griggs, A. Nagel, and O. Devereux. 2011. Data analysis to support development of nutrient criteria for Maryland free-flowing waters. Final Report to Maryland Department of the Environment. ICPRB Report 11-2. Available online at: www.potomacriver.org/pubs/pubs.

[7] Buchanan, C., H. L. N. Moltz, H. C. Haywood, J. B. Palmer, and A. N. Griggs. 2013. A test of the Ecological Limits of Hydrologic Alteration (ELOHA) method for determining environmental flows in the Potomac River basin, USA. J. Freshwater Biology doi:10.1111/fwb.12240.

[8] http://www.chesapeakebay.net/indicators/indicator/health_of_freshwater_streams_in_the_chesapeake_bay_watershed

[9] Stream Restoration Outcome in 2009 Executive Order 13508, Draft Strategy for Protecting and Restoring the Chesapeake Bay: "Improve the health of streams so 70 percent of sampled streams throughout the Chesapeake watershed rate fair, good or excellent, as measured by the Index of Biotic Integrity, by 2025." Baseline: 43 percent of sampled stream sites are rated fair, good or excellent. [Note: the baseline was changed from 45 percent to 43 percent due to recent improvements in the methodology used to calculate status of stream health (based on information from 2000-2010).]

[10] Stream Health Outcome of Chesapeake Watershed Agreement 2014: "Continually improve stream health and function throughout the watershed. Improve health and function of ten percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed."

[11] Standard Operating Procedures for Managing Living Resources Monitoring Data at the Chesapeake Bay Program, June 2013.