SWAMP
Surface Water Ambient Monitoring Program

Management Memo | Thresholds

BIOLOGY-BASED STRESSOR THRESHOLDS

The objective of this memo is to describe how biological assessment data (such as those collected using Surface Water Ambient Monitoring Program (SWAMP) bioassessment protocols) can be used to develop biologically-relevant stressor thresholds. This memo describes an objective approach for setting regulatory stressor thresholds based on the association between biological condition and stressor intensity gradients. While these relationships show a large amount of variability typical of biological data, there are clear thresholds that indicate levels below or above which stream health is maintained or degraded.

Biology-based stressor thresholds tell us the level of contaminants or other stressors above which aquatic life is consistently impacted.

Biology-based threshold values can be used to evaluate how well current regulatory criteria are protecting aquatic life beneficial uses of our waters. They can also be used to support numeric interpretation of narrative criteria. These thresholds can be used in setting and evaluating regulatory standards and utilized as performance targets in multiple applications.

Why Develop Biology-based Stressor Thresholds?

Setting appropriate regulatory thresholds for contaminants and other ecological stressors is a fundamental challenge for water quality regulatory agencies. The process is difficult for contaminants that are not naturally occurring (e.g., pesticides), but is especially so for identifying excess levels of naturally occurring constituents (e.g., nutrients, fine sediments, salt and metal ions).

California NPS Program

California Water Boards

Biological data can serve as a common currency for standardizing the way water quality thresholds are set across a range of constituents

Direct measures of ecological integrity, such as those provided by bioassessment data, can help anchor regulatory thresholds in objective data about aquatic life beneficial use attainment. Furthermore, because biological communities are one of the key beneficial uses/values being protected, biological data can serve as a common currency for standardizing the way water quality thresholds are set across a range of constituents.

Threshold Setting Process

The biological condition of streams typically have a negative relationship with many different stressors (Figure 1). In all these relationships there is an upper limit to the biological condition that is observed at a particular level of stress. Beyond some concentration (or level) of a particular stressor, sites with intact biological condition are rarely, if ever observed (see green dots in Figure 1).

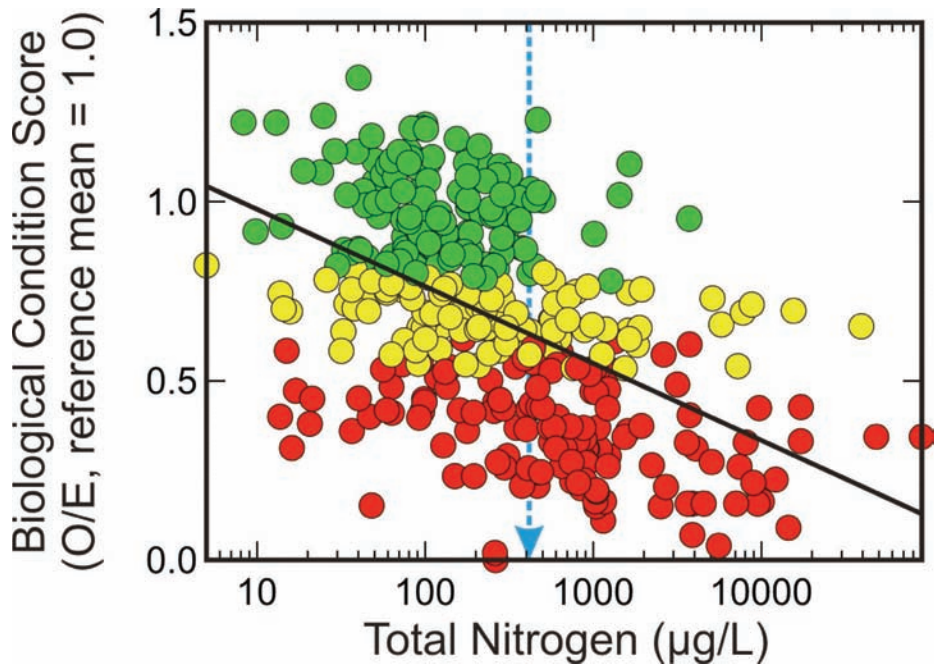

Figure 1. Statewide relationship between total nitrogen concentration and biological condition scores. Green dots represent sites in good biological condition and yellow and red dots represent sites with degraded and very degraded biological condition, respectively. The black line represents a linear best fit line and the blue dotted line represents the 90th percentile of nitrogen concentration values for sites in good biological condition. Using this approach, we might identify a statewide impairment threshold for total nitrogen at 400 µg/L.

Based on this relationship, data from SWAMP's Perennial Streams Assessment (PSA) was used to identify biological impairment thresholds for a number of stressor variables including nutrients and percent fines (Ode et al. 2011). Benthic macroinvertebrate (BMI) community indices were used to assess the biological condition of sites in the PSA dataset. Provisional thresholds were established at the 90th percentile of the good (green) distribution (represented in figures by a blue dashed line). Although there may be many reasons for using lower thresholds, higher thresholds are not likely to support aquatic life uses.

The PSA data also can be used to develop regionally-calibrated thresholds. Because biological communities have evolved to adapt to natural differences in environmental variables, thresholds for biological impairment are different for different eco-regions. For example benthic assemblages in the North Coast are less tolerant of fine sediment abundance than those in Southern California (Figure 2); this is reflected in dramatically different thresholds in these regions.

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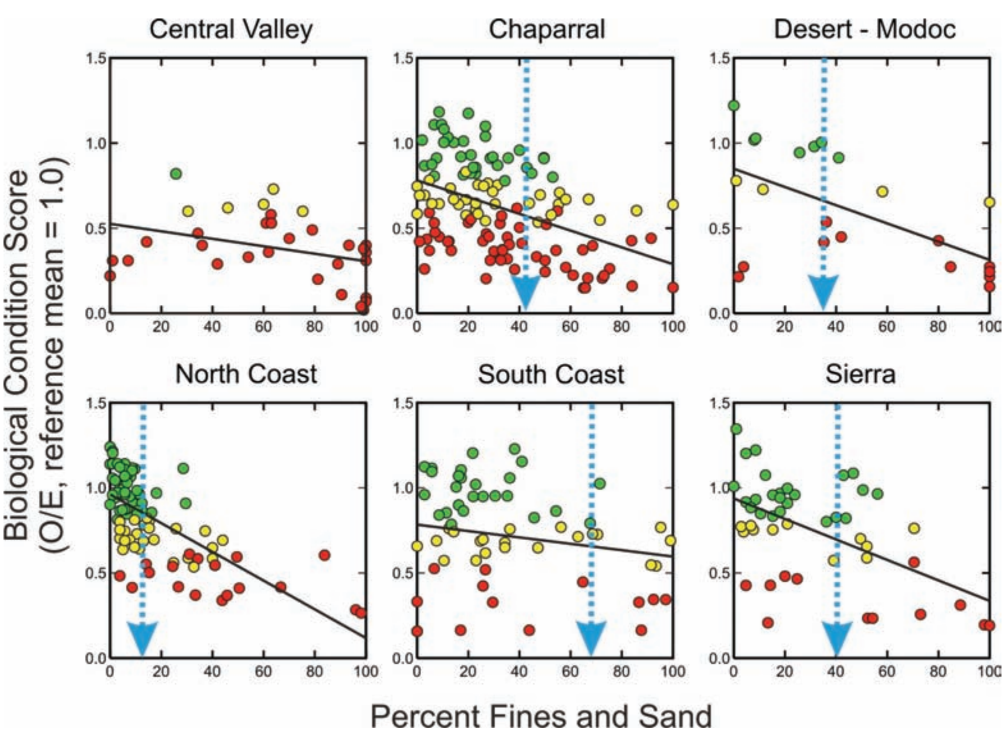

Figure 2. Scatterplots of biological condition scores as a function of the percentage of fine sediments in the sampling reach. Green dots represent sites in good biological condition and yellow and red dots represent sites with degraded and very degraded biological condition, respectively. Blue dotted lines represent the 90th percentile threshold.

Conclusions

The examples presented here illustrate the capacity of biological integrity data to help establish and evaluate water quality standards. Biology-based thresholds could be a valuable tool for establishing expectations for parameters without existing numeric criteria and for variables that are naturally occurring (e.g., nutrients, sediments, chloride, conductance, etc.). However, care must be given to ensure that such thresholds are tailored to the various eco-regions in California.

Current analysis of biological thresholds can and should be refined with the continued integration of biological integrity data from SWAMP's Reference Condition Management Program (RCMP), the Perennial Streams Assessment (PSA) program, and the Southern California Stormwater Monitoring Coalition (SMC). Scatterplots can be supplemented with data collected under a wide variety of programs including probability surveys, reference datasets and targeted monitoring efforts.

The examples presented here rely on benthic macroinvertebrates (BMIs) as indicators of biological condition. Although BMIs are an excellent indicator of general aquatic life condition, these thresholds could be strengthened by the addition of multiple lines of evidence from additional biological assemblages (e.g., algae, fish, riparian vegetation, etc.). Additional indicators might produce higher or lower threshold values so a framework for combining multiple indicator sources would need to be developed.

Biology-based thresholds could be a valuable tool for establishing expectations for parameters without existing numeric criteria and for variables that are naturally occurring (e.g., nutrients, sediments, chloride, conductance, etc.)

RCMP-PSA – SWAMP's probability (PSA) and reference (RCMP) surveys produce data that illustrate the distribution of stressor values expected for a whole region or for minimally disturbed sites in a region, respectively (see Memo: Value). The combination of biology-based thresholds with these distributions would provide a powerful framework for establishing objective and regionally-appropriate standards for a wide range of water quality parameters.

Recommendations for Management:

- The State Water Board should continue to investigate the use of biology-based stressor thresholds as an objective means to set meaningful, regionally-appropriate water quality standards. Biologically-validated stressor thresholds can be especially valuable for variables that have non-zero reference values (e.g., nutrients, fine sediments, chloride, conductance, etc.). The State Water Board should identify candidate water quality analytes that would benefit from biology-based threshold analyses.

- Constituents that are currently collected along with biological data could be analyzed immediately with data in the SWAMP-CEDEN databases. Other constituents of interest should be added to statewide biological monitoring programs (e.g., SWAMP, SMC, RMC).

- The use of biologically derived stressor thresholds should be expanded to include additional indicator groups such as fish, algae and riparian vegetation. Multiple lines of evidence could be developed by each indicator group, to add weight and precision to the biologically derived threshold value.

For more information, please contact:

SWAMP Program Coordinator
State Water Resources Control Board
Office of Information Management and Analysis
1001 I Street, 15th Floor
Sacramento, CA 95814
(916) 341-5556

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