A Biological Condition Gradient (BCG) Assessment Model for Stream Fish Communities of Connecticut and Southern New England

Michael Beauchene and Christopher Bellucci, *Connecticut Department of Energy and Environmental Protection (CT DEEP)*, and Jeroen Gerritsen and Jen Stamp, *Tetra Tech Center for Ecological Sciences*

Background

The Biological Condition Gradient (BCG) is a model that describes how communities respond to stress placed on a system. The US EPA and Connecticut Department of Energy and Environmental Protection (CT DEEP) Bureau of Water Protection and Land Reuse (WPLR) have partnered to calibrate a BCG model for freshwater fish assemblages (cold and cool) in wadeable streams of Connecticut. The two BCG models have the following benefits for describing fish communities:

- Anchored in the "natural" condition
- Conceptually very easy to understand
- Provides an "intrepretation" framework for results generated from different:
  - Sampling or Analytical Methodologies
  - Ecoregions
  - Habitat types
  - Community types
  - Management goals and objectives

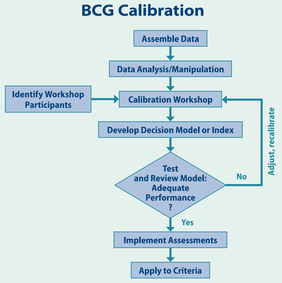


Figure 1. Flow chart of the BCG calibration process.

Methods

We followed the BCG calibration process that is summarized in Figure 1 and outlined below.

Compile fish community data – 967 samples from 676 unique stations, with sample dates ranging from 1999-2010. Site locations are shown in Figure 2.

Classify sample locations – Using The Nature Conservancy's Northeast Aquatic Habitat Classification (Olivero and Anderson 2008) each of the sampling locations were designated as either cold, cool or warm. In addition each was assigned a watershed size subclasses, using the following arbitrary thresholds: small = less than 5 square miles; medium = 5 to 50 square miles; and large = greater than 50 square miles.

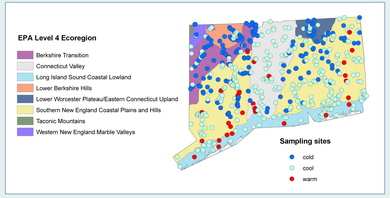


Figure 2. Locations of the fish sampling sites in the CT DEEP WPLR dataset grouped by temperature subclass.

Calibrate species attributes – Regional biologists assigned BCG attributes to taxa (Table 1). Stocked and naturalized fish of the same species were counted as separate taxa.

Assign BCG level to samples – The same biologists were provided fish taxa lists from individual samples without knowledge of sample location, so not to bias decision making, and asked to assign a BCG level to each (Figure 3). The intent of this exercise was to achieve consensus on BCG level assignments for each sample and to identify rules that the biologists were using to make their assignments. The verbal rules and decisions of the biologists were converted to quantitative decision criteria, for assigning cold and cool water samples to BCG levels.

Table 1. Taxa were assigned to one of the following attribute levels:

I.	Historically documented, sensitive, long-lived or regionally endemic taxa
II.	Highly sensitive taxa, often occur in low abundance
III.	Intermediate sensitive taxa
IV.	Taxa of intermediate tolerance
V.	Tolerant native taxa
VI.	Non-native salmonids VIa. Highly tolerant non-native taxa
X.	Catadromous fish, indicating ecosystem connectivity

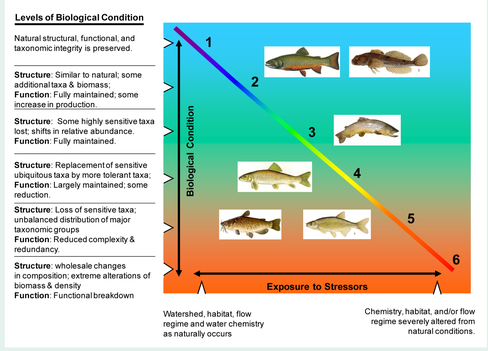


Figure 3. Conceptual model of the Biological Condition Gradient (BCG) (Davies and Jackson 2006). The following fish are shown: wild brook trout and slimy sculpin (Attribute 2), naturalized brown trout (Attribute 3), white sucker (Attribute 4), golden shiner and brown bullhead (Attribute 5).

How does the BCG model work? *Like a cascade…*

Example: coldwater sample

Does the sample meet ALL BCG Level 1 criteria?
- # Total taxa ≤ 6
- % Wild brook trout individuals > 60%
- % Attribute I + II + III individuals > 70%
- Non-native (VI + VIa) taxa - absent

YES → **Assigned to BCG LEVEL 1**

NO ↓

Does the sample meet ALL BCG Level 2 criteria?
- # Total taxa ≤ 6 if watershed size is < 10 m^2, otherwise > 2
- % Wild brook trout individuals > 10%
- % Tolerant (V + VIa) individuals < 5%
- % Non-native (VI + VIa) individuals < 12%
- % Attribute I + II + III individuals > 30%

YES → **Assigned to BCG LEVEL 2**

NO ↓

Does the sample meet ALL BCG Level 3 criteria?
- # Total taxa ≤ 6 if watershed size is < 10 m^2, otherwise > 2
- % Attribute I + II taxa > 5%
- % Attribute I + II + III taxa > 15%
- % Attribute I + II + III individuals > 5%
- % Most Dominant Attribute 4, 5, or 6 individuals < 50%
- % Non-native (VI + VIa) individuals < 20%

YES → **Assigned to BCG LEVEL 3**

NO ↓

And so on…

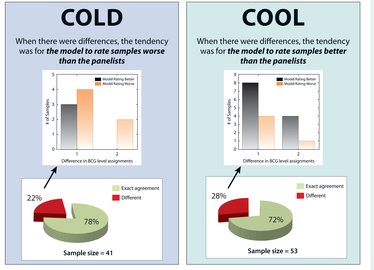
* In some situations, alternate rules had to be developed. For example, more taxa naturally occur in large vs. small streams, so total taxa richness rules were adjusted for watershed size.

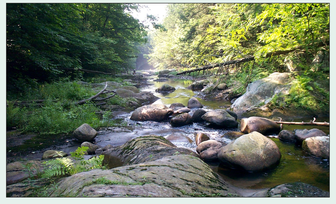
Results

Regional biologists made BCG level assignments on 41 coldwater samples and 53 cool samples. Results were used to develop quantitative decision criteria rules for cold and transitional cool stream habitats. When model performance was evaluated, the coldwater fish model matched exactly with the regional biologists' BCG level assignments on 78% of the coldwater samples and the cool model matched exactly on 72% of the samples.

Although we were able to make progress towards calibrating the BCG models in this phase of work, results indicate that more work needs to be done, particularly on the cool model. Next steps will be to refine and then validate the models. Size and temperature subclasses should also be revisited. Once the models are finalized, they could be used as a starting point for development of regional models for New England.

Results are available upon request (Mike.Beauchene@ct.gov).





Do BCG level 1 samples exist in the Northeast?

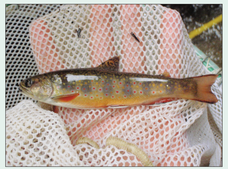
YES! – The participating fish biologists felt that BCG level 1 was attainable for small cold streams (n=4). As the definition of BCG "1" is natural condition and CT has a very limited set of native fish species, it is very apparent that cold water habitat in streams with small catchments could have fish communities similar to those found pre-human disturbance.

NO! – Unlike the fish community, macroinvertebrate communities have hundreds of species to choose from. Therefore macroinvertebrate biologists struggle with this question because many feel there is not enough information to know what the historical undisturbed assemblage in this region looked like.

The bottom line – is that it is difficult to distinguish between BCG Level 1 & 2 for small streams using either assemblage, and not any one assemblage is expected to be able to discriminate all 6 BCG levels. So let the debate continue.

Were non-native salmonids viewed as a positive or a negative?

It was difficult for the regional biologists to reach a consensus on how to rate samples with non-native trout. Non-native trout are regarded as indicators of good water quality and coldwater habitat, but they also represent an altered fish assemblage. The general consensus was that BCG level 1 required absence of non-native trout. The definition of BCG Level 1 does not explicitly state that non-natives cannot be present; however it does state that native structure must be preserved, so if non-natives are present, they cannot be displacing natives.



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- U.S. EPA Region 1: Hilary Snook
- Midwest Biodiversity Institute (MBI): Chris Yoder

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