Scientific basis for biointegrity goals: Reference concepts and the Biological Condition Gradient

Presentation to Science Advisory Panel
Dec 12, 2018
What is a “biointegrity goal”?

• A “goal” is an ecological state of a stream that corresponds to an intended management outcome. Examples:
  • Largely natural
  • Similar to reference
  • No more than a minor loss of diversity

• We can derive numbers and thresholds for biointegrity indices that correspond to these goals

• Depending on needs and context, managers can set different goals for different streams
Principles and assumptions

• Bioassessment indices are a direct way to measure support for aquatic life
• Multiple measures provide more comprehensive evidence of AL support
• CSCI and ASCIs are a standard way to measure biointegrity in most California wadeable streams
  • Additional and alternative measures (e.g., fish) may be appropriate in certain circumstances
Goals for biointegrity policy... and beyond

• Biointegrity goals are used for biological objectives, assessing management effectiveness, and other activities

• But also needed as an assessment endpoint for biostimulatory stress response models!
  • E.g., what maximum level of stress still has a high likelihood of achieving goals?
Two approaches to setting goals for biointegrity

1. Reference variability (percentile of reference)

2. Expert opinion (Biological Condition Gradient, BCG)
Reference approach

Mean: 1.0

10th percentile: 0.79
1st percentile: 0.63
30th percentile: 0.92

Likely intact
Likely altered
Poss. altered
Like altered
Very likely altered

Scores at reference sites
BCG approach

Standard narratives of condition-classes, adapted to California by panel of experts

Still reference based, but relies on expert opinion rather than statistical calculation of deviation from reference
BCG approach

Standard narratives of condition-classes, adapted to California by panel of experts

<table>
<thead>
<tr>
<th>Bin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Natural or native condition</td>
</tr>
<tr>
<td>2</td>
<td>Minimal alteration in structure or function</td>
</tr>
<tr>
<td>3</td>
<td>Evident changes in structure, minimal loss of function</td>
</tr>
<tr>
<td>4</td>
<td>Moderate changes in structure, minor loss of function</td>
</tr>
<tr>
<td>5</td>
<td>Moderate changes in structure and function</td>
</tr>
<tr>
<td>6</td>
<td>Severe changes in structure and major loss of function</td>
</tr>
</tbody>
</table>

Still reference based, but relies on expert opinion rather than statistical calculation of deviation from reference
Process for developing a BCG model

• Assemble panels of expert ecologists (2 panels for bugs, algae)
• Ask panels to adapt national definitions to California
  • Describe biological characteristics of each “bin”
  • Ascribe tolerance values to taxa
• Create a dataset of 250 sites across the state, representing different ecoregions and exposures to stress
• Panels assign sites to bins
• Crosswalk bins to observed index scores (probability-odds models)
• Identify scores associated with high likelihood of bin membership
## Who were the experts?

### Benthic Invertebrates
- Larry Brown
- James Carter
- David Herbst
- Jeanette Howard
- Bill Isham
- Jason May
- Patina Mendez
- John Olson
- Alison O’Dowd
- Andy Rehn

### Algae
- Don Charles
- Rex Lowe
- Yangdong Pan
- Robert Sheath
- Sarah Spaulding
- Rosalina Stancheva
Large statewide development data set

Panels reviewed mostly the same sites (80%)
BCG: Models crosswalk to ranges of index scores

Reference scores:
- Reference 1.2
- Reference 1.0
- Reference 0.8
- Reference 0.6
- Reference 0.4

Possible outcomes based on BCG scores:
- BCG3: Likely intact
- BCG4: Possibly altered
- BCG5: Likely altered
- BCG6: Very likely altered

CSCI scores:
- CSCI 1.03
- CSCI 0.92
- CSCI 0.79
- CSCI 0.63

Possible outcomes based on CSCI scores:
- 2. Minimally altered structure and function
- 3. Evident changes to structure and function
- 4. Moderate changes to structure
- 5. Moderate loss of function
- 6. Severe loss of function
1. Likely intact

2. Minimally altered structure and function

3. Evident changes to structure and function

4. Moderate loss of function

5. Severe loss of function

6. Very likely altered

Likely intact

Possibly altered

Likely altered

Very likely altered

Possible altered

Likely altered

Very likely altered

ASCI_H

Reference BCG

CSCI

Reference BCG
Size of data sets to determine numeric values of BI goals

<table>
<thead>
<tr>
<th>Index</th>
<th>Reference calibration sites</th>
<th>BCG calibration sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI</td>
<td>473</td>
<td>250</td>
</tr>
<tr>
<td>ASCII-D</td>
<td>369</td>
<td>250</td>
</tr>
<tr>
<td>ASCII-S</td>
<td>414</td>
<td>250</td>
</tr>
<tr>
<td>ASCII-H</td>
<td>418</td>
<td>250</td>
</tr>
</tbody>
</table>
Both approaches have been used (or evaluated) for bio/nutrient criteria in other states

- Ref proposed for San Diego Regional Board’s bio-objectives, statewide Category 1 listings

- MN, FL use BCG3 or 4 for most streams, BCG4 or BCG5 for modified uses.
Current status

• Manuscript ready for submission to journal, pending Science Panel and advisory group feedback

• Water Board staff is considering options, pending same feedback technical products
Water Board Charge Questions

• Comment on the adequacy of the data set and the analytical approaches to evaluate the range of natural variability. Comment on the adequacy of data set, the analytical approaches and findings of the development of a BCG model.

• Are there technical ways to address stakeholder concerns?
Questions?
Probability-odds model

CSCI

Hybrid ASCI
Scores associated with goals

<table>
<thead>
<tr>
<th>Goal</th>
<th>CSCI</th>
<th>ASCI-D</th>
<th>ASCI-S</th>
<th>ASCI-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref-30</td>
<td>0.92</td>
<td>0.92</td>
<td>0.93</td>
<td>0.93</td>
</tr>
<tr>
<td>Ref-10</td>
<td>0.79</td>
<td>0.80</td>
<td>0.82</td>
<td>0.83</td>
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<tr>
<td>Ref-01</td>
<td>0.63</td>
<td>0.63</td>
<td>0.68</td>
<td>0.70</td>
</tr>
<tr>
<td>BCG2</td>
<td>1.025</td>
<td>1.310</td>
<td>1.360</td>
<td>1.230</td>
</tr>
<tr>
<td>BCG3</td>
<td>0.825</td>
<td>0.950</td>
<td>0.860</td>
<td>0.970</td>
</tr>
<tr>
<td>BCG4</td>
<td>0.625</td>
<td>0.540</td>
<td>0.360</td>
<td>0.670</td>
</tr>
<tr>
<td>BCG5</td>
<td>0.325</td>
<td>NA</td>
<td>NA</td>
<td>0.300</td>
</tr>
</tbody>
</table>

BCG2: Numbers are *really high*
BCG5: Couldn’t model scores for ASCI-D, ASCI-S
BCG3 to BCG4: A very wide interval ASCI-D, ASCI-S (~0.4 to 0.5 points) vs. others (0.3 points)
2. Minimally altered structure and function

3. Evident changes to structure and function

4. Moderate changes to structure

5. Moderate loss of function

6. Severe loss of function
Comparison of means (ANOVA) and variances (Levene’s test) of Ref-Cal sites across 5 PSA regions

<table>
<thead>
<tr>
<th>Index</th>
<th>Means</th>
<th>Variances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>CSCI</td>
<td>1.36</td>
<td>0.245</td>
</tr>
<tr>
<td>ASCI-D</td>
<td>3.39</td>
<td>0.010</td>
</tr>
<tr>
<td>ASCI-S</td>
<td>1.35</td>
<td>0.252</td>
</tr>
<tr>
<td>ASCI-H</td>
<td>2.33</td>
<td>0.055</td>
</tr>
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</table>