Effective Biological Indicators for River Health Report Cards

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The science of indicators... and the art of river health report cards

• Report cards communicate complex information to the community and stakeholders

• Condense multimetric information from many indicators, reflecting the cumulative effects of a range of pressures

• Range of indicators selected to provide a holistic overview of river condition

• Indicators need to accurately reflect environmental condition, but should also be relevant to the community

• Biological and ecological indicators provide information on long term, cumulative and synergistic effects
Biological indicators

- **Biological indicator:** directly measure a component of the biology of the environment (species or group of species)
- **Ecological indicator:** ecological processes, human-environmental systems
- **Environmental indicator:** measure pressures on the environment, environmental conditions, societal responses

**Images:**
- *Pseudomugil signifer* (Townsville) – photo© Günther Schmida
- *Rheodytes leukops* (Fitzroy Basin) – photo Fitzroy Basin Association
- Mayfly larva (Gippsland, Vic) – photo© Museums Victoria
- *Lates calcarifer* (Queensland) – photo Queensland Government
- *Scylla serrata* (NT) – photo Northern Territory Government
- *Rheodytes iculops* (Fitzroy Basin) – photo Fitzroy Basin Association
Challenges with biological indicators

• Several of Queensland’s report cards have indicated they would like to include more biological indicators than at present.

• Lack of existing monitoring data is the most common reason for not including biological indicators in report cards.

• Long term monitoring programs in some areas have previously been focused on water quality.

• Biological indicators are often not directly transferable from one area to another.

• Established biological indicators are not always directly transferable from one area to another.

• Need to develop rapid and cost-effective biological assessments that can be linked with existing water quality monitoring.

• Two examples of the development of rapid biological assessments for Queensland report cards:
  • Example 1: Regionally relevant freshwater fish indicators for the Fitzroy Basin Report Card.
  • Example 2: A mud crab indicator for the Gladstone Harbour Report Card.
Why freshwater fish?

• Identified by Fitzroy Partnership for River Health’s Science Panel for inclusion in Report Card
• Important and relevant to rural and regional communities
• Commercial, recreational and Indigenous values

Effective biomonitors:

• Most species are easy to identify
• Abundant and relatively easy to sample
• Dominant organisms – biomass, feeding ecology
• Relatively long-lived
• Constantly exposed to waterborne contaminants
• Some are large enough for tissue sampling

Aim:

• Develop practical fish indicators applicable to coal mining regions of the Fitzroy Basin
Example 1: Regionally relevant freshwater fish indicators for the Fitzroy Basin Report Card  Evan Chua, Nicole Flint, Scott Wilson, Sue Vink

Methods:

• Tested 37 possible fish indicators against environmental variables
• Comprehensive surveys at 12 test sites
  • fish assemblage and individual condition
  • riparian and stream habitat
  • water quality (physchem, toxicants, nutrients)
  • sediment quality
  ✓ April 2015
  ✓ October 2015
  ✓ April 2016
  ✓ October 2016
• Surveys at 20 sites across the Fitzroy Basin
  ✓ September to December 2016
• Post-flood surveys, 9 sites, after TC Debbie
  ✓ May 2017
Example 1: Regionally relevant freshwater fish indicators for the Fitzroy Basin Report Card  Evan Chua, Nicole Flint, Scott Wilson, Sue Vink

General results

• No strong influence of sampling season

• No strong influence of upstream/downstream from coal mines

• Influenced by creek/river habitat type

• Influenced by water quality, sediment and condition of the riparian habitat (and presence of cattle grazing)

• % native species and % alien species indicators (used in other report cards) didn’t correlate well with environmental covariates

Proposed Indicators

Taxa-based indicators

• Percentage of Atheriniformes

• Number of Atheriniformes species recorded

• Percentage of Clupeiformes and Hypseleotrids

Community diversity

• Shannon Diversity

• Chao 1 Estimator

• Presence of Introduced Species*

Trophic composition

• Percentage of omnivores

Fish condition

• Fulton’s Condition Factor of *M. splendida splendida*

• Presence of individuals with abnormalities*

Developed scoring system for indicators but haven’t yet incorporated into a grading system for the Fitzroy Basin Report Card (2019 consideration)
### Example 1: Regionally relevant freshwater fish indicators for the Fitzroy Basin Report Card

Evan Chua, Nicole Flint, Scott Wilson, Sue Vink

<table>
<thead>
<tr>
<th>Site</th>
<th>% Atherinids</th>
<th>% Clupeids and Hypseleotrids</th>
<th>Number of Atherinid species</th>
<th>Shannon Diversity</th>
<th>Chao 1 Estimator</th>
<th>Introduced species</th>
<th>% Omnivores</th>
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**Fitzroy Basin Average ± standard error**

61.5 ± 2.04
Example 2: A mud crab indicator for the Gladstone Harbour Report Card
Nicole Flint, Emma Jackson, Amie Anastasi, Evan Chua, Jeremy De Valck

Why mud crabs?
• Identified in community consultation by Gladstone Healthy Harbour Partnership
• Iconic species – important to Gladstone community
• Commercial, recreational and Indigenous values

Effective biomonitors:
• Biology and ecology well understood
• Easy to identify
• Abundant and easy to sample
• Relatively long-lived
• Large enough for tissue sampling
• Resistant to handling stress

Aims:
• Develop multimetric mud crab (Scylla serrata) indicator, baselines and a scoring system suitable for the Gladstone Harbour Report Card
• Provide pilot report card grades and scores for the 2017 Gladstone Harbour Report Card

Methods:
• Identified 9 potential indicators
• Selected four as possible measures to incorporate into a multi-metric indicator
• Set baited crab pots using a standardised methodology across possible long term monitoring sites
  • Total catch, sex, carapace width, weight, abnormalities
Example 2: A mud crab indicator for the Gladstone Harbour Report Card

**Abundance** (CPUE) in each zone

\[ \text{Abundance} = \frac{\text{total number of mud crabs}}{\text{number of pots set}} \]

**Prevalence of rust lesions** in each zone

\[ \text{Prevalence} = \frac{\text{number of crabs with lesions}}{\text{total number of crabs}} \]

**Sex ratio** of oversize mud crabs, for each zone

\[ \text{Sex ratio} = \frac{\text{male mud crabs} > 150 \text{ mm}}{\text{female mud crabs} > 150 \text{ mm}} \]

**Biomass** (individual size to weight ratio, for each of male and female crabs) – *in development*
Example 2: A mud crab indicator for the Gladstone Harbour Report Card

Score = 1 - \((B-x)/(B-WCS)\)

- Abundance: \(B = \) moving average of 75\(^{th}\) %ile of abundance (3.5 in 2017) and \(WCS = 0.25\) (social baseline)

- Prevalence of rust lesions: \(B = 0.35\) (37\% highest recorded prevalence) and \(WCS = 0.05\) (baseline prevalence)

- Sex ratio (M:F): \(B = 3\) (unfished) and \(WCS = 0.25\) (25\(^{th}\) %ile and mean of historical research data)

Scores graded against Gladstone Harbour Report Card scale

<table>
<thead>
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<th>Score</th>
<th>Grade</th>
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<td>&gt;=0.85</td>
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<tr>
<td>&gt;=0.65, &lt;0.85</td>
<td>B</td>
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<tr>
<td>&gt;=0.5, &lt;0.65</td>
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<td>&gt;=0.25, &lt;0.5</td>
<td>D</td>
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<tr>
<td>0, &lt;0.25</td>
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</table>
Example 2: A mud crab indicator for the Gladstone Harbour Report Card

2017 Scores and Grades for the Mud Crab Indicator

<table>
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<tr>
<th>Zone</th>
<th>Abundance (CPUE)</th>
<th>Prevalence of rust lesions</th>
<th>Sex ratio*</th>
<th>Biomass</th>
<th>Zone 2017</th>
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- Circle = good habitat
- Yellow Circle = popular recreational crabbing
- Purple Circle = popular commercial crabbing
- Orange Circle = poor/urbanised/cleared habitat
Measurement and reporting of key ecosystem components for effective management

- Biological indicators are important for river and estuary report cards:
  - direct interpretation of environmental impacts, relatively easy to measure
  - provide longer term, cumulative, synergistic measure of environmental condition (cf. snapshot of water chemistry parameters)
  - more comprehensive assessment of river health than physchem indicators alone
  - can be clearly communicated

- Challenge of the current lack of biological monitoring, but:
  - cost-effective rapid assessments can be equally effective when they are regionally relevant
  - consider indicators that don’t require extensive lab analysis (high cost of water quality analysis)
  - can be monitored in conjunction with existing water quality monitoring, saving labour costs in rural/regional areas with long travel times
  - promise of technological advances (e.g. environmental DNA)

- Relevant and important to decision-makers and the community

- Increasing need to link state and impact monitoring with drivers and responses
Acknowledgements

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Research funding for mud crab indicator development: Gladstone Healthy Harbour Partnership (Flint)

Collaborators: Evan Chua, Scott Wilson, Sue Vink, Amie Anastasi, Emma Jackson, Jeremy De Valck