21st International RIVER SYMPOSIUM

fitzroy partnership for river health

CQUniversity AUSTRALIA

Effective Biological Indicators for River Health Report Cards

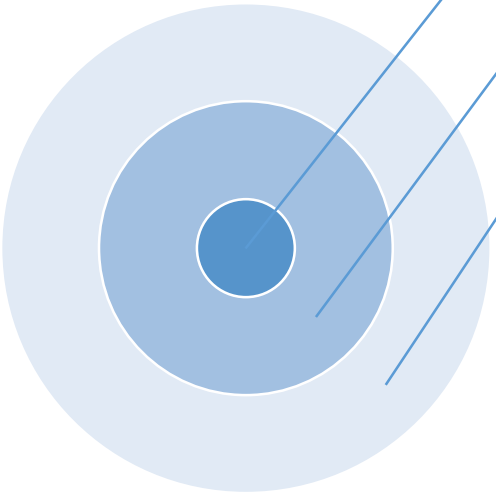
Dr Nicole Flint
Research Cluster Leader, Aquatic Ecology & Ecotoxicology, CQUniversity Australia
Science Leader, Fitzroy Partnership for River Health

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

NATIONAL REPORT CARD NETWORK

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

Mayfly larva (Gippsland, Vic) - photo© Museums Victoria

Pseudomugil signifer (Townsville) - photo© Günther Schmida

Lates calcarifer (Queensland) – photo Queensland Government

Scylla serrata (NT) – photo Northern Territory Government

Rheodytes leukops (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 monitorir indicators in report cards
- Long term monitoring pr uality
- Biological indicators are c ent areas
- Established biological ind other
- Need to develop rapid an existing water quality monitoring,
- Two examples of the dev t cards
  - Example 1: Regiona rd
  - Example 2: A mud crab indicator for the Gladstone Harbour Report Card

Example 1:

Example 2:

Example 1: Regionally relevant freshwater fish indicators for the Fitzroy Basin Report Card

Evan Chua, Nicole Flint, Scott Wilson, Sue Vink

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

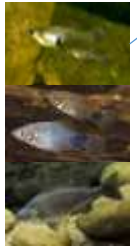
Image South Australian Government

Example 1: Regionally relevant freshwater fish indicators for the Fitzroy Basin Report Card

Evan Chua, Nicole Flint, Scott Wilson, Sue Vink

General results

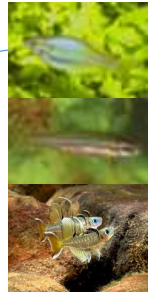
- No strong influence of sampling season
- No strong influence of upstream/downstream from coal mines
- Influenced by creek/river habitat type
- Influenced by water quality, sediment and condition of the riparian habitat (and presence of cattle grazing)
- % native species and % alien species indicators (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

	FHI Indicators										
	% Atherinids	% Clupeids and Hypseleo -trids	Number of Atherinid species	Shannon Diversity	Chao 1 Estimator	Introduced species	% Omnivores	FCF MSS	Abnormalities	Totals	FHI Score 0-100
Site:											
CAL1	5	5	3	3				3	1	31	**69**
CAL2	5	5	3	1				3	5	29	**64**
COM1	3	3	3	5				3	1	31	**69**
COM2	5	5	3	3				3	5	33	**73**
CON1	5	5	3	3				3	5	31	**69**
CON2	5	3	3	3				5	5	35	**78**
FIT1	3	3	3	1				1	5	25	**56**
FIT2	3	3	3	3				1	5	25	**56**
LDA1	3	3	3	1				1	1	21	**47**
LDA2	3	3	3	3	3	5	3	5	1	29	**64**
LIS1	3	3	3	3	5	5	3	5	5	35	**78**
MAC1	3	5	3	3				3	1	25	**56**
MAC2	3	3	3	5				1	1	29	**64**
NOG1	1	5	1	3				1	1	27	**60**
NOG2	1	3	1	3				1	1	21	**47**
THE1	1	3	3	3				3	1	25	**56**
UDA1	3	3	3	3				1	5	25	**56**
UDA2	3	3	3	3				1	5	27	**60**
UIS1	1	1	3	3				1	1	23	**51**
UIS2	1	3	3	3	1	5	3	1	5	25	**56**
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

$$= \frac{\text{(total number of mud crabs)}}{\text{(number of pots set)}}$$

Prevalence of rust lesions in each zone

$$= \frac{\text{(number of crabs with lesions)}}{\text{(total number of crabs)}}$$

Sex ratio of oversize mud crabs, for each zone

$$= \frac{\text{male mud crabs} > 150\text{ mm}}{\text{female mud crabs} > 150\text{ mm}}$$

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 75th %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 (25th %ile and mean of historical research data)

Scores graded against Gladstone Harbour Report Card scale

Score	Grade
>=0.85	A
>=0.65, <0.85	B
>=0.5, <0.65	C
>=0.25, <0.5	D
0, <0.25	E

Example 2: A mud crab indicator for the Gladstone Harbour Report Card

2017 Scores and Grades for the Mud Crab Indicator

Zone	Abundance (CPUE)	Prevalence of rust lesions	Sex ratio*	Biomass	Zone score 2017
1. The Narrows	1.00	1.00	0.00	NC	0.67
2. Graham Creek	0.52	0.95	0.36	NC	0.61
4. Boat Creek	1.00	1.00	0.11	NC	0.70
5. Inner Harbour	1.00	0.89	0.71	NC	0.87
6. Calliope Estuary	0.14	0.90	0.36	NC	0.47
7. Auckland Inlet	0.12	0.63	0.00	NC	0.25
13. Rodds Bay	0.03	0.67	0.39	NC	0.36
Harbour Average					0.56

= good habitat

= poor/urbanised/cleared habitat

= popular recreational crabbing

= popular commercial crabbing

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, <u>but</u>:
  - 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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- Collaborators: Evan Chua, Scott Wilson, Sue Vink, Amie Anastasi, Emma Jackson, Jeremy De Valck