Usefulness of Macroinvertebrates for *In Situ* Testing of Water Quality

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The thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy at the University of Canberra.

October 2008

"One thing to my mind was certain, that to make
any laboratory experiments that would compare in any
measure to what goes on in a river,
it was absolutely necessary that the water
experimented upon should be running,
and not merely exposed to light and air in a bottle."

Tidy (1880)

ABSTRACT

For various reasons, existing methods for the assessment of aquatic pollution do not always adequately address the way in which contaminants affect receiving environments and their component ecosystems. The main advantage of biological assessment over the measurements of physical and chemical aspects of water quality is that biota provide an integrated response to all prevailing influences in their environment. Biological assessment protocols have been developed for a range of test organisms, from bacteria to mammals using measurement from molecular biomarkers to indicators at the population or community level of organisation. Macroinvertebrates in particular have been popular for ecological assessment of habitat and water quality because they are small and straight forward to sample and identify using relatively simple and inexpensive equipment and readily available taxonomic keys.

However, various biological assessment techniques also have their limitations. Field-based assessment of biological communities does not provide direct evidence to determine underlying causal relationships, while laboratory or mesocosm toxicity tests are criticised for their limited ability to extrapolate to natural field conditions. To help bridge the gap, this thesis aims to investigate the efficacy of using caged macroinvertebrates *in situ* to assess the ecological condition of aquatic environments, and whether a causal relationship can be established when macroinvertebrates are deployed *in situ* at sites known to have impaired water quality. Endpoints employed in this thesis include survival, measurements of morphology (as a surrogate for growth) and condition and, for trials assessing sites that receive mine drainage, the tissue concentration of certain trace metals.

Development of an *in situ* approach to water quality monitoring and assessment will potentially provide methods for use by resource managers, community groups and aquatic researchers that are less expensive and faster to run than existing methods and will complement other approaches employed in the assessment of water quality.

In situ testing of water quality using macroinvertebrates requires the collection, handling, caging, deployment and retrieval of test organisms at sites of suspected pollutant impact. As such procedural factors may affect test organisms and potentially confound their responses, it is important to consider and understand as many of these factors as possible. Aquatic macroinvertebrates held in finer mesh cages had larger heads than in coarser mesh cages. This was likely due to increased substrate available for growth of epilithon and periphyton on

which the caged organisms could graze. Caging density had no effect on amphipod mortality over the trial period, however, individuals held at higher densities increased in size (as indicated by longer dorsal lengths) more than those held at lower or intermediate densities. Temporary storage of test organisms in laboratory aquaria may facilitate the collection of abundances required for *in situ* trials, however, tanked individuals were smaller and had lower biomasses than individuals collected and deployed immediately. While this is likely to result from differences in feeding during the storage period, it is also possible that tank storage and the "double handling" deleteriously affected them, or reduced their tolerance.

The effects of transplanting macroinvertebrates between sites varied considerably depending on the characteristics of "source" and "transplant" sites. Certain taxa suffered marked mortality within 24 hours even at their source site, indicating an adverse effect of the caging itself, or perhaps via the change in food, shelter or microclimate which could potentially render them unsuitable as test organisms in caging studies. Other taxa did not differ in survival or body size when relocated between sites, with some evidence of increased growth at sites dissimilar from their source site. In general, organisms relocated to sites that are "similar" to their source environment performed less well at the transplant site. However, organisms transplanted to "dissimilar" sites were found to be bigger than those caged and deployed back to the source site.

When employed to assess known pollution scenarios in and around Canberra, macroinvertebrate responses were, in some instances, able to be linked to specific environmental parameters or combinations thereof. In Case Study 1, findings varied in relation to the response endpoint being examined, and between test species, although concentrations of metals were significantly higher in tissue of macroinvertebrates deployed at the impact site downstream of the abandoned Captains Flat mine and increased with time exposed. In Case Study 2, freshwater shrimp suffered significant mortality within 24 hours of deployment at the impact sites, with larger individuals more susceptible at sites receiving urban stormwater runoff. While various biological effects were most closely correlated with ammonia concentrations at the site, different body size endpoints were affected in opposite ways. In Case Study 3, body size endpoints for one test organism varied consistently with respect to site and time factors, but none of the changes could be linked to any of the environmental data collected. Response variables for a different test species also indicated significant effects arising from both deployment site and time, however, each endpoint responded in a different way to the treatment factors, and aligned with different combinations of environmental data.

In general, linking of macroinvertebrate responses with environmental data was difficult because of the high variability in the environmental data. However, it was further complicated by the mismatch in the level of replication between the two datasets. As a consequence of this, the macroinvertebrate data had to be collapsed to a lower level for comparison with the environmental data, resulting in a loss of natural variability and analytical power. Since only the strongest treatment effects, which could be detected above the background "noise", were detected and modelled against the environmental data, it is possible that other "cause" and "effect" relationships may have been overlooked.

From these results, it is clear that many macroinvertebrate taxa are suitable for use as bioindicators in *in situ* trials, but that criteria used for selection of test species should definitely include more than just impact-sensitivity and abundance. However, there are several aspects associated with the experimental set up of field-based protocols involving caged macroinvertebrates that may limit their usefulness as a rapid and reliable bioassessment tool, and need to be considered when designing and undertaking these kinds of trials. It is also apparent that choice of endpoint can greatly influence conclusions, with detection of treatment effects reported in this thesis varying greatly depending on which morphological endpoint was examined.

This study clearly demonstrated that there may be significant difficulties in establishing causal relationships between environmental data and biotic responses of macroinvertebrates deployed under field conditions. However, it has also shown that deployment of caged macroinvertebrates *in situ* may assist in the determination of biological effects arising from impaired water quality, which can then serve as the basis for more focussed laboratory or mesocosm studies in which environmental conditions can be more readily controlled or monitored.

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ACKNOWLEDGEMENTS

Firstly I would like to challenge those that believe postgraduate research is a solo pursuit…that this document now appears in this form is a testament to "Team PhD" and all those that have participated along the way.

In particular I would like to thank the following:

- My supervisors Professor Richard Norris, Professor Bill Maher and Associate Professor Martin Thoms for their commitment to this project, me personally, and their contributions to the field of aquatic ecology. They have helped me broaden my strengths, but also acknowledge my limitations, and afforded me with much strength to overcome numerous hurdles. YMCA holds special memories for me !
- Land and Water Australia (formerly Land and Water Resources Research and Development Corporation) for research funding, and University of Canberra (UC) and the Cooperative Research Centre (CRC) for Freshwater Ecology who supported the research and my candidature in many ways. Special thanks to Divisional Higher Degree Committee members who have been particularly helpful.
- All those that braved Canberra's weather extremes, in particular Angie and Dan, and to Amina and Bron for endless hours spent capturing digital images of over 10,000 mostly uncooperative macroinvertebrates. Thanks also to technical staff from the UC and the CRC for Freshwater Ecology, in particular the analysts associated with the Ecochemistry laboratory.
- Ross Cunningham from Centre for Resource and Environmental Studies, Australian National University (ANU), and Christine Donnelly at the ANU's Statistical Consulting Unit for assistance with statistical analyses.
- Paul Sheahan for arranging access to the ever-elusive hydrological records and Jim Longworth for assistance with GIS interfaces.
- Australian Government Natural Resource Management Team for their investment in me while completing this thesis, in particular the Monitoring and Evaluation section.

There are also numerous people "behind the scenes" who have expended considerable energy coaxing me through the most difficult times, and whose efforts have greatly lightened the load.

I would particularly like to mention:

- Carol and Danielle with whom I share the most incredible camaraderie. I miss you both and look forward to sharing way too many beverages after we all make it up "the hill".
- My family for their dent-less enthusiasm, encouragement and the occasional "home truth" especially in the final throes.
- The amazing Pam who helped me work my way through my mysterious inner workings and just let me vent irrationally on occasion !
- Linda, David and Mike for your attempts at being interested in bugs, and for not pushing your views on me too hard !
- Those friends who have politely avoided asking the "death question", and also those rude blighters who made it their personal mission to badger me constantly !
- Rupert and Abigail for light relief, and for companionship when the rest of the world was asleep.
- Peter for his generosity and endless enthusiasm, and for not questioning my irrational mood swings and idiosyncrasies at critical times during my candidature.

"I've finished now …… do you want to use your computer ?"

Addendum

And now that, despite some significant hurdles, the thesis revisions are finally complete, I would like to extend my acknowledgements to the following:

- Two anonymous examiners whose comments and suggestions greatly improved this thesis.
- My treatment team whose expertise has helped me on the road to recovery over the last 18 months, especially Debbie Douglas, Anne Davies and Tom Sutton.
- My partner Peter for his endurance, and darling baby girl Charlotte Jane for arriving at exactly the right time ! Thankyou for reminding me of the things that matter most !

TABLE OF CONTENTS

List of Tables

LIST OF FIGURES