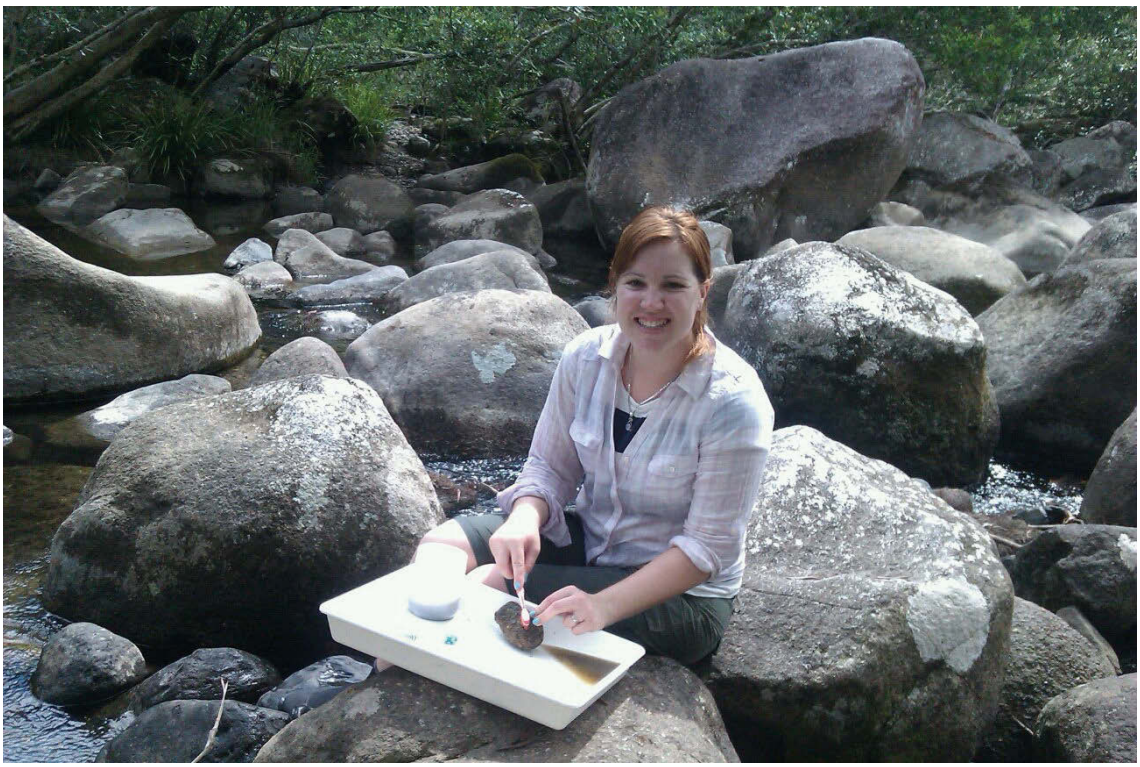
Benthic diatoms as indicators of herbicide toxicity in rivers



The author scrubbing rocks

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A thesis in fulfilment of the requirements for the degree of Doctor of Philosophy

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Ecosystem Security Team

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Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text. This research is supported by an Australian Government Research Training Program Scholarship.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Date:

23/07/17

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Preface

This thesis consists of seven chapters. Chapters 2 to 5 are written as peer reviewed journal articles and have been published in scientific journals. Chapter 6 will be submitted to a journal for peer review. They are included in this this thesis as they were when accepted by the relevant journal and therefore some minor differences may occur from the final published manuscripts. Publication details and contributions of co-authors are detailed below.

Chapter 2: Wood, R.J., Mitrovic, S.M., Kefford, B.J., 2014. Determining the relative sensitivity of benthic diatoms to atrazine using rapid toxicity testing: A novel method. *Science of The Total Environment* 485–486, 421-427.

Author contributions: Study design: R.J.W. and B.J.K., collection of data: R.J.W. and S.M.M., data analysis: R.J.W., discussion and interpretation of results: all,

drafting of manuscript: R.J.W., revising manuscript: all.

Chapter 3: Wood, R.J., Mitrovic, S.M., Lim, R.P., Kefford, B.J., 2016. How benthic diatoms within natural communities respond to eight common herbicides with different modes of action. *Science of The Total Environment* 557–558, 636-643.

Author contributions: Study design: R.J.W. and B.J.K., collection of data: R.J.W. and S.M.M., data analysis: R.J.W., discussion and interpretation of results: all,

drafting of manuscript: R.J.W., revising manuscript: all.

Chapter 4: Wood, R.J., Mitrovic, S.M., Lim, R.P., Kefford, B.J., 2016. The influence of reduced light intensity on the response of benthic diatoms to herbicide exposure. *Environmental Toxicology and Chemistry* 35, 2252–2260.

Author contributions: Study design: R.J.W. and B.J.K., collection of data: R.J.W. and S.M.M., data analysis: R.J.W., discussion and interpretation of results: all,

drafting of manuscript: R.J.W., revising manuscript: all.

Chapter 5: Wood, R.J., Mitrovic, S.M., Lim, R.P., Kefford, B.J., 2017. Chronic effects of atrazine exposure and recovery in freshwater benthic diatoms from two communities with different pollution histories. *Aquatic Toxicology* 109, 200-208.

Author contributions: Study design: R.J.W. and B.J.K., collection of data: R.J.W. and S.M.M., data analysis: R.J.W. and S.M.M., discussion and interpretation of results: all, drafting of manuscript: R.J.W., revising manuscript: all.

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DO	dissolved oxygen
EC	electrical conductivity
FRP	filterable reactive phosphorus
GBR	Great Barrier Reef
GLM	generalized linear model
NOx	oxidised nitrogen
PICT	pollution induced community tolerance
PSII	photosystem 2 inhibiting
SPEAR	SPEcies At Risk
SSD	species sensitivity distribution
TEF	toxic equivalency factor
TEQ	toxic equivalency quotient
TIS	toxicant induced succession
TSS	total suspended solids

Abstract

Agricultural herbicides are common pollutants of freshwater environments and pose a potential threat to aquatic biota. Assessing the impacts of herbicide pollution on primary producers such as benthic diatoms is essential in protecting freshwater ecosystems from degradation. Benthic diatoms are highly responsive to changes in environmental conditions and changes in community composition can be used to assess the ecological health of rivers. This thesis aims to investigate the impact of herbicide toxicity on benthic diatoms and to determine whether benthic diatoms are suitable indicators of herbicide toxicity in rivers that flow into the Great Barrier Reef (GBR). This was achieved through a series of scientific studies, each addressing key questions regarding the effects of herbicides on benthic diatoms.

Benthic diatoms exposed to herbicides in rapid toxicity tests showed varying sensitivity to herbicides, some taxa being highly sensitive whilst others were unaffected by herbicide exposure. The relative sensitivity of the diatom taxa was consistent between herbicides with differing modes of action and was not altered under reduced light intensities. Prior pollution of the collection site was influential in determining response of diatom communities to herbicide exposure; the diatom community from a highly polluted agricultural stream was less affected than the community collected from a reference site with no history of prior exposure. My thesis identifies individual diatom taxa that are most at risk of herbicide toxicity and also taxa that are tolerant and able to thrive under high herbicide concentrations. This study found that benthic diatom communities within the GBR catchment were affected by herbicide toxicity, showing a decline in sensitive taxa with increasing contamination of the site, after the wet season. Diatom communities were also influenced by other environmental variables such as nutrients and salinity and separating the individual effects of herbicides will require further research.

My thesis demonstrates the effects of herbicide toxicity on benthic diatoms at both the species and community levels. Each study in this thesis provides new insights into the effects of herbicide exposure on natural benthic diatom communities and contributes to the field of aquatic ecotoxicology. As a whole, my thesis illustrates the great potential that benthic diatoms have to assess agricultural impacts, including herbicides in rivers of the GBR catchment area.