Microbial Hazards in Changing Coastal Environments

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BSc Hons

Thesis submitted for the degree of Doctor of Philosophy

27th October 2022

Ocean Microbiology Group & Climate Change Cluster

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I, Nathan Lloyd Robert WILLIAMS declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Science at the University of Technology Sydney.

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Final word count: 63,552 (References not included)

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Acknowledgments

First, I wish to acknowledge the Gadigal people of the Eora Nation upon whose ancestral lands the University of Technology is built. I would also like to pay respect to the Elders both past and present, acknowledging them as the traditional custodians of knowledge for these lands.

I wish to express my deepest thanks to my principal supervisor, Professor Justin Seymour. It has been an absolute privilege to learn from Justin, and I thank him for shaping me into the scientist that I am today. His input and expertise on project design, academic writing, and creative ideas has been invaluable. I look up to Justin as both a mentor and as a researcher. I will be forever grateful to have had him as my supervisor.

To my co-supervisor Dr. Nachshon Siboni, I express my sincere gratitude for your guidance, and all of your technical help and advice. Nachshon, your help has been invaluable, and I would not have survived in the field or have my current knowledge on qPCR and sequencing data analysis without your help and guidance. Thank you for always providing a good laugh.

A huge thank you to Dr. Anna Bramucci, and Dr. Martin Ostrowski for teaching me to code. You have both helped me so much and increased my knowledge beyond what I thought I'd ever have in this area and sparked a new interest in which I wish to pursue in science career.

To Dr. Peter Scanes, Dr. Jaimie Potts, and Dr. Colin Johnson from DPE, thank you all for your help sampling and in the field. In particular, thank you Jaimie for offering up your house on the Central Coast as a sampling base, and thank you to your mother for allowing us to process sample in her back yard, and for the many sandwiches and cuppas on hard days of fieldwork. Thank you, Jaimie, for always being available for a chat regarding data, and for all of your hard work setting up sampling in both Rose Bay and Terrigal. I also thank Dr. Meredith Campey for all of your hard work in planning the sampling at Rose Bay.

I would also like to thank everyone from the OMG lab group of whom I have not yet mentioned, including Nine Le Ruen, James O'brien, Abeeha Kahlil, and Oscar Creasy for your support and friendship. I would also like to thank Dr. JB Raina for his critical feedback on all of my talks, pushing them to the next level, and for being an inspiring scientist that I have looked up to throughout my PhD.

I would also like to thank my desk quad, Kieran Young, Amanda Grima, and Dr. Kirsty Milner for all of your moral support as I have been writing my thesis. In particular, thank you Kieran for the many walks to get treats, the parties, and for being a good friend throughout my PhD.

Thank you, Dr. William King, for all of your support throughout my career as a scientist. You were my first inspiration to do research, and I appreciate the long talks on the phone and via zoom. Even though for most of my PhD you were halfway around the world, you are still a dear friend and a great mentor.

I would like to thank my friends and family for all their help throughout my PhD. Thank you to my mum and dad, Lloyd, and Yvonne, and to my sisters, Monique and Madalyne, for supporting my decision to become a scientist, and always taking an interest in what I do in my research. You have supported me immensely throughout my degrees and put up with my many university related mood swings. Thank you, Michelle, and Graeme Stainlay, for your support, particularly during my final thesis writing days. Thank you to my good friends Lachlan Draper and Thomas O'Sullivan for good times at the pub which have kept me sane through the hard days, and to Brandon McNally and Troy Fenton, and the Cronulla crew, for the morning ritual surfs, which kept me grounded for four years. Finally, thank you Hannah Stainlay for all of your love and support throughout my PhD. I would not have been able to get through it without you.

Statement indicating the format of thesis

This thesis is being submitted in the format of *Thesis by compilation*.

List of Publications

Williams, N. L. R., Siboni, N., King, W. L., Balaraju, V., Bramucci, A., & Seymour, J. R. (2022). Latitudinal Dynamics of Vibrio along the Eastern Coastline of Australia. Water.

Williams, N.L.R., Siboni, N., Potts, J., Campey, M., Johnson, C., Rao, S., Bramucci, A., Scanes, P., Seymour, J.R. (2022). Molecular microbiological approaches reduce ambiguity about the sources of faecal pollution and identify microbial hazards within an urbanised coastal environment. Water Research.

Williams, N.L.R., Siboni, N., McLellan, S., Potts, J., Scanes, P., Johnson, C., James, M., McCann, V., Seymour, J.R. (2022) Rainfall leads to elevated levels of antibiotic resistance genes within seawater at an Australian beach, Environmental Pollution.

Williams, N.L.R., Siboni, N., Potts, J., Scanes, P., Johnson, C., James, M., McCann, Le Reun, N., King, W.L., V., Seymour, J.R., Defining the importance of natural environmental variability and anthropogenic impacts on bacterial assemblages within intermittently opened and closed lagoons. Water Research. (submitted).

Statement of contribution of authors

Research fundings:

Chapter 2 was supported by an Australian Research Council grant (DP210101610) to JRS.

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Chapter 1:

NLR. Williams wrote the chapter and JR. Seymour and N. Siboni edited it.

Chapter 2:

JR. Seymour, N. Siboni. and V. Balaraju designed the study. NLR. Williams and V. Balaraju took all samples. qPCR was performed by NLR. Williams. ddPCR and *hsp60* PCR were performed by NLR. Williams. and N. Siboni A. Bramucci and NLR. Williams performed the 16S rRNA gene sequencing analysis. N.L.R.W. and WL. King performed the *hsp60* gene sequencing analysis. NLR. Williams. and JR. Seymour prepared and wrote the manuscript. All authors read and agreed to the published version of the manuscript.

Chapter 3:

NLR. Williams, N Siboni, M Campey, C Johnson, J Potts, P Scanes, JR. Seymour contributed to experimental design, NLR. Williams, N Siboni and C Johnson were responsible for sampling. NLR. Williams and N Siboni were responsible for sample processing and qPCR analysis, while NLR. Williams, N Siboni and A Bramucci, were responsible for 16S analysis. NLR. Williams, N Siboni and JR. Seymour contributed to writing the manuscript.

Chapter 4:

NLR. Williams, N. Siboni, S. McLellan, J. Potts, P. Scanes, C. Johnson, M. James, and JR. Seymour planned sampling locations and designed experiments. NLR. Williams, N. Siboni, and C. Johnson collected and processed samples. NLR. Williams performed qPCR, 16S analysis, MIC tools analysis and designed all figures. NLR. Williams analysed data and wrote the manuscript, and all authors contributed to editing it.

Chapter 5:

NLR. Williams, N. Siboni, S. McLellan, J. Potts, P. Scanes, C. Johnson, M. James, and JR. Seymour planned sampling locations and designed experiments. NLR. Williams, N. Siboni, W. King, N. Le Reun, and C. Johnson took and processed samples. NLR. Williams performed qPCR, 16S analysis, MIC tools analysis and designed all figures. NLR. Williams analysed data and wrote the manuscript, and all authors contributed to editing it.

Chapter 6:

NLR. Williams wrote the chapter and JR. Seymour and N. Siboni edited it.

Table of Contents

List of Tables and Figures

Appendix 1 - Latitudinal dynamics of Vibrio spp. along the Australian East Coast

Appendix 2 - Molecular microbiological approaches reduce ambiguity about the sources of faecal pollution and identify microbial hazards within an urbanised coastal environment

Appendix 3 – Rainfall leads to elevated levels of Antibiotic Resistance Genes within seawater at an Australian beach

Appendix 4 – Defining the importance of natural environmental variability and anthropogenic impacts on bacterial assemblages within intermittently opened and closed lagoons

Table 1. Site latitude and longitude.

Table 2. Primers used in study.

Figure 1. Alpha and Beta diversity of bacterial communities within each ICOLL.

Figure 2. Stacked bar graph of the relative abundance of the top 20 indicator taxa at the family level.

Figure 3. Heatmaps showing the levels of the antibiotic resistance genes.

Thesis Abstract

Coastal environments deliver many crucial ecosystem services, such as maintenance of biodiversity, and are used widely for recreation by human populations. While microbial communities within these environments underpin ecosystem services, they often incorporate pathogenic microbes (e.g., *Vibrio* species) that can proliferate under beneficial environmental conditions. Furthermore, pathogens and antimicrobial resistant bacteria (ARB), enter coastal environments via sewage contamination or animal faeces. Many processes which underpin the dynamics of endemic microbial hazards and anthropogenically introduced microbial hazards are not well defined, which hinders remediation efforts. Therefore, I aimed to increase our understanding of these processes. In Chapter 1, I introduce coastal environments, their microbial ecology, and their associated microbial hazards. In Chapter 2, I analysed the latitudinal dynamics of *Vibrio* along the eastern coast of Australia, where I defined their patterns in the abundance and diversity to reveal new insights into the distribution of potential human pathogens within a region experiencing significant ecological shifts due to climate change, along a latitudinal gradient which, in many locations have had no assessment of *Vibrio* ecology. In Chapter 3, I used Microbial Source Tracking (MST) to specify sources of faecal pollution and their impact on an urban beach, which helped to identify remediation targets. In this chapter, I applied the Bayesian statistical package *Source Tracker* to both track the spatiotemporal dynamics of specific bacterial signatures for individual stormwater drains and to quantify the relative strength of the microbial signature from different stormwater drains. To the best of my knowledge, this is the first time *Source Tracker* has been applied in this way. In Chapter 4, I investigated how rainfall leads to elevated levels of AmR bacteria at a recreationally used coastal beach. To do this, I applied the *indicspecies* statistical R package to 16S amplicon data and ran a correlation analysis between the bacteria which were indicators of sewage, with both faecal markers, and ARB. This is the first time this type of analysis has been applied in this context and it revealed strong positive correlations between faecal contamination, bacteria from storm water drains, ARB, and potential human pathogens. In this chapter In Chapter 5, I aimed to define the relative importance of natural environmental perturbations and anthropogenic impacts on bacterial assemblages within intermittently opened and closed lagoons (ICOLLs). This is the first study to provide a detailed spatial and temporal analysis of the microbial communities within ICOLL environments. In this study, I observed that sewage was a principal driver of shifts in the microbiology of ICOLLs exposed to stormwater, while natural seasonal shifts in the physio-chemical parameters controlled

microbial communities at other times. Finally in Chapter 6, I synthesise the results and conclusions of this thesis. Overall, the findings of this project have brought a new understanding to how microbial hazards can proliferate in, and enter, coastal environments. This project has also informed the water quality strategies of government agencies, and in some cases highlighted significant health risks to recreational users of coastal environments.