Microbial Processes, Structure and Diversity along the Natural Salinity Gradient of the Coorong Lagoon, South Australia; A Model for Anthropogenic Impact

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“To go away and not look back

And think of what the others say

To go ahead and change your life

Without regard to what they said

And everyone must do the same

You find yourself must again

The better things you left behind

But looking back you may go blind”

Bradford Cox with Noah Lennox – Walkabout

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SUMMARY

Aquatic microbial communities control the movement of energy, matter and elements through the biosphere and thereby mediate biogeochemical cycles, species diversity and evolution. The aquatic microbial food web describes the interactions between viruses, archaea, bacteria, phytoplankton, zooplankton and the organic/inorganic matter that mediate these cycles. Members of the microbial food web are controlled by the "top-down" pressure of mortality and the "bottom-up" physiochemical nature of the environment. Of the physiochemical parameters salinity is a major "bottom-up" controlling factor. As aquatic environments are affected by anthropogenic alterations in salinity, the microbial community will respond in turn and potentially impact on these globally important community interactions and biogeochemical cycling. This thesis investigates the processes, diversity and structure of the microbial community of the Coorong estuary, lagoon and lake system in South Australia. The Coorong is of high ecological importance and exhibits a large continuous salinity gradient which was used to examine the influence of salinity on the microbial community. Additionally, this thesis investigates the trade-off between cellular resource utilisation and potential energetic gain. The results demonstrate that salinity has clear and well defined impacts on the taxonomic and metabolic potential of the bacterial community, and on viral community diversity and production. However, when determining how "top-down" pressures alter with salinity, the impact is less clear and it is likely that the impact on both the predator and prey communities plays a role in mortality. This thesis additionally illustrates that the bacterial community can gain an energetic and resource advantage by expending energy on flagellum production, confirming theoretical predictions and highlighting a seldom investigated component of energy use and movement through aquatic ecosystems. This thesis provides the first detailed insight into the diversity, structure

and processes of the microbial community in the Coorong and shows that while some effects of anthropogenic environmental change, specifically on the structure of the microbial community, can be somewhat anticipated, microbial processes and interactions between “bottom-up” and “top-down” pressures are more complex and more research is required in order to successfully anticipate and mediate anthropogenic change.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Kelly Newton

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It is done.

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ABBREVIATIONS

a	cell radius
a_c	mean cellular lengthwise radius
a_f	flagellum major radius
AGRF	Australian Genome Research Facility
B	Brighton
B1-5	bacterial sub-population 1-5
b_f	flagellum minor radii
BDL	below detection limit
Chl *a*	chlorophyll *a*
d	day
D_m	translational diffusion
DNA	deoxyribonucleic acid
EAC	East Australia Current
EDTA	Ethylenediaminetetraacetic acid
FSC	forward scatter
HCl	hydrochloric acid
h	hour
HNA	high nucleic acid
G	Glenelg
GPS	Global Positioning System
k	phytoplankton growth rate (Chapter III)
k	Boltzmann's constant (Chapter VI)
kDa	kilodalton
km	kilometer
L	litre
LGR	lysis to grazing ratio
LNA	low nucleic acid
M	Murray Mouth
M_g	mortality due to zooplankton grazing
mg	milligrams
MG-RAST	MetaGenomics Rapid Annotation using Subsystem Technology
mol	mole

M_v	mortality due to viral lysis
N	abundance
N1/2	Noarlunga inside/outside reef
NTU	nephelometric turbidity units
O_2	oxygen
P	Port River
P_{cs}	minimum energetic power cost required for swimming
P_{fs}	energetic power cost with flagellum stabilisation
$P_{fsHelix}$	energetic power cost with flagellum stabilisation using the maximum radii of the flagella helix
$P_{fsMaxFL}$	energetic power cost with flagellum stabilisation using the maximum flagellum length
$P_{fsMinFL}$	energetic power cost with flagellum stabilisation using the minimum flagellum length
P_{ex}	energetic power cost with flagellum stabilisation including prosthecae contirubtion
P_g	phytoplankton production loss due to microzooplankton grazing
PIM	particulate inorganic matter
POM	particulate organic matter
P_p	phytoplankton production
PSU	practical salinity units
P_v	phytoplankton production loss due to viral lysis
SSC	side scatter
STAMP	STatistical Analysis of Metagenomic Profiles
Θ	mean turn angle in radians
t	time
T	absolute temperature
TE	tris-EDTA
TEM	transmission electron microscopy
TSM	total suspended matter
V1-3	virus like particle sub-population 1-3
VLP	virus-like particle
VBR	virus to bacteria ratio
WinMDI	Windows Multiple Document Interface for Flow Cytometry

^{o}C	degrees Celsius
‰	per mil
μ	growth rate
µg	microgram
µm	micrometer
µmol	micromole

ABSTRACTS ARISING FROM THE THESIS

Following is a list of the abstracts arising during the author's Doctor of Philosophy studies. Abstracts 1 to 11 are conference abstracts directly related to the candidates thesis. Additionally a version of Chapter III is undergoing revision after previous submission for peer review at the Journal of the Marine Biological Association of the United Kingdom as:

Newton K, Chapperon C, Prime EA, Jeffries TC, Paterson JS, Van Dongen-Vogels V, Leterme SC, Mitchell JG and Seuront L (2011) Differential impacts of microzooplankton and viruses on phytoplankton in a hypersaline lagoon

additionally a version of Chapter II is to be submitted for peer review at the journal Aquatic Microbial Ecology as:

Newton K, Seymour JR, Chapperon C, Prime EA, Jeffries TC, Paterson JS, Van Dongen-Vogels V, Leterme SC, Mitchell JG and Seuront L (2012) Environmental and community variability shapes top-down mortality pressures on aquatic bacteria

and a version of Chapter VI is to be submitted for peer review at the journal Microbiology as:

Newton K, Delpin MW, Seuront L and Mitchell JG (2012) Energetic benefits from marine bacterial flagellar stabilisation

1. **Newton K**, Seymour J, Jeffries T, Smith RJ, Seuront L and Mitchell JG (2012) Dramatic shifts in bacterial taxonomy and function driven by riverine input and salinity. Poster presentation: 14th International Symposium of the International Society for Microbial Ecology. Copenhagen, Denmark

2. **Newton K** (2011) Microbial Life and Death in a Coastal Hypersaline Lagoon. Oral presentation: Flinders University School of Biological Sciences Postgraduate Conference. Adelaide, Australia
3. **Newton K**, Chapperon C, Prime E, Jeffries, TC, Patterson J, van Dongen-Vogels V, Leterme S, Mitchell JG and Seuront L (2010) Differential Mortality of Bacterial Sub-populations. Poster presentation: 13th International Symposium of the International Society for Microbial Ecology. Seattle, USA
4. **Newton K**, Chapperon C, Prime E, Jeffries TC, Paterson JS, van Dongen-Vogels V, Leterme S, Mitchell JG and Seuront L (2010) Elucidation of Matter and Energy Pathways in Aquatic Food Webs. Oral presentation: Annual Scientific Meeting and Exhibition of the Australian Society for Microbiology. Sydney, Australia
5. **Newton K**, Chapperon C, Prime E, Jeffries, TC, Patterson J, van Dongen-Vogels V, Leterme S, Mitchell JG and Seuront L (2009) Assessment of the effect of salinity on viral lysis and microzooplankton grazing on flow cytometrically-defined sub-population of heterotrphic bacteria in a coastal lagoon, The Coorong. Oral presentation: 46th Annual Conference of the Australian Marine Sciences Association. Adelaide, Australia
6. **Newton K**, Jeffries TC, Seymour JR, Leterme S, Mitchell JG and Seuront L (2009) Viral Diversity and Abundance Along a Salinity Gradient. Poster presentation: 46th Annual Conference of the Australian Marine Sciences Association. Adelaide, Australia
7. **Newton K**, Jeffries TC, Seymour JR, Leterme S, Mitchell JG and Seuront L (2008) Microbial Abundance and Diversity along a Salinity Gradient. Poster presentation: 12th International Symposium of the International Society for Microbial Ecology. Cairns, Australia
8. **Newton K**, Seuront L and Mitchell JG (2008) The Impact of Salinity on Marine Microbial Communities. Oral presentation: Annual Scientific Meeting and Exhibition of the Australian Society for Microbiology. Melbourne, Australia
9. **Newton K**, Seuront L and Mitchell JG (2008) Viral Morphological Diversity Along a Salinity Gradient. Poster presentation: Poster presentation: Bioknowledge, Coasts and Catchments Postgraduate Research Conference. Adelaide, Australia

10. **Newton K**, Seuront L and Mitchell JG (2007) Morphological Diversity in Marine Bacteria in Temperate Coastal Waters. Poster presentation: Annual Scientific Meeting and Exhibition of the Australian Society for Microbiology. Adelaide, Australia
11. **Newton K**, Seuront L and Mitchell JG (2007) Investigating the Marine Viral Community Using Flow Cytometry, Microscopy and Molecular Techniques. Oral presentation: Bioknowledge, Coasts and Catchments Postgraduate Research Conference. Adelaide, Australia