Latitudinal study of the role of dimethylsulphoniopropionate in marine microbial foodwebs

By

Eva Fernandez Fernandez

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“Caminante no hay camino. Se hace camino al andar”

“Traveller, there are no paths. Paths are made by walking”

Antonio Machado // Spanish poet
& Australian aboriginal saying

Certificate of authorship

I, Eva Fernandez Fernandez declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Life Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Collection permits

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Glossary of Terms

3HP	3-hydroxypropionate
ANOSIM	Analysis of Similarities
ANOVA	Analysis of Variance
ANSTO	Australian Nuclear Science and Technology Organisation
CE	capillary electrophoresis
CCN	cloud condensation nuclei
Chl a	Chlorophyll a
CLAW	Charlson-Lovelock-Andreae-Warren
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLA	DMSP lyase activity
DMS	dimethyl sulphide
DMSHB	4-dimethylsulfonio-2-hydroxybutyrate
DMSO	Dimethyl sulfoxide
DMSP	dimethylsulfoniopropionate
DMSPd	dissolved DMSP
DMSPp	Particulate DMSP
DMSPt	Total DMSP
EA	Elemental analysis
F_v/F_m	potential quantum yield
FPD	flame photometric detector
GBR	The Great Barrier Reef
GBT	Glycine Betaine Transporter
GC	gas chromatography
GFF	glass fiber filter
GOS	Global Ocean Sampling
HPLC	High performance liquid chromatography
IAEA	Atomic Energy Agency (IAEA)

IMOS	Integrated Observing System
IR	Inside Reef
IRMS	Isotope ratio mass spectrometry
MC	Monte Carlo
MeSH	Methanethiol
MHM	MTHB methyltransferase
MMPA	methylmercaptopropionate
MS	mass spectrometry
MSNA	methane sulphinic acid
MTHB	4-methylthio-2-hydroxybutyrate
MTOB	4.methylthio-2-oxobutyrate
MTPA	3-methylthiopropylamine
MTA-CoA	methylthioacryloyl-CoA
nMDS	non-parametric multi-dimensional scaling
NMR	nuclear magnetic resonance
OR	Outside Reef
OTU	Operational taxonomic unit
PAM	pulse-amplitude-modulation
PCO	Principal Coordinates Analysis (PCO)
PCR	polymerase chain reaction
PERMANOVA	Permutational Multivariate Analysis of Variance
PH	Port Hacking
ROS	Reactive oxygen species
RV	Research vessel
SDS	sodium dodecyl sulfate
SMM	S-methyl-L-methionine
SO	Southern Ocean
SST	Sea surface temperature
TD	thermal desorption
UPLC	ultra-performance liquid chromatography

UV	Ultra violet
VPDB	Vienna Pee Dee Belemnite (VPDB)

Abstract

Dimethylsulphoniopropionate (DMSP) is a sulphur compound produced by some species of phytoplankton, coral and bacteria. It acts as a cryoprotectant, compatible osmolyte and antioxidant, and can provide high value nutrients for the whole marine microbial community. Nevertheless, research on DMSP has focused largely on its bacterial degradation to dimethylsulfide (DMS), a climatically active gas that potentially regulates local climate through an increase in cloud albedo. Therefore, other aspects of DMSP cycling, like DMSP utilisation by the marine microbial community, and especially by phytoplankton, are poorly understood. Marine sulphur dynamics, including DMSP production, cycling and DMS flux vary geographically across latitudinal space with different oceanographic characteristics resulting in different DMSP concentrations and microbial communities.

This thesis aimed to improve our understanding of the utilisation of DMSP by marine microbial communities from different oceanographic regions –the tropics (both coral-influenced and oligotrophic open waters), off shore temperate seas of mixed water masses, and late summer polar coastal waters— by investigating (1) the uptake of DMSP by different fractions of the marine microbial community, and (2) by identifying microbes that benefit from the presence of DMSP. This was achieved through a series of field-based studies that incubated natural oceanic waters enriched with DMSP over different time frames. Short incubations of 6-8 h were conducted to determine rapid DMSP uptake by the community following the progression of DMSP concentrations over time. The size separation of the community by serial filtration allowed for the quantification of DMSP that had been taken up by the microbes from the different size classes of the community. Longer incubations of up to 144 h were important for establishing longer-term responses, such as metabolism or fate of DMSP enrichment within the microbial community and DMSP-induced community shifts. Using sequencing information over time, we were also able to ascertain whether DMSP enrichment lead to any changes in DMSP metabolism and marine microbial structure.

Overall, the findings of this thesis challenge the idea that prokaryotes are the major DMSP sinks in the marine environment. Moreover, this thesis shows that phytoplankton uptake of DMSP is a common characteristic across different environments, with diatoms being one of the predominant sinks in the ocean. It has also shown that DMSP supposes an ecological

advantage to many bacteria and some phytoplankton taxa, highlighting the need for more research on DMSP degradation pathways in both bacteria and phytoplankton.