

Microbial Ecology and Biogeography  
OF THE  
Southern Ocean

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# Acronyms

**UFO** Unidentified Flying Object.





# Acknowledgements



# Abstract

# **Introduction**

This is a test of the acronyms: I saw a Unidentified Flying Object (UFO). It was not the first UFO I'd ever seen. In fact, I've seen 100 UFOs.

## **Microbial ecology of the Southern Ocean**

## **Oceanography of the Southern Ocean**

**Water masses and fronts**

**Effect of climate change**

**Role of the Polar Front in biogeography**

**Project questions and hypotheses**



# The Polar Front as a major biogeographic boundary in the Southern Ocean

Sections of this chapter have been previously published in Wilkins D., Lauro F. M., Williams T. J., Demaere M. Z., Brown M. V., Hoffman J. M., Andrews-Pfannkoch C., McQuaid J. B., Riddle M. J., Rintoul S. R., and Cavicchioli R. Biogeographic partitioning of Southern Ocean picoplankton revealed by metagenomics. *Molecular Ecology*, 2012.

## Summary

## Introduction

## Methods

### Sampling and metagenomic sequencing

Sampling<sup>1</sup> was conducted on board the RSV *Aurora Australis* during cruise V3 CEAMARC/CASO (Collaborative East Antarctic Marine Census / Climate of Southern Ocean) from 13 December 2007 – 26 January 2008. This cruise occupied the SR3 latitudinal transect from Hobart, Australia (44° S) to the Mertz Glacier, Antarctica (67° S) within a longitudinal range of 140–150° E. Nineteen samples (16 surface, 3 deep) were obtained along almost the entire latitudinal range (Figure 1).

A range of data were recorded by integrated instruments on the RSV *Aurora Australis* including location, water column depth, water temperature, salinity, fluorescence and meteorological data (TODO provide table). These data were used to locate the (TODO abbreviations package? PFZ) based on a surface temperature gradient of  $\sim 1.35$  °C across a distance of 45–65 km, placing the (TODO abbreviations? PF) at approximately  $-59.70^\circ$  of latitude, consistent with previous descriptions TODO EDITING HERE NEED SOKOLOV AND RINTOUL REF

At each station,  $\sim 500$  L of seawater was pumped from  $\sim 2$  m below the sea surface into drums stored at ambient temperature on deck. In the case of deep samples,  $\sim 10$ –50 L of seawater was collected opportunistically from Niskin bottles attached to a CTD (Conductivity, Temperature and Depth TODO give info on CTD - SeaBird?) instrument operated by an unrelated oceanographic project. Seawater samples were prefiltered through a  $20\ \mu\text{m}$  plankton net, then filtrate was captured on sequential

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<sup>1</sup>Sampling was performed by Jeffrey M. Hoffman and Jeffrey B. McQuaid

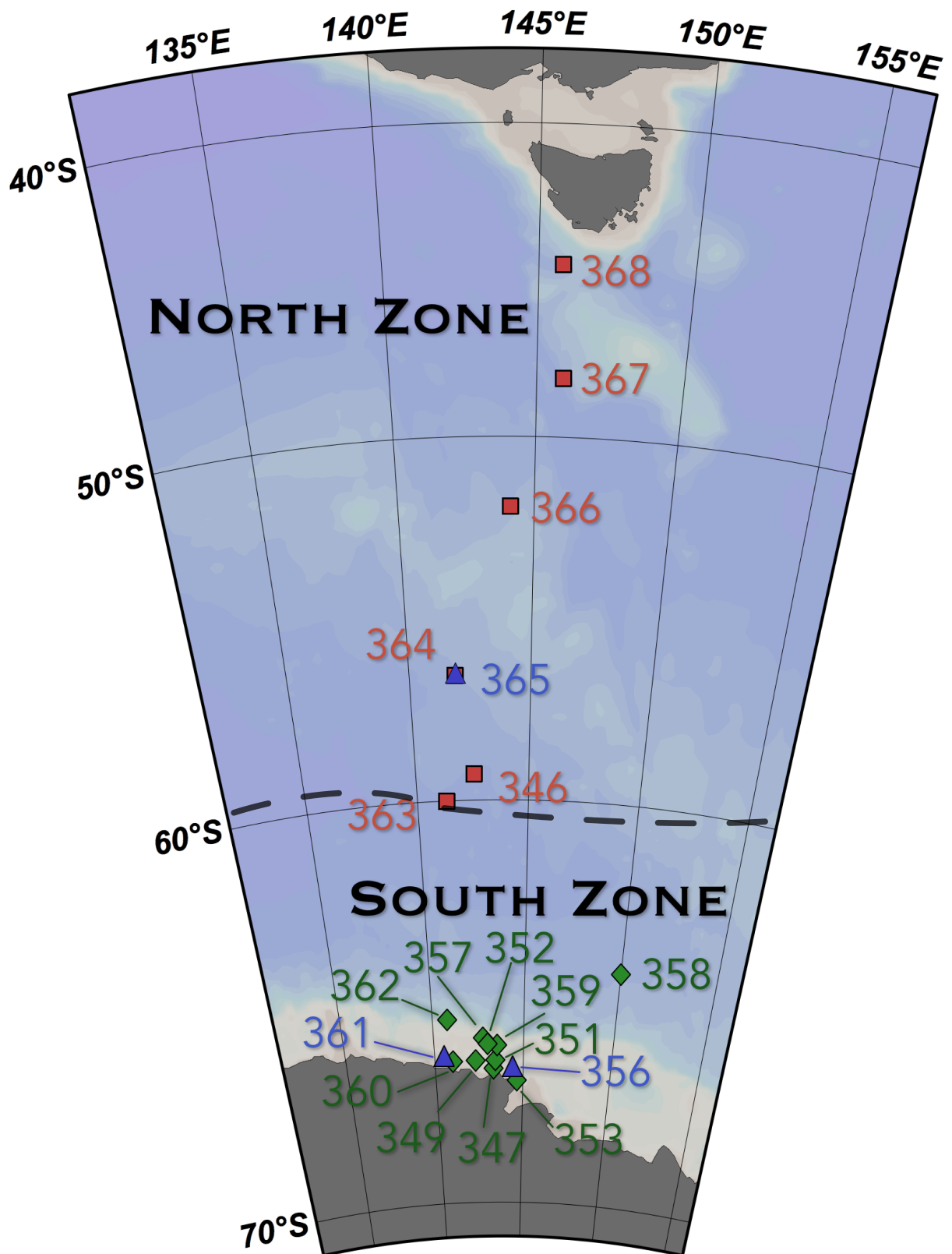


Figure 1: Sites of seawater samples used in this study. Red squares indicate surface samples from the North Zone; green diamonds samples from the South Zone; and blue triangles indicate deep samples. The dashed line gives the approximate location of the Polar Front.



3.0  $\mu\text{m}$ , 0.8  $\mu\text{m}$  and 0.1  $\mu\text{m}$  polyethersulfone membrane filters (Supor membrane disc filter; Pall Life Sciences TODO location), and immediately stored at  $-20\text{ }^{\circ}\text{C}$  (Rusch *et al.*, 2007; Ng *et al.*, 2010).

DNA extraction<sup>2</sup> was performed at the J. Craig Venter Institute (Rockville, USA) as described in Rusch *et al.* (2007). Pyrosequencing was performed on a GS20 FLX Titanium instrument (Roche, Branford, USA) also at the J. Craig Venter Institute as described in Lauro *et al.* (2011). Duplicate reads and reads with many pyrosequencing errors were removed as described in Lauro *et al.* (2011).

## **Phylogenetic analysis of metagenomic data**

## **Functional analysis of metagenomic data**

## **Results**

### **Metagenomic sequencing**

### **Phylogenetic analysis of metagenomic data**

### **Functional analysis of metagenomic data**

## **Discussion**

## **Conclusions**

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<sup>2</sup>DNA extraction was performed by Cynthia Andrews-Pfannkoch and others at the J. Craig Venter Institute



# **Meso-scale biogeographic drivers of planktonic diversity**



# Conclusions



# References

- Lauro F. M., Demaere M. Z., Yau S., Brown M. V., Ng C., Wilkins D., Raftery M. J., Gibson J. A., Andrews-Pfannkoch C., Lewis M., Hoffman J. M., Thomas T., and Cavicchioli R. An integrative study of a meromictic lake ecosystem in Antarctica. *The ISME journal*, 5(5):879–895, 2011.
- Ng C., Demaere M. Z., Williams T. J., Lauro F. M., Raftery M., Gibson J. A., Andrews-Pfannkoch C., Lewis M., Hoffman J. M., Thomas T., and Cavicchioli R. Metaproteogenomic analysis of a dominant green sulfur bacterium from Ace Lake, Antarctica. *The ISME journal*, 4(8):1002–1019, 2010.
- Rusch D. B., Halpern A. L., Sutton G., Heidelberg K. B., Williamson S., Yooseph S., Wu D., Eisen J. A., Hoffman J. M., Remington K., Beeson K., Tran B., Smith H., Baden-Tillson H., Stewart C., Thorpe J., Freeman J., Andrews-Pfannkoch C., Venter J. E., Li K., Kravitz S., Heidelberg J. F., Utterback T., Rogers Y.-H., Falcón L. I., Souza V., Bonilla-Rosso G., Eguiarte L. E., Karl D. M., Sathyendranath S., Platt T., Bermingham E., Gallardo V., Tamayo-Castillo G., Ferrari M. R., Strausberg R. L., Nealson K., Friedman R., Frazier M., and Venter J. C. The Sorcerer II Global Ocean Sampling expedition: northwest Atlantic through eastern tropical Pacific. *PLoS Biology*, 5(3):e77–e77, 2007.
- Wilkins D., Lauro F. M., Williams T. J., Demaere M. Z., Brown M. V., Hoffman J. M., Andrews-Pfannkoch C., McQuaid J. B., Riddle M. J., Rintoul S. R., and Cavicchioli R. Biogeographic partitioning of Southern Ocean picoplankton revealed by metagenomics. *Molecular Ecology*, 2012.