

# Table of content



# **General Introduction.....29**

I.	<u>Antarctica and the Southern Ocean .....</u>	<b>31</b>
a.	Geological & climatic history .....	31
i.	Tectonics and geomorphology .....	31
ii.	Climatic history .....	34
b.	Oceanographic features.....	37
i.	Current system in the Southern Ocean .....	37
ii.	Fronts and zonation .....	39
c.	A changing world .....	41
II.	<u>Origin and evolution of the Antarctic benthos .....</u>	<b>45</b>
a.	Origins: a succession of extinction and recolonisation .....	45
i.	Pre-Cenozoic origins .....	45
ii.	Cenozoic evolution of the Antarctic benthos .....	46
b.	Modern benthic life in the Southern Ocean .....	49
i.	A century of discoveries .....	49
ii.	Particularisms of the benthic fauna .....	50
c.	Biogeography and phylogeography of modern Antarctic benthic faunas .....	52
i.	Distribution of benthic life in the SO .....	53
ii.	Genetic diversity patterns .....	54
iii.	Consequences of reproductive strategies on diversity patterns .....	57
d.	Sea stars in the Southern Ocean .....	58
i.	General view .....	58
ii.	Southern Ocean sea stars .....	60
	<b>Research objectives .....</b>	<b>63</b>

# **Southern Ocean species list update .....**.....67

Southern Ocean Asteroidea: a proposed update for the Register of Antarctic Marine Species ..69

<b>ABSTRACT .....</b>	70
<b>INTRODUCTION .....</b>	71
<b>MATERIALS AND METHODS .....</b>	71
<b>DATA RESOURCES .....</b>	74
<b>ANALYSIS .....</b>	78
<b>DISCUSSION .....</b>	79
<b>ACKNOWLEDGEMENTS .....</b>	80

# **Asteroidea Database .....**.....81

Antarctic and Sub-Antarctic Asteroidea database .....

<b>ABSTRACT .....</b>	84
<b>INTRODUCTION.....</b>	85
<b>PROJECT DESCRIPTION .....</b>	86
<b>ACKNOWLEDGEMENTS .....</b>	94

# **Chapter 1 .....**.....95

Reproductive strategy as a piece of the biogeographic puzzle: a case study using Antarctic sea stars (Echinodermata, Asteroidea) .....97

**ABSTRACT .....**.....98

**INTRODUCTION .....**.....99

**MATERIALS AND METHODS .....**.....101

**Area of interest.....**.....101

**Data analyses.....**.....101

**RESULTS .....**.....104

**Sampling effort, richness patterns and endemism .....**.....104

**Biogeographic patterns of species .....**.....109

**Brooders *versus* broadcasters .....**.....111

**Biogeographic patterns of genera.....**.....111

**DISCUSSION .....**.....112

**Main patterns of Southern Ocean asteroid biogeography .....**.....112

**The importance of reproductive strategies for asteroid biogeography .....**.....114

**Across taxonomic levels and time-scales .....**.....116

**CONCLUSIONS.....**.....118

**ACKNOWLEDGEMENTS .....**.....118

<b>Chapter 2 .....</b>	<b>119</b>
Is reproductive strategy a key factor in understanding the evolutionary history of Southern Ocean Asteroidea (Echinodermata)? .....	121
<b>ABSTRACT .....</b>	<b>122</b>
<b>INTRODUCTION .....</b>	<b>123</b>
<b>MATERIALS AND METHODS .....</b>	<b>125</b>
Comprehensive sampling & DNA sequence compilation .....	125
Phylogenetic reconstruction.....	127
Species delineation .....	128
<b>RESULTS .....</b>	<b>129</b>
Species delineation .....	129
Phylogenies and divergence time estimates .....	131
Phylogeographic patterns .....	133
<b>DISCUSSION .....</b>	<b>137</b>
Species richness, genetic diversity and taxonomic implications.....	137
Dispersal capacity and biogeographic patterns .....	137
The role of past climate change.....	140
<b>CONCLUSION &amp; FUTURE PROSPECTS .....</b>	<b>141</b>
<b>ACKNOWLEDGMENTS .....</b>	<b>142</b>

# **Chapter 3 .....**.....145

The overlooked diversity of Southern Ocean sea stars (Asteroidea) reveals original evolutionary pathways.....147

**ABSTRACT .....**.....148

**INTRODUCTION .....**.....149

**MATERIALS AND METHODS .....**.....151

Richness data compilation .....151

Genetic data compilation .....152

Tree reconstruction.....152

**RESULTS .....**.....153

Sea star taxonomic diversity in the Southern Ocean .....153

Latitudinal trends in the Southern Ocean .....156

Global phylogenetic exploration .....160

Phylogeographic patterns .....161

**DISCUSSION .....**.....165

Spatial and taxonomical diversity in the Southern Ocean .....165

Large scale phylogenetic patterns .....167

Global barcode library – an asset for future studies .....168

**CONCLUSION.....169**

**ACKNOWLEDGMENTS .....**.....169

<b>General discussion .....</b>	<b>171</b>
a. Sea star diversity in the Southern Ocean .....	173
b. Distribution and genetic patterns in Southern Ocean sea stars .....	180
c. Biogeographic processes in the Southern Ocean .....	182
<b>Conclusion &amp; Perspectives.....</b>	<b>186</b>
<b>Appendices .....</b>	<b>190</b>
Appendix 1 - Chapter 1 .....	192
Appendix 2 - Chapter 2 .....	196
Appendix 3 - Chapter 3 .....	204
<b>References .....</b>	<b>221</b>