
Contents

Preface	ix
Introduction	xi
Chapter 1. A Brief History of Exploration and Discovery	1
1.1. The Age of Navigation	1
1.2. Scientific expeditions come to the fore	6
1.2.1. Pre-1914, the precursor era	6
1.2.2. Post 1950, the age of permanent settlement	9
1.3. An increase in commercial exploitation	9
1.4. Dynamics of the discovery of Southern Ocean biodiversity	12
1.5. Tools for oceanography exploration	13
Chapter 2. The Southern Ocean and its Environment: a World of Extremes	17
2.1. An ocean with undefined limits	18
2.2. The southern climate: windy and cold, with very little light	19
2.2.1. Strong winds	19
2.2.2. Extreme cold	20
2.2.3. From winter night to weak daylight	21
2.3. Ice in all its forms	22
2.3.1. Sea ice	22
2.3.2. Ice sheets and ice shelves	23
2.4. In isolation yet interconnected, the complexity of ocean circulation	24
2.4.1. Ocean currents	24
2.4.2. Ocean fronts and the zonation of water masses	26
2.4.3. A complex interplay between wind, water and ice	26
2.4.4. Water in action	28

2.5. Sediment and nutrients	28
2.5.1. Marine sediment and its origins	28
2.5.2. Oxygen and nutrients, sources of marine life	29
Chapter 3. The Ocean Through Time	33
3.1. The split of a supercontinent from the Jurassic to the Eocene	34
3.2. Global cooling at the Eocene-Oligocene transition	38
3.3. Other thermal anomalies during the Oligocene and Miocene	40
3.4. Another cold snap in the late Miocene	40
3.5. Climatic oscillations and glacial-interglacial cycles	41
Chapter 4. Southern Ocean Biogeography and Communities	43
4.1. Inventorying Antarctic marine biodiversity	44
4.2. Southern Ocean biogeography.	45
4.2.1. A rich ocean	45
4.2.2. Unique biodiversity.	45
4.2.3. Richness and latitude.	47
4.2.4. Biogeographic regions and provinces	49
4.2.5. The paradox of bipolar distribution patterns	56
Chapter 5. History of Biodiversity in the Southern Ocean	59
5.1. So much ice yet so few fossils.	60
5.2. Origins and age of Antarctic marine biodiversity	61
5.3. Break-up of Gondwana and isolation of Antarctic fauna	63
5.4. Mass extinction event at the end of the Mesozoic Era.	64
5.5. Evolution of biodiversity and ancient climatic changes.	65
5.5.1. The Paleocene-Eocene Thermal Maximum	65
5.5.2. Consequences of the late Eocene biological crisis	65
5.5.3. Glaciation and species adaptation in the Miocene Epoch	67
5.5.4. Are glacial-interglacial cycles good for biodiversity?	68
Chapter 6. Adaptation of Organisms	71
6.1. Surviving the cold and escaping the ice	71
6.1.1. Fish that make their own antifreeze	71
6.1.2. Looking out for number one, but stronger together	73
6.1.3. A good insulator	73
6.1.4. Adaptations in physiology and metabolism	74
6.2. Living with ice	75
6.2.1. Sea ice habitats	75
6.2.2. Far from the world, under the ice shelves.	77
6.3. Dealing with intense fluctuations	79

6.3.1. Hellish coastline conditions	79
6.3.2. Advantaged trophic groups	79
6.3.3. Feeding their young by endless periods of fasting.	81
6.3.4. From total night to permanent day	81
6.4. Lower metabolic rates, longer lifespans and gigantism	81
6.4.1. Metabolism and development.	82
6.4.2. Long-lived forms	84
6.4.3. Gigantism	85
6.5. Parents caring for their offspring	87
6.5.1. Two strategies	87
6.5.2. Kangaroo sea urchins	89
6.5.3. Why is there so much brooding in the Southern Ocean?	90
Chapter 7. Projections into the Future	93
7.1. The immediate future	93
7.1.1. Invasive species.	95
7.1.2. Extinctions.	97
7.1.3. Acidification.	99
7.2. The next cold event	100
7.3. Drifting continents.	101
Appendix	103
Bibliography	105
Index	115