

Chap I : General introduction.....	1
1.1. The great diversification of seabird biology	1
1.1.1. Definition	1
1.1.2. Seabirds in crisis.....	2
1.1.3. The life history	2
1.2. The roseate tern as a case study	4
1.2.1. Geographic range	5
1.2.2. Conservation status.....	8
1.3. Aims of the thesis	8
1.4. Chapter overview-rationale for the thesis.....	11
1.5. Context of the research: the Seychelles archipelago.....	16
1.5.1. Geography	16
1.5.2. Geology	16
1.5.3. Climate	17
1.5.4. Fauna and flora.....	17
1.5.5. Conservation.....	18
Chap II : General considerations on the roseate tern on Aride Island : diet and post-breeding ecology.....	20
2.1. Roseate tern diet on Aride	20
2.1.1. Introduction	20
2.1.2. Diet segregation with other species: the lesser noddy.....	21
2.1.3. Objectives.....	22
2.1.4. Methods.....	22
2.1.4.1. Study area and species	22
2.1.4.2. Diet sampling.....	23
2.1.4.3. Diet samples analysis.....	24
2.1.5. Results	25
2.1.6. Discussion	28
2.2. Roseate tern post-breeding ecology	30
2.2.1. Introduction	30
2.2.1.1. Stable isotopes & mercury analysis of feathers	30
2.2.1.2. Stable isotope signatures & mercury concentrations within a single food web	31
2.2.1.3. Changes in stable isotope signatures & mercury concentrations between different food webs	33
2.2.1.4. The sedentary vs migratory hypothesis?.....	34
2.2.2. Diet/foraging ecology segregation with other species: the lesser noddy.....	35
2.2.3. Objectives and hypothesis	35
2.2.4. Methods.....	36
2.2.4.1. Collection of feathers	36
2.2.4.2. Molt.....	37
2.2.4.3. Stable isotopes and mercury analysis of feathers and prey.....	37
2.2.4.4. Statistical analysis.....	39
2.2.5. Results	40
2.2.5.1. Diet and stable isotopes during the breeding season.....	40
2.2.5.2. Diet and stable isotopes during the nonbreeding/molting season	40
2.2.5.3. Mercury concentrations during the breeding season.....	43
2.2.5.4. Mercury concentrations during the nonbreeding/molting season	44
2.2.6. Discussion	46
2.2.6.1. Stable isotopes and mercury concentrations during the breeding season	46
2.2.6.2. Stable isotopes and mercury concentrations outside the breeding season	48
2.2.6.3. Matching ringing-recoveries and isotope values.....	50
2.2.7. Conclusions	52

Chap III : Influence of oceanographic conditions on breeding performance of roseate terns on Aride Island.....	54
3.1. Introduction	54
3.1.1. Population regulation in birds	54
3.1.2. A surrogate measure of food supply: Chlorophyll <i>a</i> ?	56
3.1.3. Application to the roseate tern population breeding on Aride.....	56
3.1.4. Objectives and hypothesis	57
3.2. Methods	58
3.2.1. Oceanography of the study area	58
3.2.1.1. Introduction.....	58
3.2.1.2. Seasonal variation of chlorophyll concentrations	58
3.2.2. Measurements of CC and ocean indices.....	59
3.2.2.1. Chlorophyll concentrations (CC).....	59
3.2.2.2. Sea-surface-temperature (SST) and ocean indices.....	61
3.2.3. Roseate tern productivity and breeding parameters	63
3.2.4. Statistical analyses.....	66
3.2.4.1. Phytoplankton bloom (CC), ocean indices and roseate tern reproductive parameters	66
3.2.4.2. Phytoplankton bloom (CC) and roseate tern timing of breeding	67
3.3. Results	68
3.3.1. Year-to-year variations in roseate tern breeding performance	68
3.3.2. CC, ocean indices and roseate terns breeding performance	70
3.3.2.1. Chlorophyll abundance	70
3.3.2.2. Regression model.....	73
3.3.3. Duration of the phytoplankton (CC) bloom, ocean indices and timing of breeding	74
3.3.3.1. Inter-year variation.....	74
3.3.3.2. SST and ocean indices	75
3.3.3.3. Logistic regression model	75
3.4. Discussion.....	77
3.4.1. Effects of annual changes in phytoplankton (CC) abundance.....	78
3.4.2. Effects of laying date and timing of phytoplankton bloom.....	79
3.4.3. Effects of ocean indices.....	81
3.4.4. Conclusion.....	81
Chap IV : Influence of nesting habitat conditions on roseate tern breeding performance.....	84
4.1. Introduction	84
4.1.1. Definition: habitat quality	84
4.1.2. The ecological trap	84
4.1.3. Measuring habitat quality	85
4.1.4. Application to the roseate tern population on Aride.....	85
4.1.5. Objectives and hypothesis	86
4.2. Methods	87
4.2.1. Description of the colony area.....	87
4.2.2. Vegetation sampling design	88
4.2.2.1. Changes in habitat occupancy	88
4.2.2.2. Permanent plots and experimental clearing	90
4.2.3. Measuring vegetation variables.....	90
4.2.3.1. Fieldwork methods.....	90
4.2.3.2. Data processing	91
4.2.4. Spatial variation in roseate tern breeding performance	92
4.2.4.1. Study quadrats in 2004 and 2005.....	92
4.2.4.2. Chick feeding rates.....	93
4.2.4.3. Breeding success.....	93
4.2.4.4. Adult body condition	94
4.2.5. Statistical analyses.....	94
4.3. Results	95

4.3.1. Vegetation sampling	95
4.3.1.1. Changes in habitat occupancy	95
4.3.1.2. Permanent plots and experimental clearing	98
4.3.2. Roseate tern breeding performance	99
4.4. Discussion	100
4.4.1. Spatial distribution of nesting roseate terns	100
4.4.2. Habitat quality and roseate tern breeding performance	103
4.4.3. Conclusion: implications for colony management	104
Chap V : Sexual maturation: age of first breeding and plumage characteristics	107
5.1. Introduction	107
5.1.1. Definition	107
5.1.2. Age of first breeding and plumage characteristics in temperate and sub-tropical roseate terns	109
5.1.3. Plumage characteristics and age at first breeding in tropical roseate terns	113
5.2. Methods	114
5.2.1. Ringing scheme	114
5.2.2. Resighting scheme	114
5.2.3. Plumage characteristics	115
5.2.4. Age of first breeding	115
5.3. Results	116
5.3.1. Age of first encounter	116
5.3.2. Age of first breeding	117
5.3.3. Plumage characteristics (as recorded in 2005)	118
5.4. Discussion	121
5.4.1. Age of first encounter and age of first breeding	121
5.4.2. Plumage characteristics	122
5.4.3. Discussing hypotheses related to the pattern of plumage maturation and age of first breeding in Aride roseate terns	124
Chap VI : Estimation of juvenile and immature survival rates	127
6.1. Introduction	127
6.1.1. Background	127
6.1.2. Seabird survival: a brief state of the art	128
6.1.3. Seabird survival: the modelling approach	129
6.1.4. Seabird survival: the effect of covariates	130
6.1.5. Objectives and hypotheses	131
6.2. Methods	132
6.2.1. Ringing and resighting (recapture) scheme	132
6.2.2. Capture-recapture modelling	133
6.2.3. Model selection and goodness-of-fit test	136
6.3. Results	136
6.3.1. Sample size	136
6.3.2. Model selection	136
6.3.3. Juvenile (one-year-old) survival estimate	138
6.3.4. Survival estimate after age 1	139
6.3.5. First return to the colony and recapture probabilities	139

6.4. Discussion.....	140
6.4.1. Statistical modelling	140
6.4.2. Survival estimates and temporal variation	141
6.4.3. Effects of environmental stochasticity	142
6.4.3.1. Inter-annual variation in survival estimates	142
6.4.3.2. Effects of tick parasitism on survival estimates	143
6.4.4. Return-recruitment estimates.....	144
Chap VII : Estimation of breeding adult survival rates.....	147
7.1. Introduction	147
7.1.1. Background	147
7.1.2. Adult vs. immature survival and effect of cohort-level covariates.....	147
7.1.3. Test of hypothesis related to the low productivity of tropical waters.....	148
7.1.3.1. Definition	148
7.1.3.2. The roseate tern as a case study	149
7.1.4. Objectives and hypothesis	150
7.2. Methods	150
7.2.1. Ringing and resighting (recapture) scheme	150
7.2.2. Capture-recapture modelling and goodness-of-fit test	152
7.2.3. Modelling the effect of covariates	152
7.2.4. Model selection procedure	153
7.3. Results	154
7.4. Discussion.....	158
7.4.1. Statistical modelling	158
7.4.2. Survival estimates.....	158
7.4.3. Effect of the Indian Ocean Dipole Mode Index on recapture rates	159
7.4.4. Comparison with other roseate tern populations	160
Chap VIII : General conclusions.....	163
8.1. Importance of the studied population	163
8.1.1. Contribution to the global conservation of the species.....	163
8.1.2. Contribution to the understanding of life-history strategies	164
8.2. Demographic characteristics of tropical roseate terns breeding on Aride Island	164
8.2.1. The roseate tern on Aride: a declining population	164
8.2.2. Reproductive success and affecting factors.....	165
8.2.3. Survival rates (juvenile, immature, breeding adult) and affecting factors.	168
8.3. The roseate tern population on Aride Island: a matrix population model approach...	170
8.4. Future conservation perspectives.....	172
Bibliography.....	176
Appendix.....	203