A NATURAL HISTORY OF THE BAZARUTO ARCHIPELAGO, MOZAMBIQUE

B.I. Everett, R.P. van der Elst and M.H. Schleyer (Editors)

OCEANOGRAPHIC RESEARCH INSTITUTE

SOUTH AFRICAN ASSOCIATION FOR MARINE BIOLOGICAL RESEARCH

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FRONT COVER: The beautiful tropical island paradise of Bazaruto. Photograph by Stewart Stanbury.

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ABSTRACT

This publication is an overview of the ecology of the Bazaruto Archipelago in Mozambique. It comprises a series of individual chapters compiled by different authors on topics ranging from the archipelago's terrestrial fauna and flora to its rich marine biodiversity, human population and conservation management. Whilst the content has a scientific basis and will contribute to further study and management of the region, it is also considered to be a valuable source of information for tourists and others who visit the islands.

ACKNOWLEDGMENTS

This Special Publication has its origins in the 1990 report by Dutton and Zolho. Subsequently, many others have contributed to its finalization, as authors or as expert advisors. It was sponsored by WWF South Africa, the conservation organisation, and the African Wildlife Heritage Trust through South African Airways. The following individuals have contributed to either or both the original report and to this Special Publication. Their contributions are acknowledged as representing an important step in the conservation and the development of marine protected areas in the West Indian Ocean.

Paul Dutton, Roberto Zolho and Sheila Ramsay are acknowledged for the original comprehensive study and reporting of the Conservation Master Plan for Bazaruto. Their work was ahead of its time and represents an important step in the proclamation and development of the Bazaruto Marine Park. Inspirational support from Johns Hanks, Allan Heydorn and especially Ken Tinley is recognised in promoting marine and coastal conservation in Mozambique and specifically the Bazaruto Archipelago. Similarly, several people supported the project in their personal capacity, including Pat Goss, Dan and Jos Landry, Ricky Jacobs, David Anderson, Tony de Freitas and a number of staff at the Oceanographic Research Institute (ORI) in Durban. While the environmental threat of major oil exploration is of concern, the EIA studies commissioned by SASOL represent an important contribution to the ecological and socio-economic understanding of the region. Besides those listed as chapter authors, individuals, who contributed to particular themes of the original study and the report, are listed:

Avifauna: Richard Brooke; Phil Hockey: Tim Crowe; Mateus Chambal; Olaf Wirminghaus; Colleen Downes. **Crocodiles:** Jon Hatton; David Tullison-Smith. **Dune dynamics:** Ken Tinley; Andrew Cooper; Peter Ramsay. **Herpetofauna:** Donald Broadley; Olaf Wirminghaus, Colleen Downes. **Legislation and Management:** Lucinda Cruz; Roberto Zolho; Helena Motta. **Mammals:** Paul Dutton. **Marine Ecosystem:** Tony de Freitas; Pat Garratt; Simon Chater; Winks Emmerson; Andrew Cooper; Peter Ramsay. **Ornamental shells:** Paul Dutton; Manuel Antonio Amorim; Kelly Landrey, Luis Avevedo. **Vegetation:** Paul Dutton, Bob Drummond. **Wildlife Management:** Jeremy Anderson.

CONTENTS

FOREWORD

Islands and their surrounding coastal areas are extraordinary environmental settings covering about one-sixth of the Earth's surface and providing special habitats which host more than half of the world's marine flora and fauna, including exotic and endemic species. Due to their high biodiversity, aesthetics and cultural values they are vital for the development of social and economic activities providing livelihood, employment and leisure opportunities to more than 500 million people living on the world's islands.

Despite their well known importance in providing a great deal of benefits to human kind, their natural functional integrity is threatened by human population growth and unsustainable development activities which exert heavy pressure over them. Furthermore, negative impacts of global climate change and resulting sea level rise make the islands some of the most fragile and vulnerable resources on the planet.

The Eastern African Marine Ecoregion (EAME), which stretches from southern Somalia to the Cape in South Africa, consists of a coastline of about 4,600 km, comprising some of the richest ecosystems in the world. It is a habitat that supports about 22 million people whose livelihoods depend to a great extent on marine and coastal resources. Some areas of the EAME are still pristine; and hotspots have been identified in the last 40 years where parks and reserves are being developed for their protection against unsustainable use. Governments and civil society in this region have been strongly engaged in promoting the sustainability of marine and coastal resources for the upkeep of leisure opportunities and recreational facilities, security and the uniqueness of the islands, thus ensuring the potential benefits for present and future generations. The failure and success stories of early establishment of conservation sites in the region have been providing valuable lessons for the development of a new approach for Marine Parks Areas currently being adopted.

The archipelago of Bazaruto is a group of 5 islands on the Mozambique coast, rich in biodiversity, including the largest dugong population in the EAME region. It has been classified as an island group of world significance and considered a priority seascape for conservation. It is a successful story in marine park conservation.

The book entitled *A Natural History of Bazaruto Archipelago, Mozambique* provides a comprehensive and multi-disciplinary overview of the social, economic and ecological aspects of the Archipelago of Bazaruto. It will be an invaluable tool for a variety of professionals (specialists as well as generalists), including, biologists, physical and social scientists, scholars, librarians, decision makers, students and civil society in general. With it the authors have provided an important input towards the conservation of the marine and coastal resources of EAME, a region with a big deficiency of scientific and technical information on the science and management of the marine and coastal resources.

Dr Bernardo Ferraz
Former Minister of Co-ordination of Environmental Affairs and passionate Conservationist

PRÓLOGO

As ilhas e zonas costeiras circundantes são áreas ambientais extraordinárias que abrangem cerca de um sexto da superfície da terra, prestando habitates especiais que acolhem mais da metade da flora e fauna marinha do mundo, incluindo espécies exóticas e indêmicas. Devido à sua elevada biodiversidade valores estéticos e culturais, a flora e fauna marinha nestes habitates são vitais para o desenvolvimento de actividades sociais e económicas, proporcionando, desse modo, susbsistência, emprego e oportunidades de lazer para mais de 500 milhões de pessoas que vivem nas ilhas.

Apesar da sua reconhecida importância em termos de proporcionar numerosos benefícios à humanidade, a sua integridade funcional natural está sendo ameaçada por um crescimento populacional humano e pelas insustentáveis actividades de desenvolvimento que exercem uma grande pressão sobre essas minúsculas unidades da terra. Os impactos negativos da mudança climática global e a consequente subida do nível do mar tornam com que as ilhas sejam uns dos mais frágeis e vulneráveis recursos do nosso planeta.

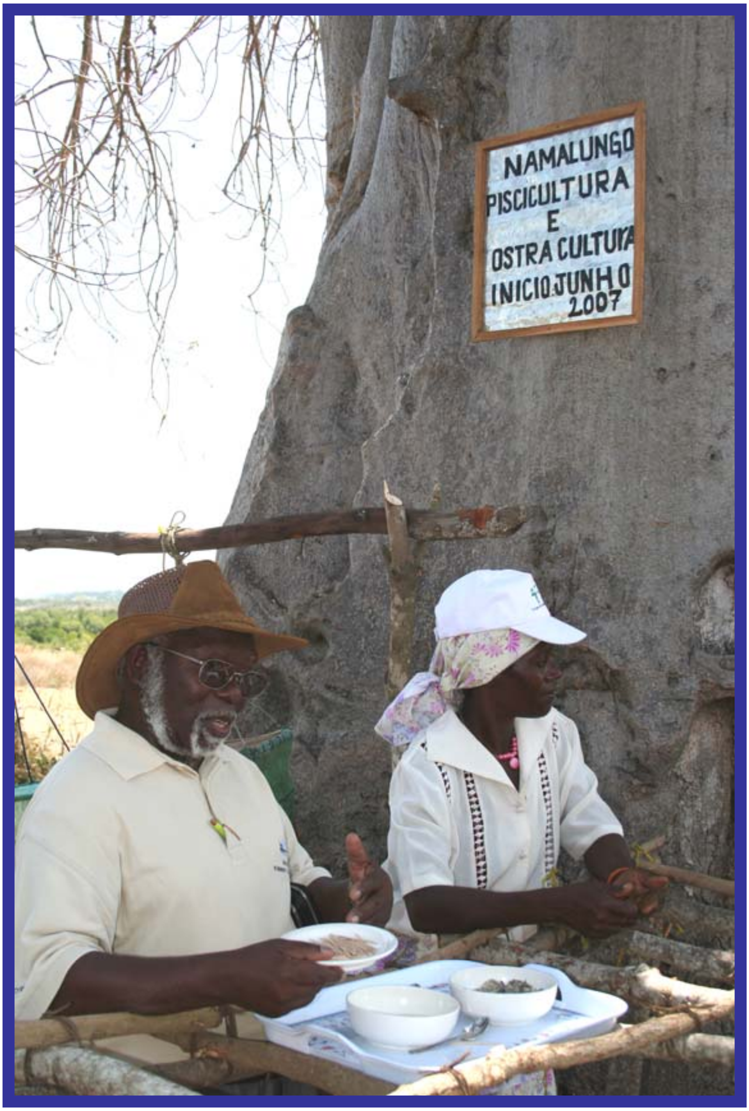
A Eco-região da Marinha da África Oriental (EMAO) que se extende do sul da Somália para o Cabo, na África do Sul, é constituída por uma faixa costeira de cerca de 4.600 km que inclui alguns dos mais ricos eco-sistemas do mundo. É um área que suporta cerca de 22 milhões de pessoas cuja subsistência depende, em grande medida, dos recursos marinhos e costeiros. Enquanto algumas partes da EMAO ainda estão intactas, outras vêm sofrendo de uma enorme pressão de utilização durante os últimos 40 anos e, como resposta, parques e reservas estão a ser estabelecidos para a sua protecção contra o uso insustentável.

Nesta região, os governos e a sociedade civil teêm-se empenhado na promoção da sustentabilidade dos recursos marinhos e costeiros com a finalidade de garantir a continuidade das oportunidades de lazer, segurança e as características individuais das ilhas, assegurando, desse modo, os benefícios potenciais para as gerações presentes e futuras. As histórias de fracasso e successo que se deram no início do estabelecimento de locais de conservação na região foram fornecendo lições valiosas para o desenvolvimento de uma nova abordagem perante zonas de parques marinhos que estão a ser adoptadas.

O Arquipélago do Bazaruto é um conjunto de cinco ilhas na costa de Moçambique, rica em biodiversidade, incluindo a maior população de dugongos da região de EMAO. Foi classificada como sendo um grupo de ilhas de grande importância mundial e considerada uma paisagem marinha prioritária para a conservação. É considerada uma história de sucesso no que diz respeito à conservação do meio ambiente através de um parque marinho.

O livro entitulado Uma História Natural do Arquipélago do Bazaruto, Moçambique, é um resumo compreensivo e multi-disciplinar que oferece uma visão do contexto social, económico e ecológico do Arquipélago do Bazaruto. Vai ser uma ferramenta valiosa para uma grande variedade de profissionais (especialistas, bem como generalistas) incluindo biólogos, cientistas físicos e sociais, pesquisadores, bibliotecários, decisores políticos, estudantes e a sociedade civil em geral. Os seus autores teêm prestado um contributo importante para a conservação dos recursos marinhos e costeiros da EMAO, uma região com uma grande carência de informação científica e técnica na área de gestão dos recursos marinhos e costeiros.

Dr Bernardo Ferraz
Ex-Ministro para a Coordenação da Acção Ambiental e entusiástico defensor do meio ambiente



Dr Bernardo Ferraz (left) (Photograph by Rudy van der Elst)

INTRODUCTION AND SUMMARY

The Eastern African Marine Ecoregion (EAME) stretches from the Horn of Africa (Somalia) to the Cape in South Africa. It is one of only about ten marine ecoregions in the world that has been singled out for special protection because of its great biodiversity and range of habitats. Along the EAME's more than 5 000 km long coast and amid its ½ million square kilometres of ocean, a total of 21 highly significant conservation sites have been identified (WWF 2004). Nine of these are located in Mozambique with four sites being of global concern. Significantly, the Bazaruto Archipelago features prominently as a site critically worthy of protection.

In 2003, the 5th IUCN World Parks Congress was held in Durban. A key recommendation that emanated was the need to greatly increase and strengthen marine and coastal protected areas and especially to create regional networks of MPAs. Networks of MPAs provide for connectivity between regions, so that migration of animals such as fish, turtles and marine mammals, larval dispersal and other key biological processes can be maintained. It was proposed that by 2012, the level of protection for each habitat should be 20-30% (IUCN 2003). Subsequently, the meeting of parties of the Convention on Biological Diversity (COP 7 & 8) set 10% <u>effective</u> protection as a minimum standard to be achieved by 2010. Similarly, transboundary MPAs were also seen as an important tool to strengthen regional protection of biodiversity and resources (www.transmap.fc.ul.pt; www.transmap-metadata.org.za). Mozambique has already made significant progress towards achieving these goals, *inter alia* with current or planned protection of the Palma, Quirimbas, Bazaruto and the Machangulo complexes.

The Bazaruto complex is clearly one of the most outstanding MPAs and conservation success stories. Besides its rich biodiversity and various habitats, it is home to indigenous people that are sustained by the archipelagos' resources, while tourists flock to the islands by plane or cruise ship, attracted by the archipelago's beauty and rich marine life.

Five islands make up the Bazaruto Archipelago. The largest is Bazaruto, covering approximately 12 000 ha. Next are Benguérua at 2 500 ha; Magaruque at 600 ha; Santa Carolina (previously called Paradise Island) at 500 ha and the minuscule island of Bangué at about 5 ha (Fig. i). These islands are located up to 20 km off the Mozambique coast within latitudes 21°30' - 22°10' S and longitudes 35°22' - 35°30' E. They are situated in the province of Inhambane, between the districts of Vilankulo and Inhassoro.

Fig. i: Map showing the Bazaruto Archipelago in relation to the Mozambique coastline.

The archipelago was formed from the present Cabo Sebastiáo Peninsula about 7 000 years ago and has a wide range of terrestrial and marine habitats including coastal sand dunes, rocky and sandy shores, coral reefs, mangrove forests and seagrass meadows. These habitats provide refuge for a great variety of plant and animal species. Over 180 species of birds, 45 species of reptiles, and 2 000 species of fish have been recorded here.

While the more than 2 000 island people are part of the overall Tsonga ethnic group whose distribution extends from Save River southwards, there has been considerable influence from other communities. Most prominent was the immigration of people from the mainland during the war years when the relative safety of the Bazaruto Archipelago attracted many thousands of refugees, thereby placing huge pressure on the natural resources. Tourism and the influence of other cultures have also changed lifestyles, especially with the introduction of new fishing technologies and the high demand for products from Asian markets – such as sea cucumbers.

Artisanal fishing with traditional methods is the main economic activity for more than 70% of the local population. The islands have a long history of artisanal fisheries, evident from age-old middens containing clay pottery and a variety of shells. As many as 60 fishing camps may be found in the archipelago, providing either fresh seafood to communities and tourists or dried products which are sold and bartered with mainland people. Although tourism to the Bazaruto Archipelago can be traced back to the 1950s, recent upgrading and new developments of hotels and resorts indicate a growing industry. Cruise ships also visit the archipelago, with more than 5 000 visitors being transferred to its beaches every year.

Historically, a limited number of scientific investigations have focussed on Bazaruto. Preliminary documentation of the avifauna took place in the late 1950, in 1969, Tinley proposed the creation of a national park around Santa Carolina Island (previously Paradise Island) to protect the vulnerable dugong population and turtle records were first collected in 1974 (Hughes a & b). However, the most significant investigation was launched in the late 1980s when Dutton and Zolho (1990) initiated their work towards developing a Conservation Master Plan for the Bazaruto Archipelago. The project was funded by World Wide Fund for Nature (WWF), scientifically guided by the Oceanographic Research Institute (ORI) and implemented in close collaboration with the Mozambique authorities, especially the Direccao Nacional de Florestas e Fauna Bravia (DNFFB). The work of Dutton and Zolho (1990) has provided a significant basis for this publication. Many of the chapters in their report were written by experts and wherever possible, these individuals were asked to update their original work. Besides updating of the information several new areas were added, including recent legal status, early shipwrecks and archaeology and seagrass habitats.

A key element in achieving success in MPA development is to raise the level of awareness of MPAs and to disseminate information to as many stakeholders as possible. In the past such information on the Bazaruto Archipelago was not freely available. It is hoped that this report, both in printed and electronic form, will stimulate more interest in the Bazaruto Archipelago and contribute towards achieving the regional objectives of protecting Mozambique's natural heritage.

The Bazaruto Archipelago first enjoyed some legal protection in 1971. Subsequently the protected area was enlarged and the legislation strengthened. Support from government institutions and NGOs, especially WWF, have contributed enormously to improving the archipelagos' protected status. However, considerable threats remain. Aside from the customary pressures brought about by fishing, tourism and associated waste management, there is also the increased threat posed by oil and gas exploitation. If hydrocarbon resources are indeed found in the region, it will require a very concerted effort to minimise impact and to allow the archipelago to retain its unique status in the region's MPAs.

As a visitor or student to the Bazaruto Archipelago, the authors hope that this informative guide will make your visit all the more rewarding. Any additions and corrections to the text will be gratefully received.

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INTRODUÇÃO E RESUMO

A Ecoregião Marítima da África Oriental (EMAO) estende-sa do ponto norte da Somália até o Cabo na África do Sul. É uma das dez ecoregiões marítimas do mundo que foi escolhida para proteção especial devido á sua biodiversidade e variação de habitats. Ao longo da costa da EMAO que tem mais de que 5000 quilómetros e dentro da sua área oceânica de meio milhão de quilometros quadrados, foram identificados um total de 21 zonas de conservação altamente significativas (WWF 2004). Nove destas zonas são localizadas em Moçambique, quatro do quais são de preocupação global. Signitivamente, o Arquipêlago do Bazaruto figura proeminentemente como uma zona crìtica, merecedora de proteção especial.

Em 2003, realizou-se em Durban, África do Sul, o 5º Congresso Mundial da UICN sobre Parques. Uma das mais importantes recomendações dessa reunião foi de aumentar e reforçar grandemente as áreas de proteção marìtimas e costeiras e, especialmente, de criar redes regionais de APM. A importancia de redes de APMs é que resultam numa conexidade entre regiões que permite a manutenção da migração de animais, tais como os peixes, tartarugas marítimas e mamiferos marinhos, da dispersção de larvas e de outros procesos biológicos importantes. Foi proposto que em 2012, o nível de proteção deve ter chegado a 20-30% (UICN 2003). Subsequentemente, a reunião dos países que assinaram a Convenção sobre a Diversidade Biológica (COP 7 & 8) açeitou um nível minimo de proteção de 10% até 2010. Semelhantemente, os APMs em zonas transfonteiras foram tambem identificadas como instrumentos importantes que podem vir a reforçar a proteção regional de biodiversidade e recursos. (www.transmap.fc.ul.pt; www.transmap-metadata.org.za). Moçambique, já tem feito um progresso significante a fim de atingirem estas metas, com proteção actual ou planeada de Palma, Quirimbas, Bazaruto e o complxo de Machangulo, entre outras.

Fig. i: Mapa mostrando o Arquipêlago do Bazaruto em relatção á linha da costa de Moçambique.

O complexo do Bazaruto é, sem duvida, umas das maiores histórias de sucesso das APMs e da conservação. Alem duma biodiversidade rica a de diversos habitats, é terra natal dum povo idigena que são sustentados pelos recursos do arquipêlago, enquanto os turistas deslocam-se, em grandes números, ás ilhas de avião e de navios cruseiros, atraidos pela belza natural do arquipêlago e duma vida marítima rica.

O Arquipêlago do Bazaruto e composto por cinco ilhas o maior sendo a Ilha do Bazaruto com aproximadamente 12 000 ha. Depois temos as Ilhas de Benguérua com 2 500 ha; Magaruque com 600 ha; Santa Carolina (prèviamente conhecida como Ilha do Paraiso) com 500 ha e a ilha minùscula de Bangué com cerca de 5 ha (Fig. i). Estas ilhas são localizadas até 20 km da costa de Moçambique entree as latitudes 21°30' – 22°10' S e as longitudes 35°22' – 35°30' E. As ilhas são situadas na província de Inhambane entre os distritos de Vilankulo e Inhassoro.

O arquipêlago foi formada, á cerca de 7 000 anos, da presente Península de Cabo Sabestião, e uma grande varição de habitats terrestres e marítimos, incluindo dunas arenosas costeiras, praias arenosas e rochosas, recifes de coral, florestas de mangal e campos de ervas marinhas. Estes habitats dão refúgio a uma grande variedade de espécies de plantas e animais. Mais de que 180 espécies de aves, 45 espécies de reptis e 2 000 espécies de peixes já foram descritos.

Enquanto as mais de que 2 000 pessoas da população das ilha fazem parte do grupo étnico Tsonga, cuja distribuição extende-se do Rio Save para o sul, tem havido uma influência consideravel doutras comunidades. A mais evidente resultou da migração de gente do continente durante dos anos da guerra quando a segurança relativa do Arquipêlago do Bazaruto atraiu milhares de refugiados assim pondo imensa pressão nos recursos naturais. O turismo e a influência doutras culturas tambem modificaram os estilos de vida da população, pricipalmente com a introdução de novas tecnologias de pesca e alta necessidade de satisfazer o mercado asiático de certos produtos marinhos tais como o pepino do mar (holotúrias).

A pesca artesenal, utilizando métodos tradicionais, constitui a principal actividade económica dos mais de que 70% da população local. As ilhas já têm uma longa história de pesca artesenal evidente atravez dos montes antigos de olaria de barro e conchas várias. No arquipêlago encontram-se cerca de 60 acampamentos de pesca que fornecem marisco e peixe fresco para a população local e para os turistas e produtos secos que são vendidos ou utilizado em troca com a população do continente. Embora o turismo para o Arquipêlago do Bazaruto já existia nos anos de 1950, recentes melhoramentos e novos desenvolvimentos de hoteis e lugares turisticos indicam o crescimento desta indústria. Navios cruzeiros tambem visitam o arquipêlago com mais de que 5 000 visitantes que deslocam-se ás praias todos os anos.

Históricamente, um número limitado de investigações científicas concentraram-se no Bazaruto. Estudos preliminares sobre a avifauna foram feitas nos últimos anos dos anos 50 e em 1969. Tinley propôs a creação dum parque natural a volta da ilha de Santa Carolina (préviamente conhecida como Ilha de Paraiso) para a proteção da populações vulneraveis de dugongos e tartarugas marítimas baseando-se nas informações colhidas em 1974 (Hughes a & b). Todavia, a investigação mais significante iniciou-se nos últimos anos 80 quando Dutton e Zolho (1990) começaram o seus estudos que tinham como objetivo o desenvolvimento dum Plano Mestre de Conservação para o Arquipêlago do Bazaruto. O projeto foi subsidiado pelo 'World Wide Fund for Nature' (WWF). A direção científica foi dada pelo Instituto de Investigação Oceanográfica (ORI) e o plano foi implementado em colaboração streita con as autoridades de Moçambique, especialmente a Direçãoção Nacional de Florestas e Fauna Bravia (DNFFB). O trabalho de Dutton e Zolho (1990) contribuio a parte principal desta publicação. Muitos dos capítulos deste relatório foram escritos por peritos e, sempre que possivel, os peritos tiveram a oportunidade de pôrem em dia os seus trabalhos originais. Alem da atualização das informações vários novos aspetos foram adicionados, incluindo a recente situação legal, antigos naufrágios e habitats de ervas marinhas.

Um elemento chave que ajudou no êxito do desenvolvimento do APM foi o aumentar do nível de conhecimento das consequências dos APMs e a divulgação da informação ao maior número possível de entidades interessadas. A esperâça é que este relatório, tanto na sua forma impressa como eletrónica, vem a estimular mais interesse em protegir a herança natural de Moçambique.

A primeira vez que o Arquipêlago do Bazaruto foi protegida por lei foi em 1971. Subsequentemente a área sob proteção foi aumentada e a legislação adquiriu mais força. O suporte de instituições governamentais e não governamentais, especialmente o WWF, têm contribuindo enormemente para o melhoramento do estado de protecção do arquipêlago. Todavia, consideraveis ameaças ainda existem. Alem da pressão usual vinda da pesca, do turismo e dos problemas associados com o tratamento do despridício, existe a nova ameaça vindo da exploração de petróleo e gás. Se os recursos de hidrocarbonetos forem descorbertos nesta região será necessário um esforço concentrado para minimizar o impacto e para permitir que o arquipêlago continua a manter o seu estado único nas APMs da região.

Como visitante ou estudante ao Arquipêlago do Bazaruto, os autores esperam que èsta guia informativa vem ajudar a fazer a sua visita ao arquipêlago mais interessante e valorizada. Qualquer adicionamento ou correcção será bem recebido.

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PART 1

THE ENVIRONMENTAL SETTING

CHAPTER 1

GEOMORPHOLOGY AND THE TERRESTRIAL AND OCEANOGRAPHIC SETTING

Geomorphology and evolutionary processes involved in the formation of the Archipelago

The Bazaruto Archipelago is situated onshore from the Mozambique coastal plain, which is largely composed of ancient delta deposits of the Rio Limpopo and Rio Save. The Bazaruto Archipelago is located south of the modern delta of the Rio Save.

The east coast of Africa has experienced a recent sea level history similar to other tectonically stable parts of the world. These sea level changes strongly influenced the geomorphological development of coastal areas. Particularly important in this regard is the documented occurrence in South Africa, Mozambique and Tanzania of a post-glacial high sea level rise of about 2m 5 000 to 7 000 years ago. The previous time the sea level was higher than its present level was approximately 120 000 years ago, during the last interglacial period.

The formation of barrier islands has been the subject of considerable debate, but they are common around most of the world's coasts. The islands appear to form during a period of relatively stable sea level and probably emerge as a result of wave action. Once they are exposed, additional sand is added to them, intertidally, to form a linear island feature, backed by a sheltered lagoonal system and fronted by the open sea. When sufficient sand has accumulated by wave action, prevailing winds begin to transport sand around and form sand dunes aligned perpendicular or parallel to the prevailing or strongest wind direction.

Once the dunes have been established, rain water, which is slightly acidic, passing through the dunes and upper beach areas dissolves calcium carbonate in shell fragments and carries it downward through the porous sand. The ground water now saturated with calcium carbonate, flows towards the sea and when it mixes with the more alkaline seawater, calcium carbonate precipitates between the sand grains. Precipitation of cement is triggered due to a rise in pH of the ground water at the seawater/freshwater interface. In this way the sediment just below the low-water mark is cemented to form beachrock. Beachrock that occurs at different depths is generally a good indicator of the changes in sea level that have occurred in the past. Movement of the island is therefore clearly indicated wherever the modem shoreline is located some distance landward of a beachrock outcrop.

In the Bazaruto Archipelago, there were two main phases of island formation. The first appears to have taken place about 120 000 years ago when Santa Carolina was formed by the processes outlined above. Submerged beachrocks north of Santa Carolina probably represent an eroded extension of this former barrier island chain. Evidence for this older island chain comes from the elevated beachrock outcrops on Santa Carolina which were formed at a higher sea level.

After the formation of Santa Carolina the sea level fell and, when it rose again, a new barrier island stabilized in the position of Bazaruto, Benguérua and Magaruque. This took place between 7 000 and 5 000 years ago. The islands have subsequently been modified by modern conditions. It is most probable that they were formerly a continuous sand body, possibly joined to the mainland in the south. The breaks between the islands are probably the result of particularly severe tropical cyclones. A similar process, under hurricane influence, is responsible for forming inlets in the barrier islands of the Gulf of Mexico.

The islands of Bazaruto, Benguérua and Margaruque have been transported landward in the past 7 000 years. Since the original island formation, the central to southern margin of Bazaruto together with the northern sand-split have migrated towards the mainland at an assumed rate of 600 m/1 000 years. Evidence for this is found in the exposed beachrock at Two-Mile reef, which was the shoreline. Most of the other reefs (for example, Coral Gardens) are also formed on exposed beachrock which marks the former shorelines but, in these cases, the distance that the islands have migrated are considerably smaller. Sand contained in the extensive sand dunes probably originated on the now eroded beach sections.

Bangué appears to have a different origin to the other islands and seems to have arisen through wave action causing a part of the flood-tidal delta to emerge. Since these deltas formed only after the main island chain, Bangué is the youngest of the islands in the Archipelago and is probably no more than 3 000 to 4 000 years old at most.

Hydrology

The area's water storage capacity is low. Fresh water lakes are present on Bazaruto and Benguera and the major storage area for groundwater on the islands is in the dunes. However, because the dunes are relatively small and the islands comparatively narrow, the storage capacity is small and seawater will be encountered at shallow depths. The dune aquifer probably has a rapid recharge rate after rains, owing to the porous nature of the sand. However, given its small volume, it will be susceptible to faecal contamination with increased habitation.

Climate and precipitation

The climate in this region is moderately humid, the average annual temperature on the islands is 24°C (summer maximum is 30°C and the winter minimum 18°C) and the average annual precipitation is 978 mm (ranging from 466 to 1928 mm) (Enosse 1998). The archipelago's rainfall is dominated by two climatic systems: the Indian Ocean Subtropical Anticyclone System of the SE Trade Wind Zone from the Zambezi River southwards, the rains falling with the passage of the depressions; and the southern end of the East African Monsoonal System.

Wind, storms and hurricanes

The energies generated by these elements are most important in shaping coastlines by direct ablation and deposition, and indirectly their effect on wave form, ocean currents and longshore drift. The annual average occurrence of hurricanes in the Mozambique channel is 3.1 with the heaviest concentration down the west coast of Madagascar. In fifty years twelve high intensity hurricanes and thirty eight medium intensity hurricanes have occurred in the region. On one occasion during October 1989, a violent but brief windstorm cut a 40 m wide path of destruction through the Bazaruto Lodge Complex.

The oceanographic setting

The Bazaruto Archipelago is washed by the south flowing Mozambique Current, which is fed tropical surface water by the Equatorial Current. Current velocities of up to 2 m/sec have been recorded. The temperature of the water ranges from 23°C in winter to 27°C in summer and salinity ranges from 35.4‰ in winter to 34.7‰ in summer. The open ocean littoral of the archipelago experiences extremes of low and high tides approximately 40 minutes ahead of Durban. The average tidal amplitude is about 3 m during normal spring tides with 4.39 m being measured during the equinox of 9 March 1989. Richards Bay, in comparison, recorded 2.34 m equinoxial tide during the same period. The tidal ranges at spring tides produce strong currents in the channels between the islands. These currents have transported large quantities of sand to form extensive flood and ebb-tidal deltas. These currents also maintain the deep channels on the landward side of the islands and transport sand across the tidal flats. Wave action is restricted to the seaward margin of the islands and prevents the formation of extensive tidal flats in that area. The back-barrier area is sheltered from direct wave action and this produces tranquil, low energy conditions.

CHAPTER 2

GEOLOGICAL EVOLUTION AND PALAEOENVIRONMENTS OF THE BAZARUTO ISLAND ARCHIPELAGO

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The Bazaruto barrier island archipelago comprises a chain of four islands extending ~70 km north of the mainland peninsula of Cabo São Sebastião. The islands are separated by tidal inlets linking the 10-26 km wide back barrier lagoon with the Indian Ocean. The islands within the archipelago have a similar geological history, though individual islands expose different areas of beachrock and dune sand bodies that reflect the influence of sea-level fluctuations and changing environmental conditions.

The coastline near Vilanculos is cliffed in places exposing yellowish-red dune sand which extends westward beneath the coastal plain. The broad expanse of cover sand conceals much of the bedrock geology which provides insight into the early evolution of the continental margin. Detail of the geological history of the bedrock strata is known from deep boreholes drilled in the search for oil and gas beneath the coastal plain (Flores 1973, Förster 1975).

The ancient igneous and metamorphic rocks at great depth beneath the islands date back to the period spanning ~1 350 to 530 million years ago (My), similar to parts of Madagascar and Eastern Antarctica. Since the rifting and breakup of the supercontinent Gondwana which created the African continent over 140 million years ago, the Indian Ocean margin of the continent has been influenced by dramatic movements of the earth's crust and sea-level fluctuations. The region west of the Lebombo Mountains, between the Limpopo and Save Rivers, accumulated thick deposits of sediment laid down by river systems draining the newly emergent African continental interior. The land subsidence continued within the Zambezi rift valley and the recent large earthquakes in the Save River valley highlight the continuing influence of deep crustal movement below the southern end of the African rift system.

The proto-Indian Ocean rose onto the continental margin by 125 Ma depositing marine silts. During the Palaeogene and Eocene (65.5–34 Ma) up to 700 m of marine limestone and marl accumulated in a marine environment reminiscent of the present day Bahaman Banks. Dramatic lowering of sea-level led to deposition of thick marine silts during the Oligocene to early Miocene (34–23 Ma). An interesting anomaly restricted to the Temane area south of the Save River is the lagoonal evaporite deposits containing layers of gypsum and anhydrite. The sea-level rose again during the middle Miocene (~12 Ma) by at least 45 m along the eastern seaboard of southern Africa, depositing limestone bearing corals, now exposed in a broad zone west of Vilanculos/Temane. It is possible that the soluble evaporate and limestone strata underlying the coastal cover sand succession could have given rise to the distinctive circular lakes in the Vilanculos area.

The significantly higher sea-levels that periodically extended onto the mainland ended with the lowering of sea-level during the Pliocene, starting about 5 million years ago. During the last 2.4 million years there have been numerous short-term, rises and falls of sea-level that influenced the development of the islands forming the archipelago. These cyclical changes were due to periodic variation in the earth's orbit around the sun and axial tilt/rotation that forced global changes in solar radiation that caused cyclical advance/retreat of polar icecaps.

Pleistocene to Holocene geology of the Bazaruto Archipelago

During the last ~2.4 million years there have been numerous "ice ages" that influenced the extent of polar icecaps and glacial ice cover in the northern hemisphere. During each ice age, large amounts of freshwater are locked up in glaciers and ice-sheets, leading to a significant lowering of the global sea-level. For example, during the last ice age or "Last Glacial", global sea-levels were c.125 m lower than they are at present. Sea-levels have been lower than present for over 85% of the last 200,000 years (Ramsay 1999) precluding the deposition of marine sediments on the Bazaruto Archipelago islands for much of this time. Analysis of long-term variations in sea-water chemistry has allowed detailed records of global sea-level changes to be reconstructed. As global climate and therefore sea-level changes, the isotopic composition of the sea-water also changes, and hence the geological history of the last 2.4 million years is divided into units, termed Marine Isotope Stages (MIS). These stages, along with the ice age (glacial) and interglacial climates they record are used to describe the periods during which the Bazaruto Archipelago was being formed or modified.

Sea-level fluctuations over the last ~130 000 years are of particular importance when investigating the geological history of the Bazaruto Archipelago. Sea-level reached a maximum of about 5 m higher than the present during the height of the Last Interglacial around 125 000 years ago, and at least one other short period of sea-level rise occurred around 100 000 years ago. Sea-level then fell as the northern hemisphere ice cover intensified, with the Last Glacial Maximum low sea-level of -125 m occurring around 18 000 years ago. As the last ice age ended, polar icecaps melted and sea-levels rose rapidly, reaching approximately present day elevations around 7 000 years ago.

The sea-level changes described above caused large dune sand bodies to accumulate on the Mozambican coast. The Bazaruto Archipelago is entirely composed of ancient beach and coastal dune sands, some of which have been "cemented" into hard sandstones over time. Precise assessment of dune forming episodes which formed the Bazaruto Archipelago is based on the first optically stimulated luminescence (OSL) dates produced in this part of Mozambique (Armitage 2003, Armitage *et al.* 2006). This technique allows geologists to determine the length of time that has elapsed since grains of dune sand were last exposed to sunlight. OSL dating therefore allows the determination of the age of ancient beaches and dune deposits forming the islands, and in turn to relate sand dune formation to past climates and sea-levels. The Bazaruto Archipelago has a complex history which is related to two main periods.

Last Interglacial; MIS 5

Cemented dunes on Santa Carolina Island and parts of Bazaruto Island suggest the existence of a more extensive barrier island. The embayment north of the lighthouse on

Bazaruto and Lighthouse Reef exposes calcified medium to fine-grained dune sands (aeolianite) (Fig. 2.1). These sands preserve steeply dipping lamination which indicates that they were deposited as part of active wind-blown sand dunes. Similar deposits form the cliffs at Ponta Goane. The cementation of the original sands is the result of partial dissolution of shell fragments as acidic rainwater passed through the dunes. This cementation rendered the dunes resistant to coastal erosion processes, which accounts for the preservation of such rocks on promontories forming the southern points of embayments (Fig. 2.2).

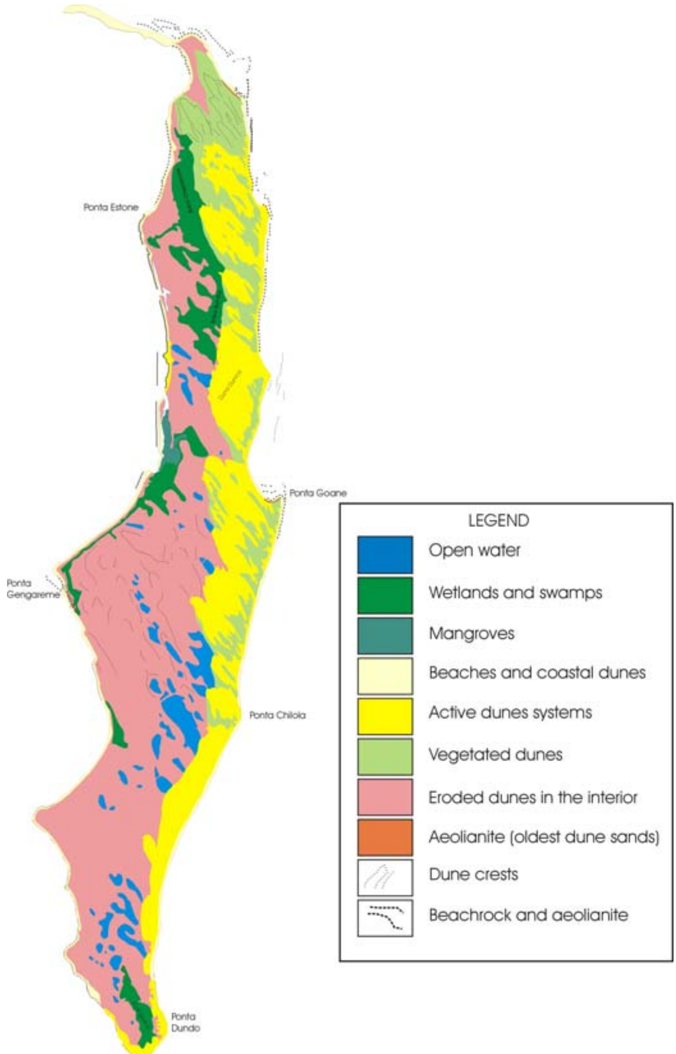

Fig. 2.1: Geological map showing the distribution of aeolianite and beachrock reefs and cliffs as well as dune sand deposits of a variety of ages forming Bazaruto Island.

Fig. 2.2: Cemented dune deposits (aeolianite) forming cliffs near Ponta Goane. The rock shows characteristic dune stratification. A reddenend weathering profile formed caps the cliff.

Penetration of roots leads to cementation around root structures forming rhizoliths. Weathering causes development of circular solution cavities that extend deep into the rock. The decalcified fill is commonly reddish residual quartz sand, well exposed in the cliffs at Ponta Goane (Fig. 2.2). A luminescence date of 128 000±100 yrs before present (B.P.) was obtained by analyzing the basal yellowish-red dune sand unit exposed in the cliff south of Ponta Gengareme (Zingarema) point on the western side of Bazaruto (Fig. 2.3). A date of 90 000±580 yrs was obtained from the aeolianite forming the northern tip of the island. These dated rocks indicate that the older elements of Bazaruto were deposited during periods of rapid sea-level change (Fig. 2.4) which occurred in the Last Interglacial (Marine Isotope Stage (MIS) 5), a warm period that coincided with a 5°C rise in sea-surface temperature (Shackleton *et al.* 2003).

Fig. 2.3: Sand cliffs forming the western shoreline south of Ponta Gengareme (Zingarema). Stacked dune sand units exposed here accumulated episodically from 128 000 to 2 000 years ago.

The climatic optimum lasted from ~128 000 to 116 000 yr B.P. (Muhs 2002) and is commonly associated with beach deposits at elevations of 5-6 m above present mean sea-level at localities along the southern African coastline (Fig. 2.4). Sea-level was lower than the present at the start of MIS 5 so it is possible that older cemented dunes underlie the weathered dune sand beneath the Ponta Gengareme (Zingarema) cliffs. Detailed records of long-term climate change during this period have been obtained from ice cores on Antarctica. These more continuous records highlight the high frequency of global climate and environmental change that occurred but is not recorded in the coastal dune record in the Bazaruto area. The aeolianite core of the windward coast of Bazaruto represents the period after a rapid lowering of sea- level from ~116 000 to ~110 000 yrs B.P. until the latter parts of MIS 5 about 75 000 yrs B.P.

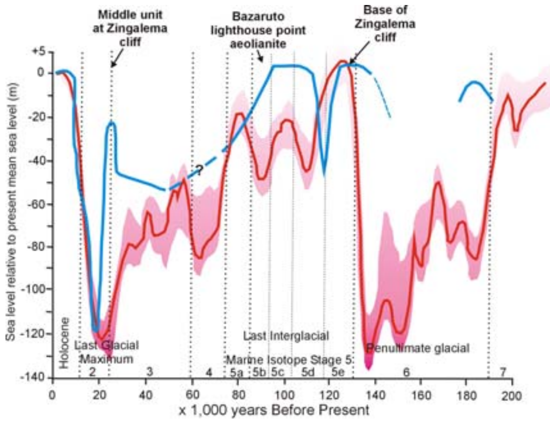

Fig. 2.4: Sea-level fluctuations over the last glacial cycle. A global sea-level curve with confidence limits is compared to the composite sea-level curve derived by Ramsay and Cooper (2002) from the southern African coastline. Date sites on Bazaruto Island are indicated relative to the project sea-level at the time of dune accretion on the island.

Last Glacial Maximum / Late Pleistocene Hypothermal; MIS 4 – 2

During the ~55k yr period of environmental cooling and lowered rainfall as sea-level fell to -125 m during MIS 4 – 2, the ancient core of the Bazaruto islands and the back barrier lagoon/tidal flats became part of the mainland. Along the Maputaland coast of South Africa, Ramsay (1996) described a series of four submerged coastlines at depths down to -95 m msl that record short stillstands during the retreat of the shoreline across the exposed continental shelf. The coelacanths discovered in a deep canyon cut across the continental shelf near Sodwana Bay in South Africa are currently using caves eroded into ancient dune rock during that period when the coastline was at a depth ~125 m lower than present mean sea-level (Uken & Green 2006). Around 18 000 to 20 000 yrs B.P. during the Last Glacial Maximum, a period when thick ice sheets covered much of Europe, North America and Asia, sea-level reached a lowstand of -125 m. The mammal and herpetofauna of the islands are species common on the mainland. This is not surprising since the area covered by the present islands has been part of the mainland for much longer periods during the Pleistocene than the relatively short interglacial periods when they were isolated by rising sea-level to form islands.

The question that inevitably arises is whether there was significant sand accretion onto the exposed island core during lowstands in sea-level, or were dune systems mobilised as a result of rising sea-level. The middle section of the yellowish red sand exposed in the cliff south of Zingarema did accumulate around 24 400±2,100 (Aber/29-BA13) years ago (Armitage 2003, Armitage *et al.* 2006) when sea-level was much lower. These dunes probably represent local reworking of the weathered older dune sands below. Remobilisation of old dune sand occurred on the Maputaland coastal plain during the same period (Porat & Botha 2008).

The climate of the coastal area was influenced by altered atmospheric circulation patterns during MIS 4 –2 and the expansion of sea ice around Antarctica which displaced the circum-Antarctic westerly winds equatorward led to cooler, drier conditions over the summer rainfall region of Southern Africa. The climate, recorded in cave stalagmites (Holmgren *et al.* 2003), preserves evidence of climatic variability during this period when the eastern margin of Southern Africa experienced a mean temperature of ~ 5-6°C lower than the preceding interglacial or the subsequent Holocene period. After the coldest phase of the last glacial period, drastic climate change resulted in a period of melting of high latitude ice sheets and polar ice caps and the rapid rise in sea-level during the "Flandrian" marine transgression.

The Holocene; precursor to the present environments

The Holocene epoch encompasses the past ~12 000 years of earth history. Evidence for dune mobility on Bazaruto during this period was derived from the crest of a degraded parabolic dune forming the undulating topography west of Ponta Goane (Fig 2.5). The low-lying areas west of the currently active barrier dune ridge is a degraded parabolic dune system with well defined interdune depressions now flooded by rising groundwater to form lakes or seasonal pans. The interior dunefield of Bazaruto Island began forming as the sea-level rose against the ancient dune core of the island, mobilising sand along the shoreline and driving it onto the islands around 8 370±540 (Aber/29-BA10) years B.P. (Armitage 2003, Armitage *et al.* 2006). The yellowish red sands forming the eroded dune limbs and the NNE–SSW aligned interdune depression lakes suggest deposition of this dune system by the same wind regime that maintains the northwestward advance of the high barrier dune. There is a strong link between sea-level and groundwater levels in coastal dune fields, providing an additional control on the age of the dune system relative to sea-level at the time of sand accumulation. The flooded depressions now occupied by deep lakes in the central region of the island suggest that the regional water table, and sea-level, was significantly lower at the time of dune formation (Fig. 2.4). Sand continued to accrete on other parts of the dune system until recently as indicated by a buried topsoil horizon dated at 4 020±460 yrs

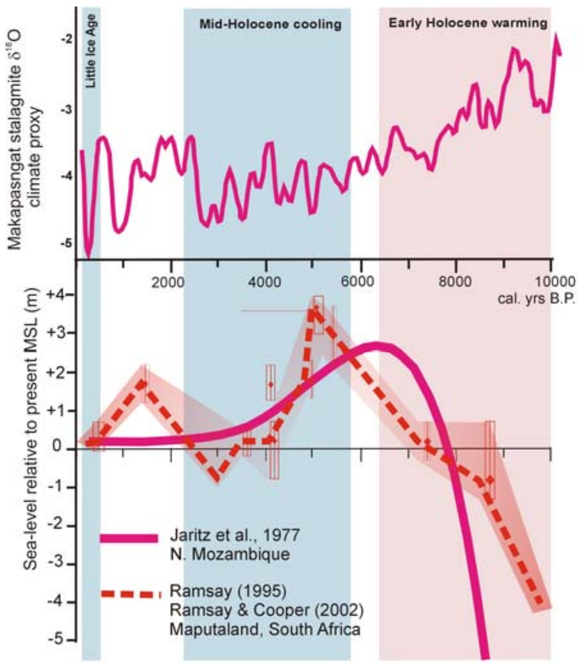

Fig. 2.5: Comparison of the Holocene sea-level curves derived from northern Mozambique (Jaritz et al. 1977) and Maputaland, South Africa (Ramsay & Cooper 2002) with the high resolution stalagmite climate proxy record from northern South Africa (Holmgren et al. 2003). The inset shows the longer term sea-level change over the last glacial cycle compared with a temperature proxy record derived from the Vostok/Taylor Dome ice core in Antarctica.

B.P (Aber/29-BA12), covered by surficial dune sands (2 410±320 yrs B.P (Aber/29-BA11) on the western side of the island.

Mid-Holocene sea-level highstand

The return of sea-level to that of the present occurred around 7 000 years ago (Cooper 1991, Ramsay 1995) but then continued to rise until about 6 000 years ago. It is this rapid rise in sea-level that was the most dominant geomorphic influence on the Bazaruto Archipelago. Ancient shorelines at various depths on the continental shelf were submerged to form reefs. The distinct line of reefs off the eastern margin of the islands, such as Two-mile Reef, are formed of beachrock that marks the former sea-level before shoreline erosion mobilized sand that accreted as parabolic dunes moving westward over the old dunes forming the core of the island. The "precipitation ridge/retention ridge" formed through coalescing parabolic dunes forms a steep slip face that has advanced over the old degraded dune landscape.

The sea-level curve derived for the Mozambique coast was published by Jaritz *et al.* (1977) on the basis of 20 radiocarbon dates from the northern coast (15° to 19° S). This curve (Fig 2.5) shows the rise in relative sea-level from -60 m at 10 000 years ago, reaching the present mean sea-level around 7 000 yrs BP, peaking at +2.5–3.0 m around 6 000 yrs BP, before receding slowly to reach present levels again between 2 000 and 1 000 yrs B.P. The Mozambican sea-level change record is similar to the more recent curves derived for the South African coastline (Jaritz *et al.* 1977, Ramsay & Cooper 2002).

It is likely that the swamps and wetlands that occupy the eastern side of the island, separated from the sea in the west only by low foredunes, are the remnants of a back barrier lagoon or mangrove swamp system that was formed during the mid-Holocene relative sea-level highstand. These former lagoons were isolated by mangrove swamps and low foredunes only recently when sea-level reached its present level some 1 000 years ago.

An interesting aspect of this Holocene sea-level peak is the possible influence of deep crustal movement related to the "unloading" effect caused by deglaciation and melting thousands of metres of Antarctic ice cover until 7 000 yrs B.P. Late Holocene relative sea-level highstands of up to +3.5 m are endemic to equatorial ocean basins. The rise in sea-level above that predicted from the melting of Antarctic ice mass alone is ascribed to visco-elastic, isostatic readjustment of the earth's crust in areas far from the glacially-loaded polar region, causing an increase in relative sea-level. This is compounded by the steric expansion of sea water due to rising sea surface temperature in response to climate change during the Holocene "interglacial" epoch (Clarke *et al.* 1978, Clarke & Lingle 1979, Pirazzoli 1991, Douglas & Peltier 2002, Mitrovica & Milne 2002).

Further studies of raised sea-levels are necessary to refine the recent evolution of the Bazaruto Archipelago. Marine erosion features such as benches, pools, wave cut notches on cut into rocky promontories and sea cliffs formed of hard aeolianite can provide quite accurate sea-level data. Beach deposits, estuarine salt flats, lagoon floors, and coral deposits are less precise indicators. Reliable elevation and age indicators are marine organisms in growth position e.g. vermetid gastropods and barnacles.

The Bazaruto island landscape

The preceding sections have demonstrated how the Bazaruto and mainland landforms are related to events influenced by global environmental change over at least the past 125,000 years. The existence of elongate lakes within the undulating interior is due to the ravages of time on the ancient dune landscape and rising groundwater. Only small remnants of the ancient core of the islands are preserved beneath cover of young dune systems. Additional interpretive detail of the different land forms and dune sand deposits of the island chain are provided below.

Barrier dunes

A series of beachrock ridges preserved in the sub-tidal zone around the island trace the former shoreline of the islands as defined by the ancient dune core as sea-level rose over the past 10 000 years. The present shoreline and growth of the eastern barrier dune complex has been created through coastal erosion in response to the rising sea-level of the past 6 000 years (Fig. 2.5). Mobilization of continental shelf sand and beaches during the marine transgression, and sediment transport in the littoral zone by longshore processes along the high energy eastern shoreline, provided abundant sand that was driven inland off the beaches by strong prevailing southerly winds. Parabolic dune systems coalesced to form the high windward barrier dune ridge along the eastern margin of Bazaruto (Fig. 2.6). This composite parabolic dune system is active in the broad embayment extending from the southern point of the island to Ponta Chilola (Fig. 2.1). The dunefield widens to the north and the distinctive 'hairpin' shape of the extended parabolic dunes is highlighted by sparse vegetation growth. The degree of vegetation stabilization of the dunes increases northwards and the two largest, scrub covered parabolic dunes that reach the western coast near Bazaruto Lodge were still prograding actively within the past 100 years (Armitage 2003).

Fig.2.6: Degraded dune topography forming the central part of Bazaruto Island. The interdune depressions have been flooded by rising groundwater and late Holocene parabolic dunes have migrated across the older dunefield.

The development of the narrow extended parabolic dune form is strongly influenced by vegetation cover. After creation of a localized "blowout" hollow, probably close to the foredunes, sand is blown from the depression forming a dune "nose". Sand deflated from the hollow is deposited on the nose, cascading down the advancing slip face, with lesser sand deposition on the flanks creating slip faces that migrate outwards at a slower rate. As the apex of the dune migrates downwind the dune limbs are commonly stabilized by vegetation. The SSW–NNE pattern of dunes forming the 90 m-high barrier suggests the dominant influence of the southwesterly wind regime over the period of sand movement. In this way parabolic dunes can ascend the windward slopes of older dunes systems and the combined effects of lateral and downwind migration leads to coalesced dune forms which create the transverse slip faces that migrate over the lower-lying old degraded dunes and interdune depression lakes to the west (Fig. 2.6). Reduction in sand supply from the inter-limb due to fluctuation of the shallow groundwater zone can stop parabolic dune migration, as will vegetation cover, which implies a strong link between climatic factors and dune formation.

Beachrock

The submerged "reefs" forming a chain that extends north from Two-Mile Reef represent a former island shoreline created soon after sea-level returned to near present levels (Cooper 1991). Beachrock results from the cementation of sandy beaches by infiltrating rain water that dissolves fine shells as it percolates, precipitating the dissolved carbonate at the interface between fresh and saline water at depth. Cementation of the beach is facilitated by intertidal wetting/drying cycles. Beachrock deposited against the old aeolianite core at Ponta Ganhala represents the northern limit of the ancient shoreline which formed at 7 300±790 yrs B.P. (Aber/29-BA2). Sea-level continued to rise thereafter causing erosion of the island core sediments and movement of the shore towards the west. The Holocene sea-level curve presented in Fig. 2.5 shows that the present sea-level was attained once again around 1,000 years ago after regressing from a high of +3 m msl (Ramsay 1995).

The bioclastic beachrock found in the intertidal zone at Vilanculos yielded radiocarbon ages of 910 $^{+120}_{-140}$ and 920 $^{+140}_{-150}$ yrs B.P. (Siesser 1974) showing how these cemented beach sands can protect shorelines from erosion (Fig. 2.7). The stabilization zeta-form embayment shoreline north of Ponta Goane also occurred around this time; shown by the beachrock that was luminescence dated at 930±90 yrs B.P. (Aber/29-BA8) (Armitage 2003, Armitage *et al.* 2006).

Beachrock deposits survive submergence and the characteristic low angle sloping form can be seen in the calcified beach deposits forming the core of shallow coral reefs.

Fig. 2.7: Beachrock armouring the beach on the western shore of Bazaruto Island. Older beachrock and aeolianite formed during periods of lower sea-level creates submerged reefs defining former shorelines along the eastern margin of the island.

Raised mangrove swamps or tidal flats

At the southern point of Bazaruto Island, recent parabolic dunes have prograded onto the flat surface of Baixa Lenguana. In the north, the Baixa Bumba/Chebobone wetland complex comprises organic-rich sands and poorly drained reed/sedge swamps. These interdune wetlands were probably linked to marine inlets during the mid-Holocene sea-level highstand around 5 000 years ago. The intertidal sands, mangroves and supratidal saline flats were abandoned as the sea regressed and isolated by coastal erosion and foredune development. The extant mangrove swamp and saline flats on the bay shoreline west of Ponta Goane probably represent a remnant of more extensive tidal inlets formed by flooding of the interdune area of early Holocene parabolic dunes forming the island interior.

Foredunes

Irregular hummocky and reversing transverse dunes define the foredunes lining the top of the beach face around the islands. These fragile dune forms develop where sand blown off the beach has been stabilized by pioneer vegetation above the level of spring high tide and storm surge swash. The sand represents the finer sand fraction and shell fragments winnowed from the beach face by the prevailing winds. The foredunes are destabilized periodically by wave incision of the steep reflective beach during storm events or where wind erosion is focussed by reduction in vegetation cover. Evidence of extreme storm events is preserved in the slack behind the foredunes along parts of the eastern shoreline where marine debris, including pumice drift clasts, accumulates and is concentrated as a lag deposit by sand winnowing. The foredunes also supply sand to the parabolic dune systems that ascend the coastal barrier dune along the eastern side of the island.

The characteristic striping in calcified dune deposits is defined by the dune slipface deposits that are commonly inclined at up to 32°. These bedding planes influence the form of submerged dunes forming coral reef substrate along the Bazaruto coastline. The form of overhangs and caves are often influenced by the thinly bedded nature of the inclined aeolian sand bedding planes (Fig 2.2).

On the lee of the island, low irregular foredunes occur above the high spring tide level between the outlets from mangrove creeks and supratidal salt flats. South of Ponta Estone a back barrier wetland has been created parallel to the beach by foredune development. The relationship between the dunes and the low lying wetland in the centre of the northern part of the island was demonstrated after high rainfall flooded the Baixa Bumba/Chebobone wetland and groundwater seepage from the surrounding dunes raised the water level in the central wetland which decanted through low points in the narrow fordunes. Large washouts created breaks where the foredunes slumped due to rising groundwater pore pressure. The resultant scour created a wide channel that retreated inland due to headcut erosion by water cascading from the raised wetland. As the channel lengthened and widened it was exploited by the sea during the following high spring tide. Unless longshore currents and dune formation heal the channel incising the foredunes this inlet might become a permanent estuary that will be lengthened during subsequent storm runoff events and will equilibrate with the mesotidal range of ~3 m (Dutton & Zolho 1990).

The future influence of sea-level rise

The luminescence dates derived from dune sand units forming Bazaruto Island and corroborated by dates from Inhaca Island to the south (Armitage 2003, Armitage *et al.* 2006) show that rising sea-level is the trigger that mobilizes dunes along the wave-dominated shorelines. The active parabolic dunes forming the eastern barrier dune cordon were probably initiated during the mid-Holocene period of high wind speeds during the sea-level highstand and have continued to accrete following the regression to present mean sea-level.

Long-term South African sea-level records indicate an absolute sea-level rise of 1.8 mm ±0.4 mm/yr that is comparable to global sea-level trends of 1.5 ± 0.35 mm/year for the 20th Century (Hughes & Brundrit 1992, Hughes & Brundrit 1995, Hughes *et al.* 1991, IPCC 2001). Recent estimates suggest an average rise of 3.0–0.7 mm/yr for the period 1993-2003 suggesting a modelled global sea-level rise of between 0.18 m and 0.59 m for the period 2090 to 2099 (IPCC 2007). The full impact of rising sea level will be felt most during periods when storm surf and surge coincides with the astronomically highest spring tides as was the case on the South African coast during March 2007.

Casuarina trees were planted on mobile dunes in an attempt to control the movement of sand across the active dunes. However, as the sand supply increases it is likely that this stabilisation technique will be unable to stop dune progradation on the eastern transverse ridge. The short term effects on the interdune lakes will not be significant. Where the dune slip face is prograding on the supratidal salt flats around the mangrove swamp, the increased tidal prism of rising sea-level should counter the burial of this habitat.

The radical changes in sea-level over the past 120 000 years and the very youthful nature of the Bazaruto Archipelago reinforces the delicate balance faced by life exploiting the littoral zone. The magnificent coral reefs that have colonised submerged dunes and beachrock palaeoshorelines close to the coast have only become established within the past ~5 000 years and must adapt constantly to the high energy shelf environment. A new threat comes in the form of future sea surface temperature (SST) increase and sea-level rise in response to anthropogenically-induced global warming. The bleaching of coral ecosystems by elevated temperatures over the past few years has been widely publicised. Coring of *Porites* coral domes on the South African coast has shown the progressive rise in SST during the past century. The coral domes preserve records of coral growth rates and climate proxy records, based on SST that can be derived from oxygen isotope ratios. The coral growth patterns also record evidence of freshwater incursions due to extreme river floods (Ramsay & Cohen 1997).

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PART II

<u>HUMAN IMPACT</u>

CHAPTER 3

ARCHAEOLOGY

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The earliest occupation of the Bazaruto Archipelago can be traced back to the beginning of the Iron Age (about 200-300 AD), with relics of settlements evident at Dundo (Pta Dondo), south-west of Bazaruto Island and at other settlements sites along the coastal dunes of the island. From a regional archaeological point of view, Bazaruto can be regarded as a very special case as it appears to have the only archaeological sites known for this period in all the islands of the South East African Coast (Anon 1980). The materials and artefacts found at these sites, suggest a connection of the Bazaruto sites with other coastal communities that at the same period were settled in between Vilanculos Bay, for example, the trading site of Chibuene developed in the later part of the first millennium AD. The recovery of Persian porcelain at Dundo, along with other pot shards found at various other archaeological sites in Bazaruto, suggest connections with a wider Indian Ocean commercial trading network. These artefacts are very similar to those found at Chibuene and other settlements around the Save River mouth, indicating the importance of the Save as a trading route. It is probable that the Bazaruto Archipelago was a part of one of the two oldest/first South East African Coast commercial centres. The first was the Mambone-Vilanculos Bay - Bazaruto complex around the mouth of the Save River and the second centre was located further north around Sofala Bay itself connecting the maritime trade routes of the Indian Ocean with the inland trade routes towards the interior African kingdoms.

Material evidence suggests that the communities that were settled in Bazaruto not only consumed, but also used for commercial purpose, the local natural resources (marine or others) and the Save River was the main “road” to reach the inland “gold” of African kingdoms (Beach 1980). Seed pearls, amber, tortoise shell, turtle carapaces and “female fish” (dugong) teeth became important goods for trade while the coastal areas in front of the islands, namely the so-called Vuhoca Coast were searched either for wood and resins or used for boat building and repair (Castro & Couto 1996; Neweitt 1997).

The link between this area and the Muslim cities of the northern coast like Kilwa, Mombasa or Malindi became progressively stronger (Barbosa 1516) and the first written sources describe the archipelago as a wealthy and prosperous area with important trade settlements of “black moors” strongly related either with the communities settled in the coastal area frontier to the archipelago, or with those of Sofala Bay. At that time the Bazaruto Archipelago was called *Húcicas Grandes* to distinguish it from the *Hucicas Pequenas,* the small and rich alluvial islands existing then in the delta of the Save River, also inhabited by communities of local “black moors”. People living in the *Húcicas Grandes* were mainly merchants while those of the *Hucicas Pequenas* were both farmers (agriculture and cattle) and traders. The former were probably the most important trade mediators in the area

Later on, at the end of the 16th Century, these communities came under the control of mulatto families from Sofala with the family of António Rodrigues being one of the most important. In 1589 he lived either on the islands of Bazaruto or in the lands edging the Monemone River near the coast. Since he owned both, he controlled all the distribution of goods and circulation of people in the area, as well as the boat building business. He was known as the only man that could provide food, boats and guides in this region and soon Bazaruto, though previously never a formal port of call, was frequented as a place were people (sailors, castaways, fishermen) could find supplies and support (da Silveira).

Meanwhile, crop and cattle stock farming also developed in the archipelago, mainly on Bazaruto and Benguérua, as both islands had important sweet water or very low salinity lagoons (Morais 1985). In the second half of the 17th Century, Bazaruto Island was known as the "island of Luís Pereira", another mulatto from Sofala, also in control of Quiloane Island, and rather well known in the area for helping Portuguese castaways trying to reach Sofala or Mozambique Island (Brito 1735). At the end of the century these families were also in control of the exploitation and trade of pearls and seed pearls in the region. These goods were traditionally traded in the Indian Ocean but were never intensively exploited by either the local communities or by the Portuguese once they had settled on the coast.

Only in the second half of the 17th Century did the Portuguese authorities start to show an interest in pearls and investigated these as possible trade items (de Martinho 1697; Newitt 1973). However, pearls and seed pearls were not seen as a priority for trade by the local people. According to their need for food and period of the year, people collected the oysters to eat. The local people did not dive for oysters and did not open them in a manner conducive to collecting the pearls – the most convenient way was to put them in the fire, which cooked and opened the shells but damaged the pearls and lowered the value that could be obtained when trading them. However, according to Ivens Ferraz, in special situations, like the famine of 1888, there could be a great increase in any of the fisheries for commercial purposes (Diaz 2001).

No matter the incredible descriptions of the skill of the "pearl fishermen" and the danger each collecting expedition involved, the results never provided the expected profits (Santos 1999; Ahu). Neither Portuguese crown projects of the early 18th Century, nor the expeditions of the second half of the century nor the establishment of the first company for pearl fisheries in Bazaruto, founded in 1891, were successful (Feliciano 1998; Diaz 2001). From the mid 18th Century on one can sense from documents that the archipelago was losing its regional importance. By the end of the 19th Century, the reports on the Islands underlined the loss of traditional authorities, the lack of people and the changing of their daily life. It is not possible to point out one single reason for this, many changes occurred in the region during the 18th Century, including long periods of drought followed by famines and epidemics, political, economic and social instability in the region and invasion by *vatuas* and *landins* (tribal groups). The contributing fact that the mulatto families of Sofala lost their power may also have had consequences for sustaining development in the area (Leisegang 1982).

It is not clear how these families lost their power but, in 1721, a local landlord called King Mucissa, was helped by the Portuguese in a fight against his brother and as a reward, Mucissa gave the lands of Vuhoca and Bazaruto to the Portuguese Crown.

These areas were the first land donations given by a local chief to the Portuguese in this area before the 19th Century (Silva 1844). Since that time, information on the Bazaruto Archipelago becomes rare and only scattered references are made considering these lands as part of the *Prazo Mambone*, mainly because the local people did not recognize the new landlords and refused to obey them or to help them against the invading *landins* (Botelho 1835) or even because the local *Prazeiro* made use of Bazaruto Island as a supply station for the slave trade (Ahu 1765).

In the 18th Century the slave trade was flourishing along the African Coast of the Indian Ocean and the French based on the Mascarenhas Islands got accustomed to frequenting the Mozambique ports where they were well known for their raids to capture slaves (Capela and Medeiros 1989). Bazaruto was no exception. Documents of the 19th Century report French incursions into the archipelago as well as the direct participation of Xavier de Ferrara - married to Maria Rodrigues who owned the *Prazo Mambone* - in the slave trade (da Silva 1884). According to da Silva, the French raids in the archipelago were responsible for the growth in anti-European sentiment that also affected the local populous' relationship with the Portuguese.

For similar reasons of slave trade, as in the case of other traders during the same period, the Dutch also made frequent stops at Inhambane and Cabo das Correntes (Ahu 1782).It is quite possible that when they were not successful there, they might have traded directly with Bazaruto. During this period many of the people that used to live in the archipelago felt threatened and became refugees living in the wooded areas on the mainland and only sporadically came back to fish or to collect oysters and seafood. In 1855, when the Portuguese authorities decided to found a *Presidio* on Santa Carolina Island (da Silva 1884), the archipelago was almost uninhabited.

Two years later, on 19 March 1857, the English ship "Ocean Query", linking Bombay to London, shipwrecked near the northern part of the archipelago. Some of the crew were given refuge at the *Presidio* and the others, including the captain and his son, reached Sofala by boat. This situation forced the Portuguese administration to reinforce the defence of the islands as the *landins* prepared an invasion to take possession of the salvaged goods. The planned invasion was not successful and the additional reinforcements did not result in more inhabitants on the islands.

An official report of 1886 mentions that the population of Santa Carolina Island was reduced to two merchants – a Brazilian and a Bathiá – living within a few "moradores" and 3 dozen prisoners guarded by a group of 12 soldiers and a commander while Bazaruto Island was completely uninhabited and Benguérua had a garrison formed by 6 soldiers and was visited only sporadically by occasional fishermen (Ferrari 1886).

In the late 19th Century, the Portuguese authorities initiated a plan to provide navigational support by creating lighthouses along the coast. Four of these were initially constructed, followed by a further 32 lighthouses that would provide comprehensive illumination of the Mozambique coastline. In 1913, the lighthouse on the northern tip of Bazaruto was constructed, providing for safety in shipping between Beira and ports to the south. The 26 m high stone tower structure, still stands today. Lighting was provided by a very large lantern that progressively turns with gravity on a threaded core to give the required lighting interval. The lens of the Bazaruto lighthouse was of the hyper-radiant Fresnel type, one of the very few ever made. Although the lighthouse is no longer operational, a visit to the lighthouse by walking up the dune is worth the effort and attests to the enormous energy that must have been expended by the local populous and the authorities in creating these structures. No doubt there are more archaeological findings to be made at the Bazaruto Archipelago.


The lighthouse on Bazaruto Island.
(Photograph by Michael Schleyer)

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CHAPTER 4

A BRIEF ACCOUNT OF THE PEOPLE OF THE BAZARUTO ARCHIPELAGO

This chapter is compiled by Rudy van der Elst and is largely based on the work produced by Consultoria em desenvolvimento Social, Maputo on behalf of Sasol's environmental impact assessment for offshore exploration in Mozambique.

It is believed that the original people that settled on the Bazaruto Archipelago are descendents of a Tsonga group of Ndau origin that migrated from north of the Save River in the 19th Century. These people probably originated from the Machanga region and other areas on the mainland opposite Bazaruto to escape from the Nguni invasions into part of Sofala and Manica Provinces at that time. The islanders are often known as the "Bazarutos" or "Mahoca" and speak a language known as "Xihoca" (or Xitsonga) which is a mixture of Cindau and Xitsua. Subsequent immigrations occurred during periods of civil war when mainland people settled temporarily on the relatively safe archipelago.

The people of Inhambane Province make up about 7% of the total population of Mozambique which is estimated at 1.4 million people. The Bazaruto Archipelago has a resident population that varies between 1 000 and 3 000 people. The demographics of the people in Inhambane Province are strongly influenced by the distribution of resources, agricultural land and fisheries resources. The social organization of fishers into Community Fishing Committees in each fishing centre along the coast is an influential institution that encourages the participation of men and women. On the islands, women and children at times crew in fishing boats where they actively participate in the collection of various marine products for subsistence and sometimes for sale. Fishers on Bazaruto appear to remain involved in their activities for many years, probably longer than in most other regions. Studies revealed that on the Bazaruto Archipelago islands and in Vilankulo most fishers said they have fished for more than 23 years.

The Tsonga people are typically coastal residents, and most fisher families on the islands are of the Mahoca ethnic group. Oral tradition recounts that the Mahoca groups brought the tradition of fishing to the islands and it is they who control the "spirits of the sea". Throughout Vilankulo, Inhassoro and the Bazaruto Archipelago coast, fishers carry out the "kuphatla" ceremony to call for spirits of the sea to provide good fishing, good weather and to avoid accidents. Normally this ceremony is made at the beginning of the fishing season. A net is cast in the sea and if the ceremony is successful a turtle will be caught in the net with other fish. A meal with the turtle and the fish is then prepared for all the people. Even on the mainland the chiefs call for families of Mahoca origin to lead ceremonies relating to fishing activities at sea. Among the families considered as having the most customary knowledge and power in this area are the "Manga", "Zivane" and "Mufume" clans. Although it is said that the "kuphatla" should be carried out at the beginning of every fishing season, in some places the tradition has become somewhat weakened and it is carried out less frequently, or is not performed by "owners of the sea". However the consequences of this are still held in awe, and an example was recounted of a ceremony in Inhassoro that did not "go well" because it was not carried out by the appropriate traditional leaders. The ceremony had to be repeated by the “Manga” family with an apology requested of the spirits.

While traditional customs are strong, religious influences along the coast are pervasive and powerful. The churches are a preferred source of communication, arbitration and counselling for women and youth along the coast. Importantly however, the church leaders are very often leaders in political, government and development spheres as well. The churches play various religious and social roles among the religious communities and religious leaders are very influential. Churches which also heal earn a great deal of support, and the use of traditional healers is given a certain tolerance by the more orthodox churches as long as it is performed discreetly.

Notwithstanding the cultural richness of the people, most invariably live in extreme poverty. Inhambane Province has repeatedly featured as one of the provinces with the highest incidence and depth of poverty. The poorer districts in Inhambane are those situated in the interior and there are reasons to believe that the micro-economy created by fisheries and the tourism sectors (especially the former) in the coastal areas has created a different poverty scenario.

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Some of the inhabitants of Bazaruto Island.
(Photograph by Michael Schleyer)

PART III

TERRESTRIAL PLANT AND ANIMAL LIFE

CHAPTER 5

TERRESTRIAL HABITATS AND VEGETATION

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The vegetation communities of the islands are categorised as follows: (1) savanna grassland, (2) marsh or edaphic grassland, (3) evergreen dune forest, (4) secondary dune forest, (5) scrub thicket, (6) swamp forest, (7) *Dialium schlechteri* and *Julbernadia* woodland, (8) thickets associated with a perched water table at base of west facing coastal sand dunes, (9) pioneer dune flora (mainly grasses and sedges), (10) mangroves and (11) salt marshes or salinas.

All these communities indicate signs of modification by the actions of humans and their domestic livestock. Apart from the remnant climax forest patches on the north western shore of Benguérua and the southern shore of Margaruque, all other vegetation types are in various stages of serial successional change.

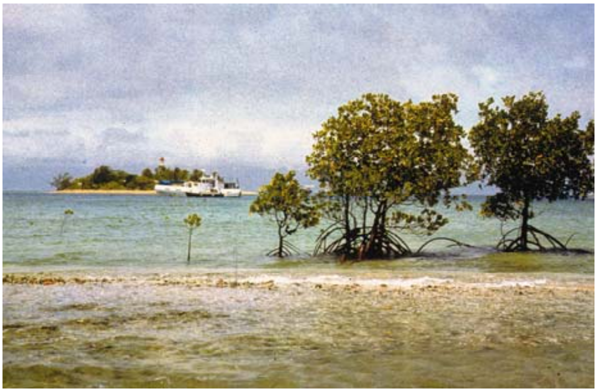
Vegetation communities found on each island

Bazaruto Island has nine vegetation types. The entire eastern edge of the island consists of a sand-dune cordon and this is covered with pioneer dune vegetation, some scub thicket in the valleys and thickets associated with a perched water table at the base. To the west of the dunes savanna grassland, scrub thicket clumps, secondary dune forest, edaphic grassland and two small areas of swamp forest can be found. The small areas of swamp forest have a very low species diversity with only two observed species: the swamp fig *Ficus trichoppoda* Bak and the fern *Thelypteris interrupta*. There is a large area of mangroves located midway down the length of the island and several freshwater lakes.

Benguerua Island has ten vegetation types. As in Bazaruto the eastern side of the island has a sand-dune cordon covered with pioneer dune vegetation. Benguerua also has savanna grassland with clumps of scub thicket, areas of evergreen dune forest, secondary dune forest, thickets associated with a perched water table at the base of west facing coastal sand dunes, edaphic grassland, a remnant tract of *Dialium schlechteri* and *Julbernadia woodland*, a small mangrove community with associated salt marshes and two freshwater lakes.

Magaruque Island is the most densely populated of all the islands and as a consequence the vegetation has been disturbed by agriculture and habitation. The island has a dune-cordon running along its eastern edge with pioneer dune vegetation, scrub thicket and secondary dune forest. Two small patches of evergreen dune forest can be found along the western margin of the island.

Santa Carolina is a small island which has been developed extensively for tourism. Despite development this island has a large mangrove community and a salt marsh on the southern side of the island and a secondary dune forest in the north.



Mangrove trees on the shore of Santa Carolina Island.
(Photograph by Rudy van der Elst)

Bangue Island, the smallest island (at 5 ha) basically consists of a long strip of beach with some pioneer dune vegetation.

Community descriptions

Savanna grasslands

This habitat is maintained principally by a perched water table and is suitable for the introduction of larger wildlife species but this would require management. Fire may be used to remove moribund material and make them more nutritiously attractive to grazing animals. Species commonly found in this plant community include: *Garcinia livingstonei, Ozoroa obovata, Adansonia digitata (only one specimen on Bazaruto), Albizia versicolor, Strychnos spinosa, S. innocua, Phoenix reclinata, Hyphaene crinita, Sclerocarya caffra, Helichrysium kraussii, Dicerocaryum senecioides, Dicerocaryun zanguebarium,* and *Digitaria* sp.

Marsh or edaphic grasslands and permanent lakes

These habitats owe their existence to an impervious layer under the sand substrate. All the island's fresh water requirements are maintained in these aquifers and water bodies. For the biologically inclined tourist they have immense interest. Species commonly found in edaphic grasslands are: *Sporoblus virginicus, Diplachne fusca, Andropagon eucomus, Juncus rigidus, Abilgarrdia trifolia, Hydrocotyle bonariensis* and *Pentodon pentadrus.*

Evergreen dune forests

Only three small remnant patches remain on Benguérua and Magaruque. Fortuitously the remnant on Benguérua was saved from further destruction by the Lodge developers. These remnant patches are a most attractive feature on both islands, and of immense interest to visiting botanists and ornithologists.

Secondary dune forests

Species commonly found in this community are: *Mimmusops caffra, Olax dissitiflora, Ehretia petoilaris, Rhus natalensis, R. nebulosa, Disopyros inhacaensis, Eulea schimperi, E. natalensis, Deinbolia oblongifolia, Cassia abbreviate, Drypetes natalensis, Sideroxylon inerme, Cassine aethiopica, C. papilosa, Suregada Africana, S. zanzibariensis, Zythoxylon delogoensis* and *Maerua triphylla.*

Scrub thickets

Species commonly found in scrub thickets are: *Eugenia capensis, E. erythophylla, Euclea schimperi, E. natalensis, Annona senegalensis, Dovylalis longispina, Diospyros rotundifolia, Mitriostigma axillare, Strychnos spinosa, S. innocua, Mundulea sericea, Dichrostachys cinerea, Indigofera cylidrica, Caesalpinae bundac, Phoenix reclinata, Hyphaene crinita, Antidesma venosum, Ochna beirensis, Croton gratissimus, Carissa bispinosa, Arthabotrys brachypetalus, Grewia sulcta, Xylotheca kraussiana, Pavetta edentula, Vitex amboniensis, Tarenna littoralis, Croton pseudopulchellius. Indigofera tincoria* and *Ludia mauritiana.*

Swamp forests

There are only three viable swamp forests on Bazaruto and Banguerua, and four which are severely damaged by agriculture. These forests are an attractive feature of the Archipelago and support the last remaining groups of samango monkey as well as a rich avifauna.

Dialium schlechleri and *Julbernadia* woodland

A small representative patch of this woodland occurs on the southern end of Benguérua. Although this vegetation type is well represented on the mainland, it would be desirable to include it as a protected area in the Archipelago. It is an attractive feature, and would be of interest to the visiting botanist and ornithologist.

Thickets associated with a perched water table and pioneer dune flora

The massive sand dunes on the eastern seaboard of the islands are distinctive and attractive features of the Archipelago's landscape. The dunes provide shelter for infrastructure and people during the adverse weather conditions frequently experienced on the exposed eastern sea front.

The islands, which are composed of mobile dunes, are advancing in a westerly direction, encroaching upon some of the larger freshwater lakes. The rate of encroachment is relatively slow as plant cover impedes the movement of these dunes. However, any practices related to tourist development, inappropriate agriculture, human habitation and excess domestic livestock, can disrupt the vegetation cover and accelerate dune movement. The planting of Casuarinas about 30-50 years ago has in some instances accelerated the erosional processes by disturbing the natural aero-dynamics of the dunes, thus causing serious blow-outs and erosion.

Below is a list of species commonly found on thickets associated with a perched water table at base of west facing coastal sand dunes and primary dune flora:

Thickets associated with perched water table at base of west facing coastal sand dunes:
Olax dissitiflora, Ehretia petoilaris, Acaia karroo, Sclerocarya caffra, Trichilia emetica, Syzygium cordatum, Balanites maughamii, Antidesma venosum, Ochna beirensis and *Brachylena discolor.*

Primary dune flora: *Ipomoea brasiliensis, Scaevola thunbergii, Cyerus maritima, Canavalia maritima, Sophora inhambanensis, Lannea sarmentosa, Halopyrum mucronatum, Lumnitzera racemose, Tephrosia canescens, Suriann maritima, Clerodendrum glabrum, Corida subcordata, Sesuvium potulacastrum* and *Sporobolus virginicus.*

Mangroves and salinas (salt marshes)
Of the five islands, only Bazaruto, Benguérua and Santa Carolina support mangrove communities and salinas. Five mangrove species are represented, *Rhizophora mucronata, Bruguiera cylindrica, Ceriops tagal, Avicennia marina* and *Sonneratia alba*. The mangrove substrate is sandy and anoxic approximately 5cm below the surface and is inundated only during spring tides. The mangrove estuaries are well known for their ecological importance in the marine environment. They are also of interest to the biologically inclined tourist. The salinas are sparsely vegetated with *Arthrocnemum perenne*, *Sesuvium portulacastrum*, *Salicornia perrieri*, *Sporobolus virginicus*, *Digitaria littoralis* and *Juncus krausii* on the slighty elevated margins.

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CHAPTER 6

TERRESTRIAL MAMMALS

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The terrestrial mammal fauna of the Bazaruto Archipelago is particularly interesting as the islands are remnants of a mainland penninsula. In addition, the islands differ in their area and number of available habitat types. Consequently present island mammalian species may represent groups able to survive extinctions typical on islands or those showing adaptation and speciation. However, the number of mammalian species found on the islands is very low compared to the adjacent mainland.

The coastal plain of south-eastern Africa is characterized by a number of sand-dune bands, each representing a former shoreline of younger age eastwards as the sea level fell (Hobday 1976). Present-day coastal dunes are estimated to have formed as recently as 5000 years ago (Fairbanks 1989) when the sea rose to its present level. Offshore islands such as those of the Bazaruto Archipelago were isolated from the mainland by the rising sea-level at this time and represent fragments of previous peninsulas. Consequently the islands of the Bazaruto Archipelago are relatively young, and peninsular in origin (Davies 1976, Maud 1980, Ramsay *pers comm.).* Furthermore, the fauna of these islands are closely related to, albeit a poor subset, the fauna on the adjacent mainland. The mammalian fauna of the archipelago has shown little change from mainland forms, and to date there are no recorded endemic species or subspecies of mammals recorded on any of the islands. This low level of endemism may be a result of the following:

a) that the intervening sea poses no great obstacle to colonisation, and that any adaptations to the island environment by resident species are constantly diluted by new immigrants, or
b) that the intervening sea poses a great obstacle to potential colonists, but that the islands are not yet old enough for new forms to have evolved, or
c) a combination of both the above.

A preliminary inventory of mammalian species for the three islands surveyed is presented in Table 6.1. Nomenclature used follows Meester *et al.* (1986) for mammals. At least 14 terrestrial species are found on Bazaruto, six on Benguérua and two on Santa Carolina Island. All are commonly found on mainland Mozambique (Smithers & Tello 1976, Smithers 1983, Meester, *et al.* 1986).

Small rodents and insectivores, which lack mobility and may not be heavy enough to set off the trap mechanisms used during surveys, are more likely to have been overlooked during the survey than larger species. One, the pygmy mouse, *Mus minutoides,* was only recorded on Santa Carolina Island, but may have been present on the other two islands. Similarly, the shrew, *Crocidura* sp. (cf. *C. silacea),* was recorded from a single individual caught in a pit-fall trap set in a marsh in the northern area of Bazaruto Island.

Generalists in their habitat requirements, like the red veld rat, *Aethomys chysophilus,* and the introduced house rat, *Rattus rattus,* are ubiquitous on Bazaruto and Benguérua islands, the latter also on Santa Carolina. The lesser bushbaby, *Galago moholi,* occurred in a variety of habitats on Bazaruto as it does elsewhere in its range (Smithers 1983), but was absent from Benguérua Island where the same habitat types are found. The bushbaby feeds exclusively on insects and gum. It is nocturnal with characteristic large eyes, relatively large ears, short nuzzle, bushy tail, and grasping hands and feet. Its eyes have a red reflection at night. The bushbaby also has an extensive vocal repertoire.

The distribution of other mammalian species with more specific habitat requirements is more restricted. The bushveld gerbil, *Tatera leucogaster,* is only found in the sand dunes along the eastern side of Bazaruto Island, but most likely also occurs on Benguérua where habitats are similar. Red squirrels, *Paraxerus palliatus,* and four-toed elephant shrews, *Petrodromus tetradactylus,* are common in the dune-slack thicket on Bazaruto Island. *Petrodromus tetradactylus* is absent from Benguérua Island, while *P. palliatus* is found in both dune-slack thicket and in evergreen forest there. The four-toed elephant shrew (average body length 350 mm and mass 200 g) has a conspicuous white eye-ring, and long, thin legs. Bouts of activity occur both day and night. They are insectivorous. Pairs are monogamous and maintain territories with a system of distinct pathways. Consequently, they are easily snared by locals. The red squirrel prefers dense foliage. It is often detected by its alarm barks or flicking tail. It is diurnal and uses vantage points to feed or to groom. It mainly feeds on kernels, berries and wild fruits but also ingests different plant material and insects.

Burrows and tracks of moles are frequently seen on the slip-faces of dunes on Bazaruto and Benguérua islands, and belong to the yellow golden mole, *Calcochloris obtusirostris.* It is the only mole found north of Inhambane on the coast of Mozambique (Meester *et al.* 1986), and has also been found on Inhaca Island (Eloff & De Graaff 1963). It has fine fur that is yellow-mustard in colour including the underfur. Body length is about 100 mm and weight 25-30 g. Its broad claws are an adaptation for burrowing in loose sand. Although most of the burrows collapse as it “swims” through sand just below the surface, more permanent burrows at 200-500 mm depth are used for resting and nesting. Although mainly nocturnal on the mainland, it has bouts of activity both diurnally and nocturnally on the islands which may be a consequence of reduced predator pressure. Individuals appear to be solitary. They use sensitivity to vibrations and smell to detect prey which includes a wide variety of arthropods, earthworms, and possibly small reptiles like lizards and geckos.

A small population of 5-15 individuals of samango monkeys, *Cercopithecus mitis,* occur on Bazaruto Island in the area near the lakes. They traverse open savanna and bush clumps to reach dune-slack thicket ca. 800 m away. On mainland Mozambique and elsewhere in central and Southern Africa, this primate occurs only in forests (Smithers 1983, Meester *et al.* 1986, Butynski 1988) where it has a broad choice of food items (Lawes 1991). On Bazaruto Island, where no true forest remains, the monkeys are limited to suboptimal, species-poor swamp forest, remnant dune forest, and the surrounding habitats. Further research into the diet and ecology of *C. mitis* on the island may reveal how a specialist primate copes in such extreme habitat types. The samango monkey is a highly social animal. However, because of a shortage of suitable feeding habitat, it appears that the group subgroups while feeding, but subgroups remain in close proximity of each other. Only the adult samango male emits loud calls. These were usually emitted when humans approached warning troop members of possible danger.

Forest antelope, the red duiker, *Cephalophus natalensis,* and the bushbuck, *Tragelaphus scriptus,* are rare and are only recorded on Bazaruto where they inhabit the more dense dune clump vegetation. Suni, *Neotragus moschatus,* have been recently introduced to Bazaruto and Benguérua Islands from the mainland as a food source, although it is likely that they occurred there previously. No carnivores were recorded on any island other than domestic cats, *Felis catus.*

Bat species found on the islands may vary seasonally as these mobile animals are capable of flying between islands and the mainland. There is a shortage of roosting sites as bats prefer secluded places such as caves, hollow trees, crevices and dense foliage. On the islands, most bats were found roosting in the roofs of man-made structures during the day. Insectivorous bats are sometimes observed hawking insects at exterior security lights. Species include the Angola free-tailed bat, *Tadarida condylura, (Mops condylurus)* which has a total body length of about 10 cm, the characteristic free-tail, dark brown to blackish upper parts and a whitish belly. Angola free-tailed bats are gregarious, living in groups of varying size, from a few individuals up to colonies of hundreds of individuals, often dependent on roost availability and food supply. On Bazaruto Island, a large colony of Angola free-tailed bats roost in the roof of the communal ablution block of one of the northern villages. The large bats observed on the islands, sometimes in fruiting trees, are fruit bats including the Egyptian fruit bat, *Rousettus aegyptiacus,* and Wahlberg's epauletted fruit bat, *Epomophorus wahlbergi.*

Habitat requirements may be a major factor affecting the distribution of more specialist mammalian species. Bazaruto Island has a total of 9 vegetation types (Dutton 1990). Benguerua Island has a total of 10 vegetation types despite its smaller size compared to Bazaruto. Magaruque Island is smaller and the most densely populated in the Archipelago (Dutton 1990), and the four vegetation types have subsequently been severely disturbed by agricultural practices and by habitation. Santa Carolina Island is small and (like Magaruque Island) has been developed extensively for tourism. It has three vegetation types. Bangué Island is no more than a long strip of beach with some pioneer dune vegetation.

Wallace (1896) was one of the first of many biologists to demonstrate that small distances of only a few kilometres between islands can create insurmountable barriers for many species, including birds. Evidence for this in the Bazaruto Archipelago is provided by Smithers and Tello (1976) who list at least 13 species of small mammals found along the mainland coast between Beira and Inhambane that are not found on the islands. Island biogeography theory predicts that species assemblages on islands are related to island size, age and distance from the mainland (Williamson 1981). The nested subset hypothesis was formulated to explain patterns in the community structure of insular faunas (Patterson & Atmar 1986). The hypothesis states that the species comprising a depauperate fauna should constitute a proper subset of those in richer faunas, and that an archipelago of such faunas arranged by species richness should present a nested series. Consistent with the status of the Bazaruto Archipelago as a group of continental land bridge islands, rather than oceanic islands, analysis shows that they are a nested subset of the mainland fauna and appear to be in "the process of relaxation". It is suggested that the mammalian fauna are non-random subsets and that extinction has occurred in a consistent sequence. The results indicate little colonisation or speciation of the mammal fauna in these relatively young islands.

Alien species

Introductions of alien species, particularly rats (*Rattus* sp. and *Mus musculus)* and cats (*Felis catus*), are rarely beneficial, particularly on islands where they often become pests and may threaten the survival of indigenous species (Poché *et al.* 1982, Van der Elst & Pryce-Jones 1987). Populations of alien rodent species on the islands of the Bazaruto Archipelago are likely to increase in numbers, causing ecological damage, unless some population control measures are introduced. The small population of *F. catus* on the north of Bazaruto Island poses a potential threat to the indigenous birds and small mammals, and must be prevented from spreading, or preferably removed from the island.

Human Pressures

Ecologically, the greatest threat to the islands' mammalian fauna is the increase in the human population, and the associated habitat destruction caused by over-utilization of resources, slash-and-burn agriculture and bush clearance. The growing tourist industry and the associated land requirements for development of facilities is also placing demands on the limited natural resources of the islands (Tomas & Dutton 1993). If the status of the islands as a National Park is to be maintained, better management of the natural resources is required, coupled with the implementation of less damaging, sustainable agricultural practices.

Table 6.1. Terrestrial mammal species found on three islands of the Bazaruto Archipelago during the 1989 survey (no information was obtained for Margaruque and Bangué). 1 – Introduced to the island

Order	Bazaruto	Benguérua	Santa Carolina
Artiodactyla	*Cephalophus natalensis* *Neotragus moschatus*[1] *Tragelaphus scriptus*	*Neotragus moschatus*	
Carnivora	*Felis catus*		
Chiroptera	*Tadarida pumila*		
Insectivora	*Calcochloris obtusirostris* *Crocidura sp. Cf. Silacea* *Tadaria*		
Macroscelidae	*Petrodomus tetradactylus*		
Primates	*Cercopithecus mitis* *Subsp. Erythrarchus* *Galago moholi*		
Rodentia	*Aethomys chrysophilus* *Mastomys natalensis* *Paraxerus palliatus* *Rattus rattus* *Tatera leucogaster*	*Aethomys chrysophilus* *Mastomys natalensis* *Paraxerus palliatus* *Rattus rattus*	*Mus minutoides* *Rattus rattus*[1]

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CHAPTER 7

REPTILES AND AMPHIBIANS

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The herpetofauna of the archipelago is a strangely unbalanced one, with some families which are well represented on the mainland completely absent. These include tortoises (Testudinidae), agamid lizards (Agamidae), girdled lizards (Cordylidae), sand lizards (Lacertidae), adders (Viperidae), platannas or clawed frogs (Pipidae) and toads (Bufonidae). Five species of lizard are endemic to the archipelago, while several other species reach their northern limits here.

Reptiles

Freshwater terrapins (Family PELOMEDUSIDAE)

The pan hinged terrapin (*Pelusios subniger*) inhabits ephemeral pans and swamps, burying itself in the mud to aestivate when they dry out. It is common in the airstrip swamp on Bazaruto Island, where most specimens show extensive fire damage to the carapace, caused when the dry swamp vegetation is burnt. Local specimens do not seem to exceed 15 cm in shell length. The shell is olive brown above and yellow and brown below, the head and limbs are blackish. In this genus the anterior portion of the plastron (lower shell) is hinged and can be raised like a drawbridge to seal the front of the shell and protect the head and forelimbs. The diet consists largely of aquatic insects and frogs, together with their eggs and tadpoles.

The yellow-bellied hinged terrapin (*Pelusios castanoides*) has been recorded from Lake Léngue on Bazaruto Island, but probably inhabits all the freshwater lakes. This species may exceed 20 cm in length. The shell is red-brown or yellowish above and yellow below. The diet includes freshwater snails and bivalves.

Chameleons (Family CHAMAELEONIDAE)

The flap-neck chameleon (*Chamaeleo dilepis*) is renowned for its ability to change colour. The basic colouration is green (females) to orange (males), with a white lateral stripe and ventral crest. When disturbed, the lizard turns yellow, with a superimposed pattern of black spots and saddles. An angry chameleon turns black with rage, but when asleep it becomes pale yellow. The interstitial skin on the throat (inflated in threat display) is usually bright orange, but in the breeding season it turns pale grey in males, so that they can approach females to mate. These antisocial reptiles will normally attack any other chameleon that enters their territory. Grasshoppers and other insects form the main diet, but a few small vertebrates are also eaten and cannibalism has been recorded.

Geckos (Family GEKKONIDAE)

Wahlberg's velvet gecko (*Homopholis wahlbergii*) is the largest local gecko, the record being a female of 227 mm total length from Bazaruto Island. It is distinguished by its smooth velvety skin and is pale grey or brownish, sometimes with a pair of black dorsolateral stripes or pale blotches down the middle of the back. They live on large trees, but often move onto buildings. They feed on large insects, also taking small lizards.

The common dwarf gecko (*Lygodactylus capensis*) is a small diurnal species with a round pupil. It is grey-brown with a pair of dark-edged pale dorsolateral stripes. They live on trees and bushes and are common on buildings. The tail has an adhesive tip like the toes and acts as a "fifth leg". Like all African geckos, the female lays two eggs under loose bark or in a crack between bricks. The diet consists largely of termites.

The tropical house gecko (*Hemidactylus mabouia*) is a very common nocturnal species on trees and house walls. Its back is covered with rows of keeled tubercles set in a matrix of small multicarinate granules, there are rows of spinose tubercles on the tail. The diet includes a wide range of insects, spiders, and even centipedes.

The baobab gecko (*Hemidactylus platycephalus*) is a larger species with smaller skin tubercles. On the mainland it lives on baobabs and other large trees. It seems to be a recent introduction to Benguéra Island, where it has only been seen on the lodge buildings, where it is very common.

Skinks (Family SCINCIDAE)

Dutton's dwarf burrowing skink (*Scelotes duttoni*) is only known from a limited area of coastal thicket north of Ponta Chinhongue on Benguérua Island. The forelimbs are reduced to tiny buds and the vestigial hindlimbs have only two toes. This slender skink has smooth scales in 18 rows at midbody and is about 12 cm long, half of this being tail. It is very dark brown above with a pair of thin golden dorsolateral stripes, the tail is blue-black (bright blue posteriorly in juveniles). The chin and throat are white, the rest of the underside mottled brown and white. These small skinks are "sand swimmers", living beneath leaf litter. Females give birth to two or three young in December.

The Bazaruto dwarf burrowing skink (*Scelotes insularis*) is also endemic to the archipelago and occurs on all the islands except Bangué Island. Although about the same size as the previous species, it is completely limbless and most specimens have regenerated tails. It has smooth scales in 18 rows at midbody. The back is pale brown, the flanks and underside dark brown. These skinks live under leaf litter in coastal thickets and feed largely on small termite workers.

The eastern coastal skink (*Mabuya depressa*) is the most common skink on the islands. It has well developed limbs and 30 scale rows at midbody, the dorsals with five or seven keels. The back is pale brown, with or without narrow dark lines on each scale row and there is a broad blackish lateral band (often speckled with white) with a white stripe below it; the underside is yellow. On the mainland this is a terrestrial species, but on the archipelago it is also seen basking on the trunks of trees and coconut palms. It is oviparous.

The variable skink (*Mabuya varia*) is the most common terrestrial skink on the mainland, but on the archipelago only a few specimens have been found on Bazaruto and Benguérua islands. This is a small species with 30-32 scale rows at midbody, the dorsals tricarinate. It is brown above with a pale dorsolateral stripe and a white lateral stripe, the underside is white. Although it normally feeds on insects, it has been known to prey upon snake-eyed skinks.

The striped skink (*Mabuya striata*) is a very common species on buildings on the mainland, but it is absent from all the islands except Santa Carolina, where it may have been accidentally introduced with building materials or freight. On Bangué Island, two skinks were seen basking on an old dugout canoe used as a brine bath, but it seems doubtful if this is a viable population. This is a fairly large robust skink with 36-38 scale rows at midbody and the dorsals have 3-7 keels. It is red-brown with a pair of broad cream dorsolateral stripes. The Santa Carolina skinks live on retaining walls and old *Casuarina* trees.

The Bazaruto writhing skink (*Lygosoma lanceolatum*) is a stout skink with small pentadactyle limbs and 24-26 rows of scales at midbody, the dorsals are tricarinate in juveniles, but smooth in adults. The specific name comes from the one or two distinctive lanceolate lobules on the anterior border of the ear opening. This skink is light grey-brown above, darker on the head and white below. The largest specimen measures 100+78 mm. This endemic species is usually found in the sand beneath leaf litter in coastal thickets.

Wahlberg's snake-eyed skink (*Panaspis wahlbergii*) is a small skink with the eyelids fused and a watchglass-like scale covering the eye as in snakes. It is slender with small pentadactyle limbs and smooth scales in 24-26 rows at midbody. The back is pale brown, the flanks dark brown with a white ventrolateral stripe. The underside is white, but in breeding males the chin and lower lip, belly, hind limbs and tail become bright orange. This common savanna species feeds mainly on termites.

The Bazaruto blind legless skink (*Typhlosaurus bazarutoensis*) is endemic to Bazaruto and Benguérua islands. It has an enormous rostral shield, with the nostrils connected to the posterior margin by long grooves. The scales are smooth in 12 rows at midbody and the tail is short and blunt. This is a dwarfed species, not exceeding 15 cm in total length. It is uniform pale orange and is found in the sand beneath leaf litter under bushes, where they feed on termites.

The Santa Carolina blind legless skink (*Typhlosaurus carolinensis*) is a larger (up to 18 cm) and more robust species. Adults have 2-4 dorsal rows of black spots on the body and 4-6 on the tail, new-born young have dark markings restricted to the head.

Plated lizards (Family GERRHOSAURIDAE)

The tawny plated lizard (*Gerrhosaurus major*) is a large (up to 50 cm), stout lizard with rough keeled rectangular dorsal scales, which are separated from 10 rows of smooth ventrals by a ventrolateral granular groove, the large scales have underlying bony plates (osteoderms). It is yellow-brown above, with or without black streaks, which become heavier posteriorly. The underside is bright yellow. This lizard is, to a large extent, vegetarian but will also take any insects, millipedes and small vertebrates that it can catch. It has been recorded only on Bazaruto Island, where one was dug out of a burrow at the base of a dune.

The yellow-throated plated lizard (*Gerrhosaurus flavigularis*) is a more slender species, which attains a length of 45 cm. The strongly keeled dorsal scales are separated from 8 rows of smooth ventrals by a granular groove. The back is olive brown with a pair of yellow dorsolateral stripes, the flanks are darker and the underside cream. This species lives in burrows in the grasslands and feeds largely on grasshoppers.

Monitor lizards or leguaans (Family VARANIDAE)
The white-throated monitor (*Varanus albigularis*) is a large robust lizard with strong limbs. The thick skin is covered with small bead-like scales which become square on the tail. Adults average 1 m in length. The back is grey-brown with rows of yellowish spots which may merge to form crossbands, as on the tail, the underside is off-white. This slow-moving lizard feeds largely on millipedes, snails and carrion, supplemented by anything else that it can catch. If cornered, it will defend itself by slashing with the powerful tail and will bite and use its sharp claws at close quarters. This lizard seems to be particularly common on Benguérua Island.

Worm lizards (Family AMPHISBAENIDAE)
The violet round-snouted worm lizard (*Zygaspis violacea*) is a small species (max. 20 cm) with soft segmented skin forming regular rings on its body and tail, which is relatively long and blunt. It is dark purple-brown, paler below, and is found in the sand beneath leaf litter. On the mainland it has been recorded from Inhambane south to Maputo, on the archipelago it is only known from Magaruque.

The slender spade-snouted worm lizard (*Monopeltis sphenorhynchus*) attains a length of 28 cm. The wedge-shaped head has a single large fingernail-shaped dorsal shield and the tail is very short and rounded. It has been found on Bazaruto Island.

Blind snakes (Family TYPHLOPIDAE)
Fornasini's blind snake (*Typhlops fornasinii*) is a very small (max. 18 cm) blackish species with a rounded snout, eyes buried beneath the head shields and a very short sharply pointed tail. There are 22-26 scale rows at midbody, with no enlarged ventrals. These little termite-eating snakes are found under leaf litter in the coastal thickets and have been recorded from all the islands except Bangué Island.

Worm snakes (Family LEPTOTYPHLOPIDAE)
The incognito worm snake (*Leptotyphlops incognitus*) is a tiny slender uniform black species with a rounded snout, eyes buried beneath the head shields, 14 scale rows at midbody with no enlarged ventrals and a relatively long tail tapering to a point. They live under logs and leaf litter where there is termite activity.

Pythons (Family BOIDAE)
The Southern African python (*Python natalensis*) is Africa's second largest snake, sometimes attaining 5 m in length. It is heavy bodied and has smooth scales in 78-95 rows at midbody, the ventrals being very narrow. The tail is relatively short, but is thick and prehensile and flanking the vent there are a pair of small claws (attached to the rudimentary pelvic girdle), which are used by the male to stimulate the female during courtship. There is a dark spear-shaped marking on top of the head, which continues as an irregular broad dorsal band which is broken up by pale olive crossbands and blotches. The underside is white speckled with black. The python probably occurs on all the islands: there are definite sight records from Magaruque and Santa Carolina.

Stiletto snakes and allies (Family ATRACTASPIDIDAE)
Bibron's stiletto snake (*Atractaspis bibronii*) is a slender snake with a flattened head and a short tail with a terminal spine. Local specimens have only 19 smooth midbody scale rows and are black above and uniform white below. The largest recorded

specimen is from Bazaruto and measured just under 70 cm. The fangs are very long and are used to stab prey in burrows, i.e. burrowing reptiles and baby rodents. Bites on humans cause local pain and swelling and often cause necrosis around the site of the bite.

The remainder of the local snakes in this family are back-fanged and harmless to man, they include the small-eyed snake (*Amblyodipsas microphthalma*), a very small species (max. 35 cm) with a blunt snout, smooth scales in 15 rows at midbody and a short tail. It is black above and white below with a dark median stripe. It burrows in the sand.

The Transvaal quill-snouted snake (*Xenocalamus transvaalensis*) is a slender species with a flattened head and pointed snout. The tail is short and blunt-tipped and the dorsal scales are smooth in 17 rows at midbody. It is black above, each scale pale-edged, and bright yellow below. A Bazaruto Island specimen measured 463 mm, a record length for this rare species.

The bicoloured quill-snout (*Xenocalamus bicolor*) is a very slender species with a small pointed head and a short blunt-tipped tail. It attains a length of 60 cm. This species has a brown or black dorsal stripe 4 to 12 scales wide, it is bright yellow laterally, paler below. It preys upon the slender worm lizard *Monopeltis spenorhynchus*.

The Cape centipede-eating snake (*Aparallactus capensis*) is a very small slender snake, grey-brown above with a darker head and a black collar, greenish white below. It has a specialised diet of centipedes.

Cobras and allies (Family ELAPIDAE)

The only elapid snake recorded on the archipelago is the forest cobra (*Naja melanoleuca*), a large shiny-scaled snake that may exceed 2.5 m in length. It is yellowish-brown above, heavily blotched with black, becoming denser posteriorly, so that the tail is often uniform black. The underside is bright yellow, heavily blotched with black and with faint grey crossbands on the throat. When disturbed this cobra rears and spreads a long narrow hood. It climbs well and is semiaquatic. Its diet includes rodents, golden moles, birds, fish and other snakes. This fast-moving snake should not be trifled with as its potent neurotoxic venom can rapidly prove fatal if it bites a human.

Typical snakes (Family COLUBRIDAE)

The half-banded wolf snake (*Lycophidion semiannule*) was described from Tete in 1854, but has never been found on the mainland subsequently and it is suspected that the original specimen actually came from Inhambane. A pair was found together under leaf litter on Benguérua Island in 1991. This small harmless snake has a flat head and short tail. The head is black with a broad cream stripe from the snout through the eye. The back is black stippled with white and pale orange, appearing blue-grey at a distance, with about 30 black crossbands on the body and black spots on the tail. The underside is black, with white at the ends of the ventrals. Wolf snakes feed on small skinks.

The eastern stripe-bellied sand-snake (*Psammophis orientalis*) is one of the most common snakes on the archipelago. It may exceed 1 m in length and is brown above, with or without paler dorsolateral stripes. White ventrolateral stripes extend onto the ends of the ventrals and are separated by black lines from a yellow median band. Lizards constitute the main diet of this fast-moving back-fanged snake.

The Mozambique shovel-snout (*Prosymna janii*) is a small, but robust snake with a flat head and angular snout, the dorsal scales are keeled in 15 rows at midbody. It is pale red-brown above with a series of paired dark brown to black blotches which are large and confluent anteriorly, but rapidly decrease in size posteriorly, the underside is uniform cream. Snakes of this genus are specialist feeders on reptile eggs. A Benguérua Island snake ate nine gecko eggs (*Lygodactylus* sp. and *Hemidactylus* sp.) during a short period in captivity. The Bazaruto Island snakes represent a northern range extension for the species, which was described from Inhambane.

The eastern shovel-snout (*Prosymna stuhlmannii*) is a more slender species which is black above and white below. It seems to be quite common on Bazaruto Island.

The natal green snake (*Philothamnus natalensis*) is one of the most common snakes on the archipelago. Averaging 1 m in length, it is bright green above (subadults may have black crossbars anteriorly) and paler below, the ventral and subcaudal scales are keeled. It is found in the swamps bordering the Bazaruto airstrip and one was caught in the dune forest on Magaruque. Its diet consists largely of frogs.

The bush snake (*Philothamnus semivariegatus*) is even more slender than the previous species and has strongly keeled ventral and subcaudal scales. It is blue-green anteriorly with black crossbars and spots, becoming uniform bronze posteriorly, the underside is yellow anteriorly. This species feeds mainly on geckos and skinks.

The boomslang (*Dispholidus typus*) is a large (1 to 1.5 m) arboreal back-fanged snake, readily distinguished by its very large eye, short head and strongly keeled dorsal scales. Juveniles have bright green eyes, grey backs with concealed blue spots (which appear when the body is inflated in anger), yellow throats and stippled maroon undersides. Adult females turn brown or grey and males become bright green. The diet consists largely of chameleons and fledgling birds taken from the nest. This snake has a potent haemolytic venom which can cause fatal internal haemorrhaging. When angered, the boomslang initially inflates its throat and then the whole body.

The savannah vine snake (*Thelotornis capensis*) is another arboreal back-fanged snake (1 to 1.5 m). It is slender, with a flattened elongate head and the eyes have horizontal pupils. The head is bright green above while the body is mottled grey, white and pink. Like the boomslang, the vine snake inflates its throat when angry and also has a haemolytic venom. Its diet includes lizards, small snakes, frogs and fledgling birds.

The herald snake (*Crotaphopeltis hotamboeia*) is a small nocturnal back-fanged snake, dark grey above and white below, with shiny black temporal patches which become prominent when the head is flattened in a threat display. Common in marshy areas, this species feeds on amphibians and is not dangerous to man.

The marbled tree snake (*Dipsadoboa aulica*) is a slender nocturnal back-fanged species which may sometimes be found under loose bark on dead trees. It is red-brown with white crossbars and a marbled pattern on the head, the underside is white with lateral brown flecks. The diet includes geckos and reed frogs.

The East African egg-eater (*Dasypeltis medici*) is a slender snake with a blunt head, large eye and strongly keeled dorsal scales. It is pink, with a series of thin brown chevrons on the neck, followed by a broken vertebral stripe and lateral vertical bars, the underside is cream stippled with brown. When alarmed, this harmless snake puts on an impressive threat display, coiling so that the constant friction of the keeled and serrated lateral scales against one another produces a loud hissing sound and the snake strikes fiercely with gaping, but virtually toothless, jaws. The diet consists entirely of birds' eggs, which are taken into the enormously distendable throat where they are weakened by being rasped against a series of projections from the vertebral column, then collapsed by muscular pressure and the contents passed down to the stomach, while the folded eggshell (plus any squab) is ejected through the mouth.

The East African egg-eating snake (*Dasypeltis medici*)

Crocodiles (Family CROCODYLIDAE)

The Nile crocodile (*Crocodylus niloticus*) inhabits the freshwater lakes on Bazaruto and Benguérua islands. The adults presumably prey largely on fish, water birds and terrapins, as large mammals (other than goats) are scarce. The local crocodiles will certainly stalk any human they see on the lake shore, evidently aspiring to become man-eaters!

Amphibians

Rubber frogs (Family MICROHYLIDAE)

The red-banded rubber frog (*Phrynomantis bifasciatus*) is a slow-moving pear-shaped burrowing frog. It is black with a pair of pink or orange dorsolateral bands and a spot on the rump, the underside is mottled grey and white. This frog spends most of its time underground feeding on termites. During the rains it emerges to breed in temporary pools and the male makes a distinctive trilling call. The tadpole is a filter feeder, which can be seen hanging motionless in the water except for the vibration of the whip-like tail tip.

Typical frogs (Family RANIDAE)

The knocking sand frog (*Tomopterna krugerensis*) is a blunt-headed robust species with reduced webbing on the feet and a mottled brown and white dorsal pattern. It apparently takes the place of toads on the archipelago and is very common around buildings at night, where it feeds on the insects attracted to light. These frogs breed in temporary pans and the males have a distinctive "knocking" call.

The broad-banded grass frog (*Ptychadena mossambica*) is a small species with a pointed snout and extensive webbing between the toes. It is olive brown above, usually with a broad pale vertebral band. It occurs in marshy areas.

The dwarf puddle frog (*Phrynobatrachus mababiensis*) is one of the smallest southern African species, not exceeding 20 mm in total length. The warty dorsal skin is grey-brown with symmetrical darker patches and sometimes a pale vertebral line. The slender toes are almost devoid of webbing. They inhabit shallow pools in marshy areas and the mating call is a buzzing noise that sounds more like an insect. They eat a lot of mosquitoes.

Tree and reed frogs (Family HYPEROLIIDAE)

The brown-backed tree frog (*Leptopelis mossambicus*) is a large frog, having big eyes with vertical pupils and adhesive disks on the tips of fingers and toes. It is red-brown above, with a dark patch on the side of the head extending back to above the shoulder and a dark horseshoe-shaped dorsal blotch that breaks up posteriorly. Juveniles are uniform pale green apart from white lines bordering the mouth and on the backs of the legs. During the rains the males may be heard calling in the swamps bordering the Bazaruto airstrip, the call is a brief "cluck" or "auk".

The bubbling kassina (*Kassina senegalensis*) is a small frog with prominent eyes with vertical pupils and it runs rather than jumps. It is light grey to olive with three to five broad dark dorsal stripes, the lateral ones usually broken up. In the daytime they hide in grass tussocks or under vegetable debris. During the breeding season the males have a distinctive "quoip" call, like the noise made by a cork being drawn from a champagne bottle, but they are hard to find in the grass.

The tinker reed frog (*Hyperolius tuberilinguis*) may be uniform bright green or patterned in red-brown above, it is creamy white below, the vocal sac of the male being yellow. The large eye has a horizontal pupil and the fingers and toes have large adhesive discs. During the rains the distinctive tapping call of the male (like a tinker repairing a pot) can be heard in the swamps bordering the Bazaruto airstrip, where they are abundant in the reedbeds.

The small waterlily frog (*Hyperolius pusillus*) has been recorded from a shallow pan on Bazaruto Island. It is pale green with a few black dots above, translucent greenish-white below, with yellow discs on the tips of fingers and toes.

The painted reed frog (*Hyperolius marmoratus*) is a distinctive species, the dorsum is black with five white stripes, each with an orange line down the centre, the insides of the thighs, lower belly and fingertips are bright red. There is also a subadult yellow phase. The tinkling call can be heard in swampy areas during the rains.

CHAPTER 8

BIRDS OF THE BAZARUTO ARCHIPELAGO

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The archipelago is rich in birdlife. The diversity of habitats and its prominent location for stop-over and flyway for migrating birds contributes to this rich avifauna. Over the years a number of amateur birdwatchers and professional ornithologists have contributed to an understanding of the avifauna of the Bazaruto Archipelago (van Eyssen 1958; Wheeler & Brooke 1961; Brooke *et al* 1990; Dutton & Zolho 1990). Together, more than 180 species have been recorded during these observations and more are likely to be documented by the keen birdwatcher (Reina 1998). Not surprisingly, the avifauna is strongly influenced by coastal birds, such as waders and especially terns. However, the overall bird diversity is rich and rewarding to the "twitcher" and ornithologist alike. The fact that Bazaruto is protected and that the harvesting of birds is considered negligible, means that bird populations are relatively safe, providing habitat degradation and invading species are carefully controlled.

Birds of the coastal bush

The vegetation of the islands supports a wide diversity of bird species. Besides the typical indigenous coastal vegetation normally found in this region, there are also stands of casuarinas and coconut palms. Although the trees on Bazaruto are not as large and developed as those on Inhaca Island, there are many similarities in the bird populations. Fruit eating birds are, however, not as prevalent on the archipelago as one would expect considering the considerable crop of fruit produced by the marula trees. Typically the birds seen in the coastal bush here are the shrikes, bulbuls, white-eyes, sunbirds and weavers. Robins, especially the red-capped robin-chat, can be seen and heard at dusk and dawn low down in the bush. Shrikes are reasonably common, including the brightly coloured orange-breasted bush-shrike. The call of the boubou is never far away, nor indeed the call of the white-browed coucal. The fork-tailed drongo, African green-pigeon, black-collared barbet, and several species of weaver are all evident. A walk from Bazaruto Lodge to the beach or towards the lighthouse, will reveal a great diversity of bush birds, especially in cooler parts of the day. There are substantial open and grassland areas where pipits and longclaws occur. Here too the bee-eaters are more evident, often associated with swallows and palm-swifts.

Birds of the shore

Bazaruto justifies special protection as a site of significance for wetlands and waders. The extensive sand and mud flats on the leeward shores of the islands are important habitats attracting large numbers of Palaearctic waders. Terns are especially prevalent and most commonly seen roosting on the north-western beaches of Bazaruto Island after their feeding forays in the marine environment and inshore bay areas. Most common are the common and little terns. However, the Caspian, bridled, lesser crested, roseate, sandwich and swift terns are all species commonly found. One of the archipelago's most impressive sights is its greater and lesser flamingos that may be found in large numbers at several places on the inland shores, the beaches to the south and around Santa Carolina. The peninsula of Cabo São Sebastião and Bartolomeu Dias are also attractive to the flamingos. Waders are seasonally very common. Most prominent are the terek, wood, curlew and marsh sandpipers, the common greenshank and sanderlings. Rarer waders also occur at times including the Eurasian oystercatcher. On the eastern beaches the white-fronted sandplovers are prominent. Spotting birds in the archipelago would not be complete without sightings of the five kingfisher species recorded, especially the elusive mangrove kingfisher.

Lake birds

The lake habitat on Bazaruto Island provides an interesting environment and contributes substantially to the avifauna. At least three species of duck, grebes, cormorants, pelicans and African fish eagles are common there, many feeding on the aquatic plants or the populations of fresh water fish including tilapia. Herons too are common here, as indeed they are on much of the archipelago, with at least ten species recorded.

Pelagic seabirds

Although the archipelago does not normally support populations of pelagic seabirds, as do the islands further offshore, such as Europa, there are frequent visits of species such as the red-footed booby, the Cape gannet, the great frigatebird and the lesser frigatebird. Sooty terns and brown noddies also periodically visit Bazaruto, but mostly as a result of stormy weather at sea.

Rare and invader birds

The archipelago does periodically have visits from rare birds. Examples include the Palaearctic form of the peregrine falcon. Pratincoles and ospreys are also some of the rarer species that may be encountered. Unfortunately, the house crow has established itself on Bazaruto, although its impact on the other birds is not yet at the levels of that seen on Inhaca Island. It is probable that the presence of pied crows is keeping the house crow population in check.

Table 8.1. Avifauna of the Bazaruto Archipelago, a compilation of records as provided by the authors listed in the references in addition to personal observations by R van der Elst and R. Little. 1=Santa Carolina, 2=Bazaruto, 3=Benguéra, 4=Magaruque, 5=Bangué, X=occurrence, 0=breeding and +=oceanic. (All family, species and common names are according to Hockey *et al* 2005).

		Islands				
Family/species	**Common name**	**1**	**2**	**3**	**4**	**5**
PODICIPEDIDAE						
Tachybaptus ruficollis	Little grebe/Mergulhao do cabo		0	0		
PROCELLARIIDAE						
Procellaria aequinoctialis	White-chinned petrel/Galinha do cabo		+			
HYDROBATIDAE						
Oceanites oceanicus	Wilson's storm-petrel/Casquilho		+			
PELECANIDAE						
Pelecanus onocrotalus	Great white pelican/Pelicano branco	X	X			
Pelecanus rufescens	Pink-backed pelican/Pelicano cinzento		X	X	X	
SULIDAE						
Morus capensis	Cape gannet/Alcatraz do cabo		+			

PHALACROCORACIDAE						
Phalacrocorax lucidus	White-breasted cormorant/Covo de peito branco	X	X	X	X	
Phalacrocorax africanus	Reed cormorant/Corvo marinho africano		X	X	X	
ANHINGIDAE						
Anhinga rufa	African darter/Mergulhao serpente		X	X		
FREGATIDAE						
Fregata minor	Greater frigatebird		X			
Fregata ariel	Lesser frigatebird					
ARDEIDAE						
Ardea cinerea	Grey heron/Garca real	X	0	X	X	X
Ardea goliath	Goliath heron/Garca gigante		X			
Ardea purpurea	Purple heron/Garca vermelha		0	0		
Egretta alba	Great egret/Garca branca		X			
Egretta garzetta	Little egret/Egret pequena	X	0	X	X	
Egretta intermedia	Yellow-billed egret/Egreta do bico curto		X			
Bubulcus ibis	Cattle egret/Garca boieira		X	X	X	
Butorides striata	Green-backed heron/Garca de cabeca negra		0			
Nycticorax nycticorax	Black-crowned night-heron/Goraz		X			
Ixobrychus minutus	Little bittern/Garcenho pequeno		X			
CICONIIDAE						
Anastomus lamelligerus	African openbill/Bico aberto		X			
Ephippiorhynchus senegalensis	Saddle-billed stork/Jabiru		X			
Leptoptilos crumeniferus	Marabou stork/Marabu		X			
Mycteria ibis	Yellow-billed stork/Flamingo falso		X			
THRESKIORNITHIDAE						
Threskiornis aethiopicus	African sacred ibis/Ibis sagrada	X	X	X	X	
Bostrychia hagedash	Hadeda ibis/Singanga		X	X		
Platalea alba	African spoonbill/Colhereiro africano		X	X		
PHOENICOPTERIDAE						
Phoenicopterus ruber	Greater flamingo/Flamingo grande	X	X	X	X	X
Phoenicopterus minor	Lesser flamingo/Flamingo pequena		X	X		
DENDROCYGNIDAE						
Dendrocygna viduata	White-faced duck/Pato de cara branca		X			
Thalassornis leuconotus	White-backed duck/Pato de costas franca		X			
ANATIDAE						
Anas erythrorhyncha	Red-billed teal/Pato do bico vermelho		X			
Plectropterus gambensis	Spur-wing goose/Janda		X	X		
ACCIPITRIDAE						
Milvus migrans	Black kite/Rabo de bacalhau	X	X	0		
Elanus caeruleus	Black-shouldered kite/Pineireiro cinzento		X			
Circaetus pectoralis	Black-chested snake-eagle/Guincho de peito preto		X			
Kaupifalco monogrammicus	Lizard buzzard/Mioto papa lagartos				X	
Haliaeetus vocifer	African fish-eagle/Aguia gritadeira		X	X		
Circus ranivorus	African marsh-harrier/Aguia sapeira		X	X		
Pandion haliaetus	Osprey/Aguia pesqueira		X			
FALCONIDAE						
Falco eleonorae	Eleonora's falcon		X			
Falco peregrinus	Peregrine falcon/Falcao real		X	X		
Falco subbuteo	Eurasian hobby/Falcao tagarote			X		

PHASIANIDAE						
Coturnix delegorguei	Harlequin quail/Codorniz arlequim					
TURNICIDAE						
Turnix sylvaticus	Kurrichane buttonquail/Codornizinha		X	X		
RALLIDAE						
Amaurornis flavirostris	Black crake/Codornizao preto		X	X		
Sarothrura rufa	Red-chested flufftail/Franga d' agua pigmeia de papo vermelho			X		
Porphyrio madagascariensis	African purple swamphen/Galinha sultana			X		
Gallinula chloropus	Common moorhen/Galinha d' agua africana		X	X		
OTIDIDAE						
Lophotis ruficrista	Red-crested korhaan/Abetarda de crista		X			
Lissotis melanogaster	Black-bellied bustard/Abertarda de barriga preta		X			
JACANIDAE						
Actophilornis africanus	African jacana/Jacana			X		
HAEMATOPODIDAE						
Haematopus ostralegus	Eurasian oystercatcher/Ostraceiro		X	X		
CHARADRIIDAE						
Charadrius hiaticula	Common ringed plover/Borrelho de coleira	X	X	X	X	X
Charadrius leschenaultii	Greater sand plover/Borrelho de leschenault	X	X	X		
Charadrius marginatus	White-fronted plover/Borrelho de fronte branca	X	X	X	X	
Charadrius mongolus	Lesser sand plover/Borrelho de Mongolia	X	X	X		
Charadrius pecuarius	Kittlitz's plover/Borrelho do gado		X			
Charadrius tricollaris	Three-banded plover		X			
Pluvialis squatarola	Grey plover/Tarambola cinzenta	X	X	X	X	X
Vanellus armatus	Blacksmith lapwing		X			
SCOLOPACIDAE						
Arenaria interpres	Ruddy turnstone/Rola do mar	X	X	X	X	X
ActitIs hypoleucos	Common sandpiper/Macarico das rochas	X	X	X	X	X
Calidris alba	Sanderling/Pilrito sanderlingo	X	X	X	X	
Calidris ferruginea	Curlew sandpiper/Pilrito de rabadilha branca	X	X	X	X	
Caridris minuta	Little stint/Pilrito pequeno	X	X	X		
Limosa lapponica	Bar-tailed godwit/Fuselo		X	X	X	
Numenius arquata	Eurasian curlew/Macarico real	X	X	X	X	
Numenius phaeopus	Common whimbrel/Macarico galego	X	X	X	X	
Tringa glareola	Wood sandpiper/Macarico silvestre			X	X	X
Tringa nebularia	Common greenshank/Perna verde	X	X	X	X	
Tringa stagnatilis	Marsh sandpiper/Macarico dos pantanos			X	X	
Xenus cinereus	Terek sandpiper/Macarico terek	X	X	X		
RECURVIROSTRIDAE						
Himantopus himantopus	Black-winged stilt/Perna longa		X	X		
DROMADIDAE						
Dromas ardeola	Crab plover	X	X	X	X	
BURHINIDE						
Burhinus capensis	Spotted thick-knee/Alcaravao do cabo		X	X	X	
Burhinus vermiculatus	Water thick-knee/Alcaravao d' agua		X	X		
GLAREOLIDAE						
Cursorius temminckii	Temminck’s courser		X			
Glareola pratincola	Collared pratincole/Perdiz do mar		X	X		
LARIDAE						
Chlidonias hybrida	Whiskered tern		X			

Larus cirrocephalus	Grey-headed gull/Gaivota de cabeca cinzenta	X	X	X	X	X
Sterna albifrons	Little tern/Churreca		X	X		
Sterna anaethetus	Bridled tern		X			
Sterna bergii	Swift tern	X	0	X	X	
Sterna bengalensis	Lesser crested tern	X	X	X	X	
Sterna caspia	Caspian tern/Gaivina maior	X	X	X		
Sterna dougallii	Roseate tern	X	X	X		
Sterna hirundo	Common tern/Andorinha do mar comum		X	X	X	
Sterna sandvicensis	Sandwich tern/Garajao			X		
COLUMBIDAE						
Streptopelia capicola	Cape turtle-dove/Rola do colar	X	X	X	X	
Streptopelia semitorquata	Red-eyed dove/Rola preta	X	X	X	X	
Streptopelia senegalensis	Laughing dove/Rola do Senegal		X	X		
Treron calvus	African green-pigeon/Pombo verde		X	0	X	
Turtur chalcospilos	Emerald-spotted wood-dove/Rola esmeraldina		X	X	X	
PSITTACIDAE						
Poicephalus cryptoxanthus	Brown-headed parrot/Periquito de cabeca castanha	X				
CUCULIDAE						
Chrysococcyx caprius	Diederick cuckoo/Cuco bronzeado maior		0	X	X	
Chrysococcyx klaas	Klaas's cuckoo/Cuco bronzeado menor		X	X		
Ceuthmochares aereus	Green malkoha/Cuco verde		X	X	X	
Centropus superciliosus	White-browed coucal/Cuco de Burchell	X	X	X	X	
TYTONIDAE						
Tyto alba	Barn owl	X	X			
STRIGIDAE						
Scotopelia peli	Pel's fishing-owl/Corunjao pesqueiro				X	
CARPIMULGIDAE						
Caprimulgus fossii	Square-tailed nightjar/Noitibo de Welwitsch		X	X	X	
Caprimulgus pectoralis	Fiery-necked nightjar/Noitibo de pescoco dourado		X	X		
APODIDAE						
Apus affinis	Little swift/Guincho pequeno		X	X		
Apus caffer	White-rumped swift		X			
Apus horus	Horus swift		X			
Cypsiurus parvus	African palm-swift/Guincho das palmeiras			X		
COLIIDAE						
Urocolius indicus	Red-faced mousebird/Rabo de junco de face vermelha		X	X	X	
CERYLIDAE						
Ceryle rudis	Pied kingfisher/Pica peixe malhado	X	X	X	X	
Megaceryle maximus	Giant kingfisher					
ALCEDINIDAE						
Alcedo cristata	Malachite kingfisher/Pica peixinho de poupa			X		
Ispidina picta	African pygmy-kingfisher			X		
DACELONIDAE						
Halcyon senegaloides	Mangrove kingfisher					
MEROPIDAE						
Merops persicus	Blue-cheeked bee-eater/Abelharuco persa				X	
Merops pusillus	Little bee-eater/Abelharuco dourado			X		
Merops superciliosus	Madagascar bee-eater/Abelharuco olivaceo	X	0	0	X	

CORACIIDAE						
Coracias caudatus	Lilac-breasted roller/Rolieiro de peito lilas	X	X	X	X	
UPUPIDAE						
Upupa africana	African Hoopoe/Poupa		X	X	X	
BUCEROTIDAE						
Tockus nasutus	African grey hornbill/Bico de serra cinzento			X		
Tockus alboterminatus	Crowned hornbill/Bico de serra castanho		X	X		
HIRUNDINIDAE						
Hirundo rustica	Barn swallow/Andorinha da Europa	X	X	X	X	
Psalidoprocne holomelaena	Black saw-wing/Andorinha preta			X		
Pseudhirundo griseopyga	Grey-rumped swallow		X			
Riparia paludicola	Brown-throated martin		X	X	X	
Riparia cincta	Banded martin			X		
DICRURIDAE						
Dicrurus adsimilis	Fork-tailed drongo		X			
CORVIDAE						
Corvus albus	Pied crow/Seminarista	X	0	0	X	
PYCNONOTIDAE						
Andropadus importunus	Sombre greenbul/Inhola	X	X	X	X	
Pycnonotus triclor	Dark-capped bulbul/Tuta	X	X	X	X	
MUSCICAPIDAE						
Cercotrichas leucophrys	White-browed scrub-robin/Tordo de peito estriado		X	X	X	
Cossypha humeralis	White-throated robin-chat		X			
Cossypha natalensis	Red-capped robin-chat			X		
SYLVIIDAE						
Acrocephalus gracilirostris	Lesser swamp-warbler		X	X		
Bradypterus baboecala	Little rush-warbler			X		
CISTICOLIDAE						
Cisticola juncidis	Zitting cisticola/Fuinha de Mozambique		X	X		
Cisticola natalensis	Croaking cisticola/Rouzinol do Natal		X			
MUSCICAPIDAE						
Muscicapa adusta	African dusky flycatcher			X	X	
MONARCHIDAE						
Terpsiphone viridis	African paradise-flycatcher/Papa moscas do Paraiso	X	X	X	X	
MOTACILLIDAE						
Motacilla capensis	Cape wagtail/Alveola do Cabo		X		X	
Anthus caffer	Bushveld pipit/Petinha de Richard		X	X	X	
Anthus cinnamomeus	African pipit		X			
Anthus similis	Long-billed pipit		X			
Anthus trivialis	Tree pipit			X		
MALACONOTIDAE						
Laniarius ferrugineus	Southern boubou		X			
Prionops plumatus	White-crested helmet-shrike/Atacador de poupa branca			X		
Tchagra australis	Brown-crowned tchagra/Picanco de cabeca castanha		X	X		
Tchagra senegalus	Black-crowned tchagra /Picanco assobiador		X			
LANIIDAE						
Lanius collurio	Red-backed shrike/Picanco de dorso vermelho		X	X	X	
STURNIDAE						
Creatophora cinerea	Wattled starling/ Estorninho de caruncula			X		

Lamprotornis chalybaeus	Greater blue-eared starling/ Estorninho metalico		X	X		
Lamprotornis corruscus	Black-bellied starling/Estorninho metalico			X		
NECTARINIIDAE						
Anthreptes reichenowi	Plain-backed sunbird				X	
Chalcomitra amethystina	Amathyst sunbird/Beija flor ametista de Kirk			X		
Cinnyris bifasciatus	Purple-banded sunbird/Beija flor de peito roxo		X	X	X	
Cyanomitra veroxii	Grey sunbird	X				
PASSERIDAE						
Passer domesticus	House sparrow/ Pardal dos telhados	X	X	X	X	
Passer griseus	Northern grey-headed sparrow/ Pardal de cabeca cinzenta	X	X	X	X	
PLOCEIDAE						
Euplectes axillaris	Fan-tailed widowbird/Viuva de espaduas vermelhas	X	X	X		
Euplectes ardens	Red-collared widowbird		X			
Ploceus cucullatus	Village weaver/ Tecelao de capucho		0	X		
Ploceus intermedius	Lesser masked-weaver/ Tecelao de cabanis		0	X	X	
Ploceus ocularis	Spectacled weaver/ Tecelao de lunetas		0	0	X	
Ploceus subaureus	Yellow weaver	0	0	0	X	
Ploceus velatus	Southern masked-weaver /Tecelao de mascara		X	X	X	
Quelea quelea	Red-billed quelea/ Pardal de bico vermelho			X		
ESTRILDIDAE						
Estrilda astrild	Common waxbill/ Bico de lacre comum		X	X	X	
Spermestes cucullatus	Bronze mannikin/ Freirinha		0	X		
VIDUIDAE						
Vidua macroura	Pin-tailed whydah/Viuvinha malhada		X	X		
FRINGILLIDAE						
Crithagra mozambicus	Yellow-fronted canary/ Xerico		X	X		
Crithagra sulphuratus	Brimstone canary/ Xerico grande	X	X	X	X	

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PART IV

MARINE ECOSYSTEMS AND FAUNA

CHAPTER 9

MARINE ECOSYSTEMS

Most of the island shores are sandy, with occasional sandstone outcrops at higher levels, levelling out lower down where there are often reef flats of low, eroded sandstone or dead coral heads and rubble. The living coral reefs themselves are found subtidally, and their upper fringes are usually only exposed at equinoctial spring tides. In other areas, as the tide retreats, vast expanses of open sand may be exposed and at peak spring tides one may be able to walk out a kilometre or more. These sandbanks are cut by channels, which may be silty and harbour extensive beds of marine grasses. Muddy sand or mud is present in a few bays, and even a limited number of mangrove stands occur (by: Richard N. Kilburn, see chapter 12)

Sandy beaches and sand flats

Sandy beaches on the seaward side of the island are subjected to wave action, which dominates sedimentary dynamics there, as opposed to tidal currents. On the western side, low energy conditions create broad expanses of sand flats, which provide a range of habitats for various organisms. The surface of these sandflats are protected by algal and marine angiosperm growth, which provide browsing for molluscan fauna. Areas stabilized by algae are also suitable for the habitation of infauna, such as burrowing bivalves, etc. The algal mat is important in stablizing the sand flats. This is illustrated by the fact that, where vehicles traverse the substratum, the algal mat is disturbed and subjected to redistribution by current action. The current also appears to keep the sand in periodic motion, thereby possibly preventing permanent habitation by infauna.

Seagrass beds

Associated with the sand tidal flats are distinct patches of marine grass angiosperms, principally *Thalassiodendron ciliatum, Cymodocea rotundata, Halodule uninervis* and *Zostrea capensis*. These grass "meadows" are habitats for a rich marine fauna, including the dugong which graze largely on *C. rotundata*. The seagrass beds, over and above providing grazing area for dugong, are important as nursery areas for fish and provide habitats for Mapalo (sea cucumbers). Every possible effort must be made to preserve them; they are sensitive to disturbance and on no account can channel dredging across them be considered for tourist development. A change in drainage patterns and velocities would impair their detritus retention abilities and the beds would become impoverished and die.

Intertidal rocky shores

The stability of intertidal rocky areas enables colonisation of these areas by a variety of organisms. Rocky areas which have been stranded from the shoreline owing to island migration provide areas for corals to colonise and form small reefs with suitable conditions to support a typical reef-associated fauna. Apart from being valuable habitats for a great diversity of marine organisms, intertidal rocky reefs provide protection for associated beach zones and infrastructures.

Coral reefs
These reefs are the most interesting of all marine ecosystems in terms of biological diversity and are described in detail in chapter 11. They also perform the function of breaking the kinetic energy of wind and tide induced waves, thus reducing the impact on the beach zone and infrastructure.

CHAPTER 10

SEAGRASS BEDS

Salomão Bandeira[1], Delfina Muiocha[1] and Michael Schleyer[2]

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Seagrasses are angiosperms (flowering plants) that have adapted to live in marine medium and shallow waters all over the world, forming either mono-specific or mixed-species meadows (den Hartog 1970; Green & Short 2003; Gullstrom *et al*. 2006). In order to do so, seagrasses have undergone unique adaptations such as developing a specific morphology, made up of rhizomes, roots and stems for anchorage; acquisition of air lacunae for vertical buoyancy and gas pumping for underground nutrient uptake; flowers with hydrophilous pollination; vivipary for some species and adaptation for nutrients uptake into the plant tissue by both roots and leaves. For the region of the Bazaruto Archipelago, Inhassoro and Vilanculos, nine species of seagrasses have been identified, namely: *Thalassodendron ciliatum*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Syringodium isoetifolium*, *Halodule uninervis, Halodule cf. wrightii* (all members of Cymodoceaceae family), *Thalassia hemprichii*, *Halophila ovalis* (Hydrocharitaceae) and *Zostera capensis* (Zosteraceae) (Mafambissa 2002; Dias 2005).

In the inshore bay region of Bazaruto, the seagrass meadows cover about 88 km^2 in shallow and subsidiary waters less than 5 m depth (Guissamulo 2005). Extensive sand flats are found between the islands and mainland in the Bazaruto Archipelago. These are interspersed by channels that drain the Bay and are maintained by strong currents. The latter arise from the enormous tidal flux that results from the spring tidal range of nearly 4 m in the region. The shallower reaches of the sand flats are locally inhabited by seagrass beds, with associated algal growth. These seagrass meadows are dominated by *Thalassodendron ciliatum*, *Thalassia hemprichii*, *Cymodocea rotundata* and *Halodule* species (Dias 2005). The seagrass meadows of this region are not uniformly distributed and generally occur in distinct community associations with each other. Thus, 11 such communities can be recognised viz. *Cymodocea rotundata*, *Cymodocea rotundata*/*Halodule uninervis*; *Cymodocea rotundata*/*Halodule uninervis*/*Thalassia hemprichii*; *Cymodocea rotundata*/*Thalassia hemprichii*; *Halodule uninervis*/*Thalassia hemprichii*; *Halodule wrightii*/*Thalassia hemprichii*; *Halophila ovalis*/*Thalassia hemprichii*; *Nanozostera capensis*; *Thalassodendron ciliatum*; *Thalassodendron ciliatum*/T*halassia hemprichii*; *Thalassia hemprichii* (Fig. 10.1) (Dias 2005; Relatório Final da Avaliação do impacto ambiental 2006). *Cymodocea rotundata* and *Thalassodendron ciliatum* tend to form rather mono-specific mats along edges of Bazaruto Bay and Inhassoro, the latter in subtidal areas (Dias 2005; Relatório Final da Avaliação do impacto ambiental 2006). The longest *T. ciliatum* were found at Inhassoro with leaves up to 126 cm (Bandeira & Gell 2003).

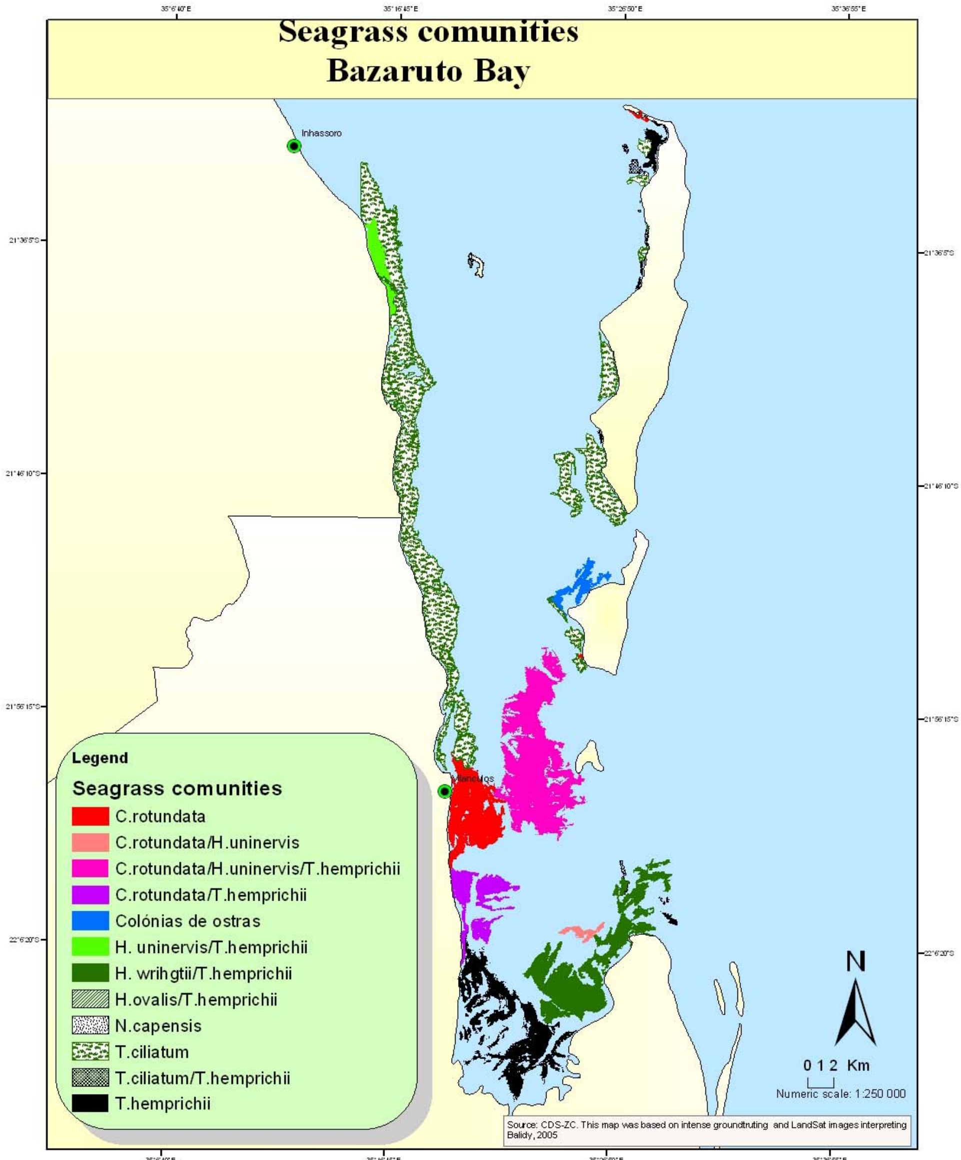

Fig. 10.1: Seagrass communities in the Bazaruto Bay.

In terms of area coverage, *Thalassodendron ciliatum* and *Cymodocea rotundata meadows are the* most extensive seagrasses communities covering respectively 45,5% and 32,6 % per area, respectively (Dias 2005).

The more diverse communities of seagrasses occur in shallow waters in the bay, taking up 9,9% by area. On average there are three to four species of seagrasses per meadow including some mono-specific types like *Thalassodendron ciliatum* and *Cymodocea rotundata*. These two species account for the highest mean biomass (438,5 ± 401 g/m^2 of dry mass without ash and 70.67 ± 77.3 g/m^2 of dry mass without ash, respectively). The biomass of most other species is lower than 50 g/m^2. *Thalassia hemprichii* is the species which appears to be more associated other species (Relatório Final da Avaliação do impacto ambiental 2006).

Seagrass meadows comprise grazing grounds for the dugong population of Bazaruto and provide important nursery areas for fish. The distribution of dugongs appears closely related to the occurrence of seagrasses suitable for their feeding, such as the preferred seagrass genera of *Halodule* and *Halophila.* (Dias 2005; Sambane 2006). Dugongs normally graze on seagrasses in a depth range of 1-5 m (Guissamulo 2003). The seagrass species selected by dugongs for feeding usually have a high amount of nutrients and are easy to digest as they have low levels of fibre and phenols (Sheppard *et al*. 2007). The species, *Halodule uninervis,* has a high quantity of ash, nitrogen (protein) and neutral detergent fibre, important to sustain most of the nutritive requirements of the dugong. Similar properties are found in *Halophila ovalis* and *Halodule uninervis,* with the latter having a higher starch concentration. Both these species tend to occur more commonly associated with species such as *Cymodocea rotundata* and *Thalassia hemprichii* (Dias 2005). *Cymodocea rotundata* and *Zostera capensis* are also eaten by dugong in Bazaruto although they are generally less preferred.

Seagrass beds are primary producers and are enormously productive, generating nutrients and sources of food for a great diversity of life. These beds also provide shelter and hence meadows invariably support a rich marine fauna. In the Bazaruto Archipelago at least 153 species of invertebrates have been identified (Dutton & Zolho 1990), including echinoderms (starfish, sea-urchin, brittle starfish and sea cucumbers), crustaceans (crabs, amphipods and isopods), molluscs (bivalves, including sand oysters *Pinctada imbricata*, cockles, snails, slugs, cuttlefish and squid), coelenterates (jellyfish and certain coral species) and a great diversity of fishes (Relatório Final da Avaliação do impacto ambiental 2006). Out of this diversity, six species of gastropod are believed to be endemic to the Bazaruto Archipelago, namely: *Conus pennaceus bazarutensis*, *Epitonium pteroen*, *Epitonium repandior*, *Fusiaphera eva*, *Thracia anchoralis* and *Limatula vermicola* (Plano de maneio de Bazaruto 2008-2012).

Other animals are also found amongst the frond of the seagrass beds. Among the more common invertebrate species are the sea-urchins (*Eucidaris metularia, Diadema setosum, Echinothrix diadema, Astropyga radiata*) and starfish (*Astropecten* spp. *Asterodiscides belli, Culcita schmideliana, Pentaceraster mammilatus, Protoreaster* spp. and *Lynckia spp.*) One of the more common holothurians is the elongated, snake-like sea cucumbers (*Synapta* spp.). Although holothurians were generally once very common, such as *Holothuria edulis, H. scabra*, *H. nobilis*, locally known as *makajojo,* these have been severely over- exploited by the Asian "boom-and-bust" fishery for sea cucumbers. This commenced at the end of the Mozambique civil war and now these species are rare throughout East Africa. Many species of grastropods and bivalves also occur in these beds (Relatório Final da Avaliação do impacto ambiental 2006).

Invertebrates are harvested by local fishing communities from the seagrass beds. This occurs mainly over a few days of the spring tides and includes especially the sand oyster *Pinctada capensis* and the shell *Volema pyrum.* The more important crustaceans harvested from amongst the seagrasses are the crabs *Portunus sanguinolentus, P. pelagicus and Callapa indica*. Lobsters also occur in places, especially *Panulirus* *ornatus,* as well as many species of hermit crabs (Relatório Final da Avaliação do impacto ambiental 2006).

In places the seagrass beds are noticeably patchy, forming areas of lush, almost circular, growth in otherwise fairly barren sand. This is more conspicuous when seen from the air but can also be seen when travelling over the seagrass beds by boat. This has puzzled scientists for some time – but a possible explanation now exists. The seagrass beds form a tangle of vegetation within the middle of which leaf litter generated by the seagrasses becomes trapped. The patches are discrete and appear to form closed systems.

Pearl oysters (*Pinctada imbricata*), known as *mapalo*, occur in abundance in the seagrass beds and these attach themselves to the stems of the seagrasses by their byssus threads. Mapalo produce small pearls that are usually of poor quality on Bazaruto but some species are cultivated elsewhere for a better quality product. They are suspension-feeders and subsist on detritus particles as the water column clearly supports little phytoplankton. While the surrounding water is turbid, the water is relatively clear over the seagrass beds. The mapalo filter out much of the suspended particulate matter within the seagrass beds, subsisting on the breakdown products of fallen leaves trapped within the tangle of vegetation. Nutrients are in turn recycled back to the grass beds in the excretory products of the mapalo. Each bed thus appears to comprise a closed oasis within the less productive sandflats.

The mapalo beds are partially exposed at full spring low tides and local women walk some distance onto the sand flats to harvest this abundant resource. In years gone by, mapalo comprised a staple protein, especially during the war years when refugees flocked from the mainland to the islands. Large middens of discarded mapalo shells can still be seen at some places on Bazaruto; some used to harden sand roads in Vilanculos. An estimate of the total stock from 1989 data yielded a figure of 1.55×10^8 mapalo in the archipelago as a whole. Field measurements of a sample weight indicated that this number amounted to a total biomass of 1 860 tonnes of flesh (wet weight). The animals were seen to be highly fecund and the sex ratio and gonad index of a subsample suggested there were slightly more males, while 79% of the specimens collected in early summer were in a reproductively ripe condition.

Seagrass meadows are a significant and essential component of the ecosystem in the Bazaruto Archipelago and they underpin much of the environmental goods and services that are generated in that region. Their role in sustaining biodiversity, nursery function and their contribution to local food security is clearly of value. But seagrass meadows are also vulnerable, not only to natural events such as storms and climate change, but also to insensitive development and alteration of habitat. Dredging, port construction and alterations of water flow can seriously impair the seagrasses of a region. In the case of the Bazaruto Archipelago, destruction of seagrasses will impact severely on the survival of turtles and especially the endangered dugong. Thus, while seagrasses are a fascinating subject for study, they are amongst the most sensitive and important habitats that require protection in the Bazaruto Archipelago.

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CHAPTER 11

CORAL REEFS

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The coastline of Mozambique (Fig. 11.1) extends from 10° to 27° S, encompassing a full spectrum of reef types, from the fringing and island reef complexes found on either side of the Mozambique-Tanzania border (Hamilton & Brakel 1984; Wells 1988; Obura *et al*. 2000; Rodrigues *et al*. 2000a) to the high-latitude marginal reefs of southern Africa (Schleyer 2000). The reefs in the Bazaruto Archipelago are concentrated primarily around Bazaruto Island (Fig. 11.2) and constitute a major attraction for the ecotourism industry that operates amongst the islands. They are isolated from those in northern Mozambique by the Sofala Banks off Beira, derived from the Zambezi delta, and from those to the south off Inhambane and in southern Mozambique (Fig. 11.1).

Fig. 11.1: Map of Mozambique showing its principal reef areas (from Schleyer, et al., 1999).

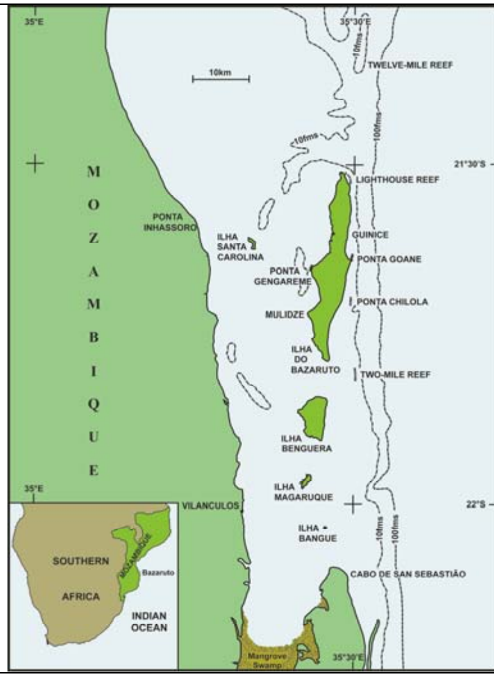

Fig 11.2. Map of the Bazaruto Archipelago showing locality of the coral reefs.

The archipelago is exposed to the warm waters of the Indian Ocean in the Mozambique Channel with mean monthly sea temperatures of 23-28°C (SADCO data), salinities of 35.0-35.4‰ (SADCO data) and a maximum tidal flux of 3.8 m (British Admiralty Chart 2932, 1972). The prevailing south to south-easterly winds generate swells of up to 5 m and the region is periodically subject to cyclones in the southern hemisphere summer.

On their eastern side, the larger islands have reefs exposed to deep water but, on the western, mainland side, a build-up of sediment has formed a shallow system of channels and seagrass beds.

The reefs are variable in nature and range from sparse coral growth or a thin veneer of corals on underlying Pleistocene sandstone substrata to true hermatypic reef formations. The former are similar to reef structures found further to the south in South Africa (Ramsay & Mason 1990; Ramsay 1996). However, while soft (leather) corals are more abundant than hard (stony) corals on reefs further south (Schleyer 2000), the hard corals are both more abundant and diverse on the Bazaruto reefs. The reefs can be divided into three types: submerged sandstone reefs, submerged fringing reefs and patch reefs. Apart from these, some sedimented rocky shelves exploited by local fishermen are found in shallow water north of Santa Carolina Island, and isolated rocky massifs are found off the mainland immediately to the south of the Bazaruto National Park. A list of the corals found in the Bazaruto Archipelago is presented in Table 11.1 and illustrative values of the percentage cover of the benthic biota found on the reefs in Table 11.2.

The largest submerged sandstone reef is found 12 nautical miles (hence the name Twelve-mile Reef) north-north-east of Bazaruto Island at a depth of between 18 and 24 m. It consists of a flat rock substratum that drops into fissures, gulleys and low walls to the surrounding sediment. The shallower reef top has a mixed coral community of which 1-2 m carpets of *Cladiella kashmani* and other soft corals are notable. However, in view of its depth, corals are relatively sparse and a number are species that do not have a symbiotic relationship with algae. The reef community is more mixed in the gulleys where sponges and some sea squirts occur, as well as a sparse community of black corals and seafans.

The smallest submerged sandstone reef, Ponta Gengareme (or Zingarema), is found on the western shore of Bazaruto Island, and comprises a steep wall that falls away from a rock shelf just exposed at full low tide. This wall forms part of the perimeter of a deep hollow (17 m) encircled by sand bars on the inner side of Bazaruto. It is subjected to strong tidal variations and the water is turbid. The corals found here are particularly sparse, consisting mostly of those species that do not need light to support a symbiotic relationship with algae. The large honeycomb oyster (*Hyotissa hyotis*) is a notable inhabitant amongst turret coral colonies under overhangs.

A number of submerged fringing reefs are found on the exposed, eastern side of Bazaruto Island. The substructure to these appears to be Pleistocene sandstone arising from a submerged coastline (Ramsay 1996). Typical amongst these are Lighthouse Reef, Guinice, Ponta Goane and Ponta Chilola. All comprise an inner reef zone, a shallow fringing reef top and an outer reef zone. The inner reef zone consists of bommies and patches of reef in shallow water (5 – 15 m), the tops of which are nearly exposed at low tide. The area is subjected to strong tidal flushing. The coral community is varied and includes digitate, honeycomb, brain, tabular, plate, and leather corals with patches of staghorn corals. Encrusting genera are also present. Giant clams, anemones and sponges add to the variety.

The shallow fringing reef top constitutes the upper and outer edge of the reef and is subjected to swell-driven surge and tidal flux at all but the lowest of tides. As a result, thickets of staghorn corals flourish at the inner edge of this zone with an occasional colony of pillared staghorn coral. These are interspersed by some colonies of massive porous corals.

The outer reef is exposed to the full force of the sea and prevailing long-shore currents. As a result, it is an area of high turbidity and sediment movement. The coral community in this zone is thus tolerant of these conditions but relatively sparse. Sediment-tolerant soft corals and encrusting, tabular, honeycomb and star corals are relatively abundant here.

Two-mile Reef, also a submerged fringing reef, lies between Bazaruto and Benguera islands (Fig. 11.2) and is more exposed to the sea than the preceding fringing reefs. It thus has all of the attributes described above, but in a more concentrated form. While its outer edge is as depauperate as this zone on the other reefs, it has a shallow (5 m) coral garden at its northern point that is particularly rich in staghorn corals and tabular and digitate acroporids. Inside and to the south are found the full spectrum of corals recorded in the region, including thickets of fire corals. There is a break in the middle of the reef and an interesting concentration of nodular colonies of daisy corals is found on the sediment in this gap.

The third type of reefs, patch reefs, occurs as isolated small patches of reef found at various other points around Bazaruto Island and off Santa Carolina Island. Their coral communities tend to be sparse, and consist of sediment-tolerant and often transient honeycomb, brain and soft corals. Colourful starfish are often observed near patch reefs on the inside of Bazaruto Island, being associated with the adjacent seagrass beds. Mulidze (Fig. 11.2), a locality where such patch reefs are found, is notable as it also has fossilised casts of an extinct worm. These artefacts are like stove-pipes in appearance and protrude from the sand at 7 – 10 m depth.

Isolated rocky shelves are found inshore of Bazaruto Island to the north of Santa Carolina. These are low features that emerge from the surrounding sand flats and are flat, heavily sedimented and subjected to turbidity. As a result, their coral communities tend to be sparse, and consist of sediment-tolerant and often transient corals. The large honeycomb oyster is a notable inhabitant, as are colourful starfish, being associated with the adjacent seagrass beds. Seaweeds are slightly more conspicuous on these reefs but do not become abundant due to the prevailing turbid conditions. While they are important fishing spots for local communities, being relatively sheltered and close to Inhassoro, they do not constitute an important coral environment. Kingfish Reef would fall into this category.

Conversely, at the opposite extreme, the Camel's Hump and Amphitheatre are rocky massifs located outside the Bazaruto National Park off Cabo São Sebastião. These are similar in origin, structure and depth to Twelve-mile Reef but are located in the turbid water that empties from the bay between the islands and Vilanculos. The benthos on these reefs is thus impoverished relative to that found on Twelve-mile Reef.

Coral diversity

Most of the corals found in the Bazaruto Archipelago have a wide Indo-Pacific distribution, a few being East African regional endemics (Table 11.1). A new soft coral species, *Cladiella kashmani*, was found in the Bazaruto Archipelago (Benayahu & Schleyer, 1996) and appears to be limited in its distribution to East Africa.

In terms of diversity, Bazaruto has slightly more hard coral species than found on South African reefs (99 vs 90; Riegl 1996; Schleyer 2000) but fewer soft corals (27 vs 41; Benayahu 1993; Benayahu & Schleyer 1996). In both cases, the biodiversity is lower than that found in northern Mozambique (Riegl 1996; Benayahu *et al*. 2002). However, it is of note that the attenuation in soft coral species with distance from the equator is counterpoised by a subsequent increase in their diversity with the southern admixture of tropical and temperate waters (Benayahu *et al.* 2002).

The reefs themselves are varied in structure and offer a range of diving experiences for the ecotourism industry. They are a valuable resource as they comprise an isolated node of reef development between the limited reefs in southern Mozambique and South Africa and the more extensive coral reefs north of Beira. While true reef accretion is found in the latter, the former are marginal in nature (Schleyer 2000); the Bazaruto reefs share attributes of both.

Management Issues

The most spectacular diving is to be found in the outer reef areas where large fish are encountered and on the shallow, fringing reef tops where an abundance of staghorn corals, with a diversity of other corals and colourful reef fish occur. While the former are resilient to recreational divers, staghorn corals and digitate acroporids on the latter reefs are particularly sensitive to diver damage.

SCUBA divers exploring coral reefs.
(Photograph by Nuno Quartin)

The following recommendations were thus formulated for their management (Schleyer & Celliers 2006). The principles upon which they are based are outlined with their underlying rationale. These principles are in turn based on extensive experience of the reefs in southern Mozambique and South Africa, of their intensive use for ecotourism in KwaZulu-Natal, and on a study of reef damage in the latter area (Schleyer & Tomalin 2000).

Diver competence

Sea conditions on the southern African coast are relatively turbulent, making the reefs more susceptible to diver damage compared to most other localities. Diver competence and behaviour must therefore be given greater attention than usual, leading to their emphasis in the recommendations that follow. As a first, general rule, the use of gloves by sport-divers should be strictly prohibited. The greatest damage caused by divers to a reef is from holding and colliding with corals, resulting in abrasion and breakage. If unprotected hands are a diver's first defence when swept onto a reef, avoidance becomes the preferred strategy and diver contact with the reef is reduced. This applies to all groups of divers, whether SCUBA or snorkel divers, or spear-fishermen. Points specific to the different diver categories follow:

- Buoyancy control is the main means whereby a SCUBA diver stays clear of the reef but is a skill which varies with diver competence. Reef management should take this into account and certain reefs should be restricted and made accessible only to divers of demonstrable competence, i.e. those who have dived recently and are experienced divers of advanced qualification. The *Acropora*-rich areas, particularly in the coral garden at the northern tip of Two-mile Reef, fall into this category.
- Some Bazaruto dive operators require snorkel divers to wear wet suits without weight belts. This ensures diver buoyancy and encourages a horizontal swimming posture. It is a commendable practice as it prevents novices from "walking" on the reef. Its only disadvantage is that, if a snorkel diver does duck dive to look at something, a hand-hold may be sought to stay underwater. Visits of large numbers of snorkel divers from passing cruise ships require specific management in view of their size.
- Spear-fishermen should avoid entering the sea over a reef, thus preventing coral damage from trampling or tangling with the spear-gun buoy line. The present park regulations preclude fishing activities by tourists close to the islands, so this recommendation only applies to local, artisanal spear-fishermen.

Diver restrictions

The present prohibition on the removal of anything from the reefs by sport-divers and the restriction on spear-fishing to game-fish should be retained. Dive numbers are still nowhere near those attained at more popular localities on the southern African coast but consideration should be given to capping the dive numbers at a site if reef damage becomes a problem or if they approach limits recommended by Schleyer and Tomalin (2000).

Reef zonation

The following zonation for diving activities is recommended for the principal reef areas:

- Outer reef areas: These are generally subjected to the greatest water turbulence and their coral community tends to consist of robust and resilient species of soft and hard coral. Most are thus suitable as open areas for unrestricted diving.
- Inner reef areas: These areas are susceptible to diver damage where they are rich in branching hard coral species. Here diving should be restricted according to diver competence and, depending on their sensitivity, some areas should be closed.

- Reef tops and coral gardens: These are shallow areas in which plate, tabular, digitate and branching corals are susceptible to breakage by trampling and diving activities. Coral gardens are particularly popular with novice snorkel and SCUBA divers but such areas should be restricted to divers of competence, or even closed according to coral sensitivity.

Boat operations

Boats should be prohibited from anchoring on or adjacent to the reefs to prevent anchor damage. Divers should be tendered from the surface at all times, enhancing their safety and providing further employment opportunities for the islanders as skippers. Permanent moorings should never be placed on the reefs. Apart from damage they cause on reefs in turbulent regions, such as Bazaruto, when they are washed to and fro in the surge, they always focus diver entry with concomitant damage to a single locality.

Closed sites

The closure of reference monitoring sites and of sensitive sites is recommended. These will be invaluable for the assessment of the effects of reef use and as breeding refugia. The latter should always be in an up-current situation to promote recruitment on down-current reefs. Heavily dived areas should be closely monitored for excessive diver damage. Finally, it may be advantageous to select and zone the sites for closure in liaison with reputable dive operators within the Bazaruto ecotourism industry. This could result in a better product and would introduce elements of co-management that almost certainly would engender greater user support.

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Table 11.1: Corals collected on the Bazaruto reefs.

ALCYONACEA
Tubiporidae
Tubipora musica Linnaeus, 1758
Alcyoniidae
Cladiella australis Macfadyen, 1936
Cladiella kashmani Benayahu & Schleyer, 1996
Cladiella krempfi Hickson, 1919
Lobophytum crassum von Marenzeller, 1886
Lobophytum venustum Tixier-Durivault, 1957
Lobophytum patulum Tixier-Durivault, 1956
Sarcophyton flexuosum Tixier-Durivault, 1966
Sarcophyton gemmatum Verseveldt & Benayahu, 1978
Sarcophyton glaucum Quoy & Gaimard, 1833
Sarcophyton subviride Tixier-Durivault, 1958
Sarcophyton trocheliophorum von Marenzeller, 1886
Sinularia abrupta Tixier Durivault, 1970
Sinularia brassica May, 1898
Sinularia erecta Tixier-Durivault, 1945
Sinularia flexuosa Tixier-Durivault, 1945
Sinularia grandilobata Verseveldt, 1980
Sinularia gravis Tixier-Durivault, 1970
Sinularia heterospiculata Verseveldt, 1970
Sinularia leptoclados Ehrenberg, 1834
Sinularia macrodactyla Kolonko, 1926
Sinularia notanda Tixier-Durivault, 1966
Sinularia polydactyla Ehrenberg, 1834
Sinularia triangula Tixier-Durivault, 1970

Xeniidae
Anthelia glaucum Lamarck, 1816
Sansibia flava May. 1889
Xenia impulsatilla Verseveldt & Cohen, 1971
Nephtheidae
Dendronephthya sp.
Stereonephthea sp.
SCLERACTINIA
Acroporidae
Acropora anthocercis Brook, 1893
Acropora austera Dana, 1846
Acropora cf. cerealis
Acropora clathrata Brook, 1891
Acropora cytherea Dana, 1846
Acropora abrotanoides Lamarck, 1816
Acropora divaricata Dana, 1846
Acropora formosa Dana, 1846
Acropora gemmifera Brook, 1892
Acropora horrida Dana, 1846
Acropora hyacinthus Dana, 1846
Acropora retusa Dana, 1846
Acropora nasuta Dana, 1846
Acropora palifera Lamarck, 1816
Acropora robusta Dana, 1846
Acropora secale Studer, 1878
Acropora tenuis Dana, 1846
Acropora valida Dana, 1846
Astreopora myriophthalma Lamarck, 1816
Montipora aequituberculata Bernard, 1897
Montipora cf. undata
Montipora hispida Dana, 1846
Montipora monasteriata Forskål, 1775
Montipora peltiformis Bernard, 1897
Montipora tuberculosa Lamarck, 1816
Montipora venosa Ehrenberg, 1834
Agariciidae
Gardineroseris planulata Dana, 1846
Leptoseris explanata Yabe & Sugiyama, 1941
Leptoseris hawaiiensis Vaughan, 1907
Pachyseris speciosa Dana, 1846
Pavona cf. clavus
Pavona decussata Dana, 1846
Pavona minuta Wells, 1954
Pavona varians Verrill, 1864
Caryophiliidae
Gyrosmilia interrupta Ehrenberg, 1834
Dendrophyliidae
Dendrophyllia cf. robusta
Tubastrea micranthus Ehrenberg, 1834
Turbinaria frondens Dana 1846
Turbinaria mesenterina Lamarck, 1816
Turbinaria peltata Esper, 1794

Turbinaria reniformis Bernard, 1896
Faviidae
Cyphastrea serailia Forskål, 1775
Echinopora gemmacea Lamarck, 1816
Echinopora hirsutissima Milne Edwards & Haime, 1849
Echinopora lamellosa Esper, 1795
Favia favus Forskål, 1775
Favia pallida Dana, 1846
Favia speciosa Dana, 1846
Favia stelligera Dana, 1846
Favites abdita Ellis & Solander, 1786
Favites flexuosa Dana, 1846
Favites pentagona Esper, 1794
Goniastrea peresi Faure & Pichon, 1978
Goniastrea edwardsi Chevalier, 1971
Goniastrea pectinata Ehrenberg, 1834
Leptastrea transversa Klunzinger, 1879
Leptastrea purpurea Dana, 1846
Leptoria phrygia Ellis & Solander, 1786
Oulophyllia crispa Lamarck, 1816
Platygyra daedalea Ellis and Solander, 1786
Platygyra sinensis Milne Edwards and Haime, 1849
Plesiastrea versipora Lamarck, 1816
Fungiidae
Cycloseris sp. cf. *somervillei*
Fungia Fungia fungites Linnaeus, 1758
Fungia Pleuractis scutaria Lamarck, 1801
Fungia Verrillofungia cf. concinna
Merulinidae
Hydnophora exesa Pallas, 1766
Hydnophora microconos Lamarck, 1816
Hydnophora rigida Dana, 1846
Mussidae
Acanthastrea echinata Dana, 1846
Lobophyllia hemprichii Ehrenberg, 1834
Symphyllia valenciennesi Milne Edwards and Haime, 1849
Oculinidae
Galaxea fascicularis Linnaeus, 1767
Pectiniidae
Mycedium elephantotus Pallas, 1766
Pocilloporidae
Pocillopora damicornis Linnaeus, 1758
Pocillopora eydouxi Milne Edwards & Haime, 1860
Pocillopora verrucosa Ellis & Solander, 1786
Seriatopora hystrix Dana, 1846
Stylophora pistillata Esper, 1797
Poritidae
Goniopora cf. columna Dana, 1846
Goniopora lobata Milne Edwards & Haime, 1860
Goniopora somaliensis Vaughan, 1907
Goniopora stokesi Milne Edwards & Haime, 1851
Porites cylindrica Dana, 1846
Porites lobata Dana, 1846

Porites lutea Milne Edwards & Haime, 1851
Porites nigrescens Dana, 1846
Porites Synarea rus Forskål, 1775
Porites solida Forskål, 1775
Siderastreidae
Coscinaraea columna Dana, 1846
Coscinaraea monile Forskål, 1775
Horastrea indica Pichon, 1971
Psammocora contigua Esper, 1797
Psammocora digitata Milne Edwards & Haime, 1851
Psammocora haimeana Milne Edwards & Haime, 1851
Psammocora nierstrazi Horst, 1921
Psammocora profundacella Gardiner, 1898
Siderastrea savignyana Milne Edwards & Haime, 1850
MILLEPORINA
Millepora platyphylla Hemphrich & Ehrenberg, 1834
Millepora tenella Ortmann, 1892

Table 11.2: Percentage cover of the major biota on reefs within the Bazaruto Archipelago (from Schleyer & Maggs, 2008).

Reef	Aquarium	Inner Two-mile Reef	Outer Two-mile Reef	Lighthouse Reef	Twelve-mile Reef	Kingfish Reef	Amphitheatre	Camel's Hump
Hard coral	41.6	39.5	34.1	43.4	15.4	6.6	3.3	3.0
Soft coral	4.4	3.5	8.7	6.8	14.3	0.1	8.6	18.9
Black coral	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.4
Anemones, etc.	2.5	3.7	3.4	2.7	0.0	2.7	0.3	0.3
Bivalves	0.0	0.2	0.1	0.2	0.0	1.3	0.3	0.3
Other invertebrates	0.7	1.1	3.4	1.0	17.2	6.4	15.4	13.6
Foliaceous seaweed	1.4	2.8	10.6	2.6	4.5	26.4	10.5	4.9
Coralline seaweed	0.9	6.4	0.1	1.6	0.9	0.0	2.2	0.4
Dead coral	18.8	2.6	0.7	9.0	0.5	0.3	0.3	0.1
Bare reef, rubble & sand	29.7	40.1	38.0	32.3	44.4	55.6	57.6	56.9

CHAPTER 12

MOLLUSCS

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The Mollusca – the phylum containing snails, cowries, limpets, mussels, clams, octopuses, etc is the largest and most diverse group of animals in the sea. In number of species they peak in tropical waters, where they consequently play an important role in most ecosystems. The Bazaruto Archipelago is no exception, and over 500 species of molluscs are so far known to inhabit this small area.

Although the aesthetic appeal of seashells is obvious to all, the adaptations and habits of the animal that makes them are even more fascinating, and their role in the ecology is an extremely important one. Not only are they consumed by a very wide range of animals, from other molluscs, fishes and turtles, to man, but in turn they prey on a diversity of other creatures, from minute plankton and even bacteria to corals, other molluscs and even crustaceans and small fishes. The free-swimming larvae of most tropical molluscs play an equally important role in the plankton. Burrowing molluscs aerate and rework the sand or mud while others bore into rocks or coral, their tunnels posthumously providing shelter for a range of small animals. Filter-feeding molluscs clear suspended matter and concentrate heavy metals in their tissues. Each of the marine ecosystems in the Bazaruto Archipelago has its own characteristic mollusc fauna.

The beaches

We will begin with the high-water level, much of which is sandy. Where they occur, the sandstone outcrops are heavily eroded in the splash zone, with depressions and caverns, and little if any visible plant life. Although the long daily periods of exposure to sun, heat and wind render this zone too inhospitable for most animal life, several characteristic molluscs are able to survive. Particularly well adapted to extremes of exposure are various gastropods (snails) that are able to trap water inside their shells, such as the little periwinkles *Nodilittorina natalensis* and *Littoraria glabrata*, and the ridged, cream or pink nerite *Nerita plicata*. Of the three species, the smooth, striped *L. glabrata* lives highest up the shore, with *N. plicata* and the nodular, grey *N. natalensis* somewhat lower down. All three snails have free-swimming larval stages, to facilitate dispersal. Additionally, the two periwinkles shed minute floating egg capsules (resembling microscopic flying saucers) into the plankton; nerites attach their capsules to the rock surface, the tough walls protecting the larvae and keeping them moist until they hatch. All can keep cool by controlling evaporation, and *Nerita plicata* is reported to orientate itself away from the sun in the morning, and towards it in the afternoon.

In high water caves and under rock overhangs are found the mottled grey nerite *Nerita undata* and the big chiton *Acanthopleura brevispinosa* (which can mould its armadillo-like body to conform tightly to irregularities in the rock). All such high-level molluscs are grazers, scraping up lichens and microscopic algae, as well as plankton deposited by the falling tide, using a feeding structure called a radula, which is a flexible ribbon with rows of microscopic hardened teeth.

Slightly lower down the shore, on exposed rock surfaces, a belt of black rock oysters, *Crassostrea cuccullata* (sometimes called *Saccostrea cucullata*), is typically present. Sheltering among the oysters and in nearby hollows may often be found the grazing snail *Planaxis sulcatus*, which resembles a mottled brown periwinkle but has a basally notched aperture; in this species, the eggs are brooded inside a special brood pouch and released as free-swimming larvae. In cracks and deep crevices lives the little grey, black or white mussel, *Parviperna nucleus*, attached by a tuft of tough threads called a byssus, in which may be found several species of tiny commensal bivalves and gastropods. A small predatory black and white whelk, *Thais savignyi*, is common here too, preying on barnacles and small oysters, into whose shell it drills.

Further down, around the base of rock outcrops, other nerites will be found, particularly the polished nerite, *Nerita polita*, which hides under the sand by day, emerging mainly at dusk to graze on the algal film. Also frequently found are colonies of ceriths (family Cerithiidae), particularly the nodulous black or grey *Clypeomorus bifasciata* and *C. petrosa isselii*, which have somewhat similar habits to *Nerita polita*.

On sandy shores the low-level rocks tend to be barren because of wave-driven sand-scouring, although the limpet *Cellana radiata* (more commonly known as *Cellana capensis*) thrives here. At low tide its saucer-shaped shell, held against the rock by an extremely powerful disc-shaped foot, traps water, providing moisture and oxygen for a ring of highly specialised secondary gills. Predators live here too, such as the knobbly black mulberry shell, *Morula granulata*, which eats barnacles.

Steeper sandy shores tend to be too compacted for most burrowers, although where there is some wave movement, colonies of various species of wedge mussels of family Donacidae may be present, as high up as high neap-tide level. These burrow vertically, 2-5 cm below the surface, communicating with the water above through two short siphons, through which they draw in water containing microscopic organisms on which they feed. The most conspicuous are *Donax lubrica* and *D. veneriformis* (the latter previously misidentified in Mozambique as *Donax faba*). Both species vary greatly in colour, but *D. lubrica* is more triangular and the inner ventral margin of its shell is very finely toothed, but smooth in veneriformis. In sheltered coves, strange slash-like marks in the surface of the sand may betray the presence of the seldom seen little bivalve *Paphies africana*, whose very asymmetrically triangular shell measures only about 7 mm.

The sandflats

Although a superficial stroll over the vast sand-flats that emerge from the sea at low spring tide would suggest that they are as barren as a desert, a great diversity of animals hide beneath the surface, where it remains damp and relatively cooler. Locating them requires a sharp eye and some experience – one needs to scrutinize the surface for the slightest bump, shadow or disturbance which might betray the presence of ones quarry, perhaps a slender, glossy augur shell, a brightly coloured, rugged mitre or a pink-rayed clam. However, as the tide turns or the sun begins to set, many species will emerge to look for food, and in fact such scavengers may be lured out with fish-heads or other carrion. During peak spring tides, steeper banks of clean sand may also heat up to such an extent that burrowing molluscs pop up onto the surface, to lie about helplessly awaiting the incoming tide.

Burrowing molluscs are mainly either filter- or detritus-feeders, or else carnivores that prey on other animals. Filter-feeders draw in water over their large gills and trap plankton for food, whereas detritus-feeders scoop or suck up surface sediment that is often rich in decomposed particles, microscopic plants and animals and even bacteria. Most particle-feeders in the Bazaruto Archipelago sandflats are bivalves (molluscs with a shell comprising two halves or valves). Dominant bivalve groups are venerid clams (Veneridae), tellins (Tellinidae), sunset clams (Psammobiidae), trough shells (Mactridae) and cockles (Cardiidae). Such bivalves burrow by thrusting the axe- or finger-shaped foot down into the sand, pumping blood into it so that it expands to form an anchor, and by contracting the foot muscles to drags itself after the foot.

The largest family of bivalves in the Bazaruto group is the Veneridae, which contains at least 22 species. There is a wide diversity of form between the different species of venus clams, from compressed to swollen, smooth to strongly ridged, and from pure white to vivid brown or purple; all venerids have a strongly-toothed hinge. They are not rapid burrowers, and tend to be found in the channels, particularly amongst marine grass. Amongst the most distinctive are *Circe scripta* with its triangular, flattened valves and radial ridges that increase in number by splitting, and the little wedding-cake venus, *Placamen tiara*, which has delicately recurved concentric ridges. Most are shallow burrowers, drawing in water through their rather short siphons, and removing edible particles.

Tellins live buried on their left side, extending two long separate siphons from the sand surface, one of which (the inhalent siphon) moves over the surface, drawing in detritus particles. Among the larger and more conspicuous are the following: *Tellina perna* and *T. pharaonis* have smooth, pink or white valves that are beaked behind, *T. semilaevis* resembles *T. perna* but has fine sculpture on its right valve (plus a pink cross on the peak of the shell), and two species with fine concentric ridges and pink rays, the elongate *T. philippii* and the deeper, more triangular *T. staurella*. The most distinctive tellin is the shallow-burrowing *Arcopagia scobinata*, which has heavy, rounded valves with strong rasp-like sculpture. Perhaps the commonest is the little *Macoma dispar* whose shiny, compressed valves appear smooth, although the right one is slightly silky in appearance and under magnification shows shallow oblique grooves, which assist in burrowing by acting like a ratchet to reduce backwards slipping.

A superficially similar family to the tellins (but with a small angular projection from the shell margin behind the beak), are the sunset clams, which have much the same mode of life, although they feed on both suspended and detrital matter. The commonest species on the Bazaruto sandbanks is the delicate pale violet *Gari pallida*, which has fine oblique grooves. (Another member of the family, *Asaphis violascens*, which has strong, rough radial ridges, prefers sand or gravel among rocks.)

Having very short siphons, cockles burrow very shallowly, and lie vertically immediately below or at the surface of the sand. When threatened by a predator they are able to erupt from the sand by kicking with the powerful finger-shaped foot, and escape by a series of bounds. The commonest cockles on open sandbanks are the roughly sculptured orange red *Vasticardium assimile* and the angular white *Fragum retusum*, although in the intervening grassy channels the little white *Parvicardium transclathratum* may live in dense populations.

Trough shells are large, more or less smooth clams with a big socket in the hinge that holds the elastic ligament. They are filter-feeders with their two siphons fused together. Common species are the brown-rayed *Mactra glabrata lilacea* (with purple-tinged interior) and *Mactra rochebrunei* (with more oval outline).

Also may be mentioned certain bivalve families that supplement or replace filter-feeding by using special bacteria that live on their gills to (simply stated) convert chemicals known as sulphides into carbohydrates that can be digested by the clam. The best known are the platter shells of the family Lucinidae, a few of which may be locally common in the area. For example, in the muddy north bay of Benguera Island, an extensive colony of the globular white *Anodontia edentula* lives sunken into the surface of the mud. Other species such as *Loripes clausus* are deeper burrowers, forming dense colonies whose presence is revealed only by vast accumulations of empty shells. The rarest species is the large, unusually flat, pale mauve *Eomiltha voorhoevei*, of which only a few empty shells have been found in the islands.

Particle-feeding snails are usually much less common than bivalves on the sandflats. The strombs (family Strombidae) are one such group, feeding on fine algae and detritus. They are remarkable on several counts. For example, their eyes, beautifully ringed with colour, have unusually acute sight – anyone observing a stromb in a jar of seawater may be disconcerted to find themselves being observed back! The outer lip of the shell even has a deep notch, which provides a peep-hole for the long eye-stalks. Unlike most sea snails strombs progress by jumping, using vigorous kicks of the long foot. The operculum (the “lid” or “door” that closes the aperture when the snail retracts) is claw-like and serrated, not only providing a good grip, but serving as a defense weapon, capable of inflicting a scratch on the attacker. When competing for a female, male strombs have even been observed using their serrated operculum to keep one another at bay! Of the half-dozen or more species inhabiting the archipelago, the beautiful *Strombus plicatus columba*, with a widely flaring, wing-like lip, inhabits banks of clean sand. Others such as the distorted *Strombus gibberulus* and the slender *S. fusiformis* inhabit sand with rubble, and yet others prefer the reef flats.

A range of burrowing snails completes the food-web by preying on the particle-feeders or scavenging on dead flesh. The dominant carnivores inhabiting the Bazaruto sandbanks are some 15 species of moon snails of the family Naticidae. These voracious predators may be detected by the trail that they leave on the surface, at the end of which will be found a streamlined, mucous-coated wedge, with body flaps that partly or entirely cover the shell. Moon snails are among the few mollusc groups in which the turgidity of the foot is assisted by seawater that is taken up into internal cavities. On coming in contact with a bivalve or with another snail, the prey is seized in the foot and a hole bored into its shell, using the radula and an acid secretion; the underlying flesh can then be scooped out. Such holes, which are slightly funnel-shaped in section, are very commonly seen in empty shells, usually indicating that the inhabitant has served as a meal for a moon snail. Certain other predatory snails (family Muricidae) also drill through the shell of their prey but the resulting hole is less funnel-shaped. The egg masses of moon snails – a brittle, near-circular collar impregnated with sand – are also commonly seen washing about the surface of sandbanks. The most common moon snails are the pure white *Polinices mammilla* and the grey *Natica gualteriana.*

Small bivalves and gastropods serve as prey for a range of other snails, all of which have the front end of the aperture elongated into a spout, or at least forming a deep notch. This supports a fleshy siphon that can be waved about or protruded from the sand to draw in water from a distance, which is then tested for the scent of potential prey. The larger predatory gastropods may be found prowling the sandflats (although rarely exposed between the tides) singly. One conspicuous species is the big tulip shell *Fasciolaria trapezium*, which uses its powerful, deep red foot and the edge of its shell to prize open bivalves and gastropods. Others, such as the long, slender spindle shells *Fusinus colus* and *F. tuberculatus*, and the triangular paradise whelk *Volema pyrum*, feed mainly on polychaete worms.

The Bazaruto complex is also inhabited by six species of tun shells (family Tonnidae), whose large, thin, globular shell houses a surprisingly small body, but which can expand to swallow an entire sea cucumber. Helmet shells of 5 species (family Cassidae) prefer areas of rubble, where they can find sea urchins on which they prey. They feed on the urchin by either drilling a hole in the test of the urchin or by inserting there proboscides through the urchin's anus. The spectacular red helmet shell (*Cypraecassis rufa*), highly prized for the carving of cameos, is uncommon in the Bazaruto Archipelago and usually seen only by divers; it uses its heavy shell to crush urchins to gain access to the flesh inside.

Among the most brilliantly coloured mollusc are the olive shells (Olividae), whose cylindrical, highly polished shells are usually patterned with zigzag stripes or spots of brown or green, although black individuals also occur. Olives may form large colonies, prowling the shallows in search of small bivalves. Like many carnivores they will also eat dead flesh, and anglers fishing near sandbanks on occasion will reel in their catch to find an olive shell wrapped around the bait. Much more rarely encountered on the Bazaruto sandbanks is the spectacular harp shell *Harpa cabritii*. Harps have been observed catching small crabs, which they seize in a similar manner to moon snails, but devour in a manner somewhat similar to a spider, by injecting saliva containing enzymes and then sucking up the digested tissues. (Many advanced gastropods digest their prey externally in a similar manner). Another remarkable habit of harp shells is their ability to shed part of the foot when stressed, as a lizard does its tail.

In the channels and on rarely exposed sandbanks may occasionally be found a range of augur shells of the family Terebridae with long, sharply tapering shells, adapted for burrowing. Some such as *Terebra subulata* and *T. maculata* are vividly spotted with black or dark brown, others such as *T. dimidiata* and *T. quoygaimardi* are brightly coloured with salmon-pink or orange. Because the shell consists of a very large number of spiral turns and the foot is small they are able to withdraw deeply inside, and as a result, the shell often carries repaired scars indicating unsuccessful attacks by moon snails or crabs. Augers feed on worms, which are swallowed whole.

Other common carnivores are various murex snails (family Muricidae), a few of which may be found on the sandbanks (although most muricids are rock-dwellers). Two species are notable on account of their extremely long, tubular canal, supporting the siphon, which can therefore draw in and "sniff" water from a considerable distance away. These are the common grey *Murex brevispina* with short spines, and the much rarer *Haustellum haustellum*, which is spineless and has an orange aperture. *Murex brevispina*, at least, is a communal spawner, and groups of females collaborate to lay their horny egg capsules in a large cylindrical mass, somewhat resembling a giant loofah, that may be found washing about the sandbanks. Although the identity of these structures is often an object of speculation, its origin will usually be revealed by the presence of one or more female murexes, clinging to the mass and adding their clutches of capsules. Each capsule contains several to many eggs, which hatch as free-swimming larvae or crawl-away young, depending on species. Clumps of egg capsules of different species of muricid are used in African traditional medicine, and may be seen for sale in mainland markets.

Also common on sandflats, more so where there is muddy sediment, are colonies of dog whelks (family Nassariidae), snails with two tiny tails at the end of their foot, and an operculum that has a serrated edge. These are opportunistic scavengers, rapidly drawn to carrion, which they can scent from a long distance away. Many have the underside of the shell greatly thickened, as a hindrance to the attack of moon snails. For example, the little South African tick shell (*Nassarius kraussianus*), that reaches its northern limits in the Bazaruto area, often shows shallow drill-scars indicative of an escape. Others such as *Nassarius papillosus, N. fenistratus* and *N. conoidalis* have nodules that make it more difficult for a moon snail to secure a grip.

An unusual habitat for small sandbank molluscs are masses of fine, white, tightly intertwined, calcareous worm tubes which may occasionally be found buried in the sand. One such cluster of aggregated tubes, from a sandbank between Santa Carolina Island and the mainland, sheltered no less than two previously undescribed species of bivalves.

Muddier sandflats are often carpeted with meadows of seagrass (particularly *Thalassodendron*), which grow particularly lushly in the channels. These constantly generate rich organic debris and provide several unique microhabitats. Wading amongst these, and feeling in the silt between their roots (this requires fairly strong nerves, as there are many creatures that prick, bite or pinch) will produce a wealth of burrowing molluscs. The leaves themselves are inhabited by small snails that graze on the epiphytic algae that coat their surfaces. These include little top shells (*Jujubinus suarezensis*), a slender horn snail (*Cerithium rostratum*) and the exquisite emerald nerite (*Smaragdia rangiana*), a 5-7 mm snail with a polished emerald-green shell. Several scallops also live attached to the seagrass leaves by their byssus, a clump of extremely strong, somewhat elastic threads, secreted by the scallop's foot. The most common is the senatorial scallop (*Mimachlamys sanguinea*), whose orange or brown shell is usually coloured dark red by a coating of sponge (genera *Mycale* and *Callyspongia*); this association provides attachment for the sponge and protection for the scallop, as sponges are of little interest to predators. The edge of the mantle has a row of light-sensitive eyes, which can detect light and movement.

Amongst the grass, which provides shade and moisture even during the most extreme low tide, may be found a wealth of molluscs. These even include some of the cowry species that are more characteristic of reef habitats, such as the gold-ringed cowry (*Cypraea annulus*), the similar but more angular money cowry (*Cypraea moneta*) – once used as currency in the early 19th Century in parts of Africa and Asia - and occasionally even the large, spotted tiger cowry (*Cypraea tigris*), which is often found living in pairs.

In these channels may also be found large clusters of the small pearl oyster *Pinctada radiata* (locally known as the “sand oyster” or “mapalo”) and the horse mussel *Modiolus philippinarum,* anchored together by their tangled byssal fibres. They are both exploited for food and as a result have become relatively scarce. The large black-lip pearl oyster (*Pinctada margaritifera*) also occurs, living attached to reefs below low tide. Valuable pearls are produced on rare occasions, and were once an important product of the islands.

Pen shells (mainly *Pinna muricata*) live vertically embedded in muddy sand, with only the gaping end at the surface (a hazard to bare feet on account of its near razor sharpness). After death the empty shells remain as an underground chamber, providing a safe refuge for a number of gastropods, particularly the triton *Cymatium cingulata* and the cowry *Cypraea caurica*, and of course their egg capsules.

Because of the absence of rivers on the islands, mangroves are rare, although a few isolated clumps of trees occur. The white mangrove, *Avicennea marina*, provides a specialised habitat for several molluscan species. On its trunk lives the characteristic mangrove creeper*, Cerithidea decollata*, which during high spring tides climbs a metre or two and attaches the lips of its shell to the bark with a ring of mucus. During neap tides it descends onto the mud below, to graze on microscopic fungi and algae. Apart from its tidal migrations, the mangrove creeper is unusual in that the apex of the shell is progressively discarded as it grows, so that perfect shells are only present in juveniles. This is probably a protection against the thin early whorls being eaten away by organic acids or crushed by predatory crabs. Mangrove periwinkles, *Littoraria scabra* and *L. intermedia* (several others probably await recording) can be found on the branches and leaves which rasp up microscopic plants and the surface cells of the leaves. These periwinkles brood eggs and embryos internally, releasing well-developed, swimming larvae.

The stick-like breathing roots of the white mangrove, as well as the prop roots of *Rhizophora*, frequently bear masses of oysters, often elaborately frilled or winged, and usually purplish-black in colour. This species, *Crassostrea forskahlii*, resembles the common rock oyster, *C. cuccullata,* but lacks the dense radial ridges that cover the upper valve of unworn individuals.

On the fringes of the mangroves may sometimes be found a large, tapering, dark brown creeper, *Terebralia palustris*, whose shell reaches a length of 11 cm or more. These snails may congregate in considerable numbers to feed on the fallen leaves of the mangrove trees. Young ones feed on detritus.

The coral reefs

Around most of the islands are patch reefs, extending from extreme low tide down to 24 m. Live coral reefs present an impressive spectacle of diversity because of the variously coloured soft and hard corals and their brilliantly hued attendant reef fishes. Yet far fewer species of molluscs are found on the living reef than under the adjacent dead coral heads and rubble. However, some molluscs are always associated with soft or stony corals, on which they live and feed, for example the egg or false cowries of the family Ovulidae, live on soft corals and gorgonians. As in true cowries, the mantle (the skin-like body tissue that secretes the shell) is expanded over the shell when the creature is undisturbed, and closely matches the host on which the animal lives. For example, the poached egg cowry (*Ovula ovum*) has a glossy, pure white shell (with orange yolk-coloured interior!), but will rarely be seen alive except by those in the know. If you should swim over a black soft coral and note a paler grazing track, look for a black lump at its termination. This may be a poached egg cowry, whose conspicuously white shell is hidden by its black mantle. Other egg cowries can be found on different types of soft corals, particularly gorgonians (sea whips and sea fans).

Egg cowries appear to do little damage to their coral hosts, in contrast to whelks of the genus *Drupella*, two species of which occur in the Bazaruto Archipelago, namely the white *Drupella cornus* and the smaller brown *D. fragum*. These little snails emerge at night to devour coral polyps, by pouring saliva, containing digestive enzymes, onto the polyps and sucking up the resultant mucoid "soup". Although individuals do little damage, population explosions have elsewhere caused extensive damage to reefs.

On the bases of corals may be found various species of coral shells, family Coralliophilidae. These are always associated with corals, feeding on soft tissue and probably also stealing food captured by the coral, but never become abundant enough to do damage. Some coral shells such as the almost limpet-like *Quoyula madreporarum,* are capable of only limited movement. Others (not yet recorded from the Bazaruto Archipelago but certain to occur) even live inside the stony skeleton of the coral, their spiral shell growing into a long worm-like tube as the coral grows, in order to keep contact with the water outside.

Most molluscan coral borers, however, are bivalves, whose presence is revealed by figure-8 shaped openings on the surface (usually on the underside of the coral head). The most common on Bazaruto are date mussels (family Mytilidae), of genera *Lithophaga* and *Leiosolenus*, which have a cylindrical brown shell (in the latter genus coated with lime). Date mussels bore by secreting a chemical that breaks down the lime of the coral; some species inhabit living coral, the free-swimming larvae entering initially through the mouth of the coral polyp. Less common are the flask shells of family Gastrochaenidae, which have a fragile widely gaping shell.

In contrast to the molluscs that take advantage of corals, may be mentioned one of its "protectors"! The large trumpet triton (*Charonia tritonis*) on rare occasions may be seen on deep-water coral reefs, where it preys on starfish, including the notorious "crown-of-thorns" (*Acanthaster planci*), which may do extensive damage to reefs by eating the polyps.

Reef flats

The reef flats are littered with dead coral heads, associated rubble and loose rocks. Here molluscs may initally appear almost absent, as almost all hide by day, or at least when the tide falls. An exception is the giant clam, one species of which (*Tridacna maxima*) may be a conspicuous feature of undisturbed reefs. From a distance these appear as large, wavy, worm-like objects, mottled in various shades of green, brown, yellow, etc. On approaching these curious objects – which often respond by expelling a jet of water – they are seen to be the greatly thickened mantle edges of giant clams, filling the gap between the two heavy, jagged-edged valves. Giant clams are not only the largest living bivalves but are the only ones to live hinge-downwards. The common Mozambican *Tridacna maxima* is not the largest in the group, attaining a length of only about 20-30 cm; a second, much rarer species, *T. squamosa*, which lives amongst live coral below tide limits, is even smaller. Giant clams are remarkable in that their mantle tissues contain commensal algae (zooxanthellae), which receive shelter from the clam (whose mantle even has special transparent cells to allow light to penetrate); in return, the clam receives nourishment in the form of glucose, produced through photosynthesis. Younger clams (which are initially male, later simultaneous hermaphrodites) supplement this with filter-feeding.

The true diversity of the reef flats lies in their cryptic fauna. Turning over a lump of coral or an encrusted rock will reveal a wealth of hidden animals, too many (over 200 species of molluscs) to discuss in detail. Many of these are so well camouflaged as to be nearly invisible. Of course in the tropics effective camouflage (or mimicry) may permit the most vivid of reds, oranges or yellows, as these colours also occur in sponges, bryozoans, anemones, ascidians, etc. which are inedible to most predators. Conversely, in some molluscs the most garish of colour combinations may serve as a warning, alerting predators to the fact that they have noxious secretions. The multitude of nudibranchs, shell-less sea slugs (not covered in this chapter), fall into this category.

One interesting combination of defense mechanisms, combining mimicry and rapid response, occurs in the file shell *Limaria fragilis*, which commonly occupies crevices on the underside of coral heads. This bivalve has long, deep red tentacles that protrude from the crevice like those of a sea anemone. However, if disturbed, the file shell begins to clap its valves together, enabling it to swim erratically away. However, if seized in the hand, the creature begins to shed (autotomise) its tentacles, which are very sticky and continue to wriggle like worms. (Although it has been suggested that the mucus is repugnant to predators, the flesh was pronounced “quite tasty” by the writer).

Generally, turning over rocks and coral blocks (which should always be returned to their original position to protect the communities living under them) will reveal a wide diversity of species. These include several species of keyhole limpets (family Fissurellidae), most of which have a hole or slit in their shell for the expulsion of stale water and waste-products. The green-rayed *Diodora ruppelli* is the most common, but perhaps the most unusual is the rectangular *Scutus unguis*, which resembles a Roman shield. Keyhole limpets normally graze on sponges, although in captivity *Scutus unguis* will eat practically anything, from bread to ham! An occasional small abalone or perlemoen (*Haliotis pustulata*) may also be found, crawling unusually rapidly on its broad, flat foot. Its ear-shaped shell, with nacreous (pearly) interior, bears a row of holes for the intake and expulsion of water.

Molluscs with a somewhat abalone-like shell, but lacking the row of holes and with a more distinct spire, are *Pseudostomatella orbiculata* and the rough-shelled *Granata sulcifera*, which belong to a totally different family, the Trochidae. Most Trochidae are known as top shells, having a conical shell and small aperture. They generally live under rocks or coral, or in crevices, crawling about grazing on sponges or microscopic algae. Some are brilliantly coloured, *Trochus cariniferus* being rayed with red and green and *Clanculus puniceus* being brilliant red, dotted with black.

A very large number of gastropod species from a wide range of families will be found in such cryptic habitats, far too numerous to discuss. A number of bivalves will also be found here. Some have the lower valve cemented to the surface, in oyster-like fashion: these include various species of spirally twisted jewel-box oysters (family Chamidae) and thorny oysters (family Spondylidae) with massive, ball-and-socket hinges. Others are attached by a flexible byssus, for example, the bristly ark shells (family Arcidae), such as *Barbatia foliata* and *B. setigera*; these can survive under low-oxygen conditions, having red blood caused by the presence of the efficient oxygen-carrying pigment haemoglobin. Other bivalves may be found in crevices, such as the little venus shell *Irus irus macrophyllus*, recognizable by its elaborately frilled concentric sculpture, and frequently sulphur-yellow colour.

The massive “green snail” (*Turbo marmoratus*) may even be found on undisturbed shores. Its pearly shell interior was once utilized in the manufacture of buttons.

At least 30 species of cowry inhabit the region, although all are widely distributed across the Indian Ocean. Most can be found under rocks or coral at or below low tide level, although some like *Cypraea mauritiana* prefer exposed outcrops where there is a strong swell, and others, like the onyx cowry (*Cypraea onyx adusta*) and Lamarck’s cowry (*Cypraea lamarcki*) like muddy areas (the latter is often collected on fishtraps). Although the polished, strikingly coloured shell is so conspicuous, a live cowry may be well camouflaged as the two flaps of the mantle may cover the shell, not only hiding the gloss but simulating a sponge, coral or a silted or encrusted rock. They are usually grazers but their ecological role as a group is complex as some have restricted diets, feeding only on sponges or corals, but others such as the Arabian cowry (*Cypraea arabica*) and Lamarck’s cowry eat virtually anything (the former will even attack other cowries, while the latter devours everything from algae and stinging hydroids to dead fish). Live cowries should never be casually picked up, as all too frequently they will prove to be perched on top of a circular mass of egg capsules, each containing several to many eggs. The eggs will only hatch if brooded by the mother, who keeps them clean of silt and microscopic pests; she has also been observed pushing away intruders with her shell.

A cowry lays its eggs on some coral.
(Photograph by Michael Schleyer)

At the other extreme are various families of predatory carnivores. Among the most highly evolved are the cone shells of the family Conidae, easily recognized by their cone-shaped shell and long, narrow aperture. These are usually found among rocks or coral, or in sand near or under them, although some, like *Conus arenatus*, *C. zeylanicus* and *C. tessulatus*, live buried in open sandflats. Cone shells not only have a poison gland, but a modified radula of harpoon-like teeth with which to inject the venom. Once the prey is dead or paralysed, it is swallowed whole. Most cones feed on polychaete worms, a small proportion (like the textile cone, *Conus textile*) on other molluscs, and a few sting and swallow small fishes. Most cones can be handled with impunity, although mollusc-eaters can deliver a painful sting to the unwary human. The most dangerous are the fish-eaters, whose venom is potent enough to have caused a number of human fatalities. At least four such species inhabit the Bazaruto Archipelago, namely the geographic cone *(Conus geographus*), the tulip cone (*C. tulipa*), the striated cone (*C. striatus*) and the cat cone (*C. catus*). Ironically, from cone venom chemists have isolated bioactive substances, termed conotoxins, that are proving to have medicinal value as powerful pain-blockers.

Other families of predators are the tritons (family Ranellidae) and the frog shells (Bursidae), which paralyse their prey, either other molluscs or polychaete worms, by squirting their acidic saliva onto the prey item. Most tritons inhabiting the reef flats have a bristly or hairy outer shell layer (the periostracum) which protects them from boring predators. In both families the female broods her eggs, like cowries, except that the egg mass usually resembles a half-orange. The larvae of most tritons spend a very long time in the plankton before settling – one species is reported to have a larval life of up to a year.

Two species of vase shells, *Vasum turbinellus* and *V. ceramicum*, are sometimes found prowling the reef flats in search of worms and bivalves. Their thick, triangular, black shells have projecting nodules and strong transverse ridges on the inner lip of the aperture which help to accelerate retraction of the foot. Even more striking is the branched murex, *Chicoreus ramosus*, whose large, swollen shell bears three ribs which are developed into spines and little frills, and the inner lip of its aperture is coloured deep pink. Despite its size, it usually lives buried in rubble with the topmost spine protruding. It preys on other molluscs.

Those rocks or coral lying on muddy sand or mud seldom shelter much life, as bacterial action usually produces sulphide gases and reduces oxygen. However, on very rare occasions one may find here a little limpet with the shell apex near the end and a red body. This is *Plesiothyreus galathea*, which has haemoglobin in its blood, to enable it to live under oxygen-poor conditions. Most molluscs have a less efficient bluish blood pigment called haemocyanin.

Some other molluscan associations

Relationships of molluscs within the food-web extend further than those of simple carnivore and prey or herbivore and plant. Many are either commensals or parasites. Commensals live together to share homes or food, to the detriment of neither (although often to the visible benefit of only one). Parasites live on other animals, drinking their blood, grazing on their body tissues or stealing their food. However, the differences between the two categories are not always obvious, and that between parasites and carnivores may also be disputable. For example the various whelks and false cowries that devour the mucus, food strings and polyp tissues of coral colonies are usually regarded as carnivores, but as they rarely kill the host organism may equally well be viewed as parasites.

The association of certain molluscs with corals has already been discussed, as well as zooxanthellae in giant clams. Several species of bivalves live within sponge masses, namely *Vulsella vulsella* and *Crenatula mytiloides*, which derive protection from their hosts (few creatures prey on sponges). In submerged gulleys, fern-like hydroids should always be scrutinized for the zebra wing oyster (*Electroma physoides*) which lives attached by a byssus. This is a delicate, little black-lined bivalve that is well camouflaged against its host; the oyster benefits from the fact that many hydroids can deliver a painful sting, affording it protection from predators.

After death, many gastropod shells are taken over by hermit crabs, and will be found to carry on its underside one or more small white, ribbed limpets, *Sabia conica*. This species changes sex with age, beginning as a male, which is attracted to settle on the shell near the host shell's aperture where it has access to the hermit crab's mucus and faeces, on which it feeds. After it has developed into a female, a new male is attracted to settle on the shell.

A spirally coiled snail, *Separatista helicoides*, may on rare occasions be found attached to large tube-worms, presumably stealing food, although details of the relationship are unknown. Another relationship that can be viewed as parasitic is that of the small sundial shells of the genus *Heliacus*, which shelter between the polyps of colonial sea-anemones called zoanthids, on which they feed.

True parasitism is known to occur in gastropods of the families Eulimidae and Pyramidellidae, which suck the body fluids of various other animals. Most species so far found in the Bazaruto Archipelago are minute and still unidentified, but a few are large enough to be conspicuous. *Melanella cumingi* is an extremely smooth and glossy white species, probably parasitic on sea cucumbers. Buried in the sand and seldom seen are several larger species (4 cm or more) of the genus *Pyramidella*, which have a high sharp spire and strong ridges on the inner lip of the aperture. These are reported to live by drinking the body fluids of acorn worms. More common species are the grey-blotched *Pyramidella maculosa*, the brown-spotted *P. acus*, and the beautiful *P. terebellum* (which may be a synonym of *P. dolabrata* of the tropical Atlantic), which is glossy white with brown spiral lines.

Shell-collecting in the Bazaruto archipelago

Visitors often collect seashells which are taken back as a souvenir of their visit to Bazaruto. However, most shells found along the shore will often have been bleached by the sun and reflective sand. Brightly coloured, glossy and undamaged shells are often offered for sale by local fishermen, usually having been collected alive. Visitors should be aware that overcollection of live specimens has already upset natural population structures and damaged ecosystems. The more showy species invariably become scarce on Bazaruto, such as the "bazarutensis" form of Conus pennaceus, which has been targeted on account of its apparent endemicity. So, all conservation-minded visitors are urged to resist collecting shells as mementos. Leaving washed up shells on the shoreline adds to the experience of the next visitor and by not purchasing freshly killed shells you will be contributing to the Archipelago's long term conservation. It is worth noting that some countries (e.g. South Africa) do not allow the importation of any marine organisms without an import permit.

CHAPTER 13

FISH AND FISHERIES

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The Indo-Pacific region is exceptionally rich in marine life and nowhere is this more evident than amongst the fishes found in the Bazaruto Archipelago. Aside from the fact that Bazaruto is located in an ecologically-rich tropical zone, it is the diversity of ecosystems so close together that contribute to this ichthyological wealth. With open ocean to the east, seagrass meadows and intertidal flats to the west, in addition to coral reef and sandy shore ecosystems, the diversity of fishes is enormous. This diversity also supports the harvesting of fish, which is equally diverse in its nature, ranging from subsistence fishing to artisanal, recreational and industrial fisheries.

The diversity of fishes

By visiting the different habitats, distinctly different fish assemblages will be encountered, each with its unique morphological features and habits.

Seagrass meadows

Extensive areas of seagrass occur in the region between the islands and the mainland. These seagrass beds comprise a number of different species, including *Cymodocea rotundata*, *Zostera capensis and Thalassodendron ciliatum.* All of these are flowering aquatic plants and not seaweeds or algae, as is commonly presumed. However, some algae may be interspersed with the seagrasses, often encrusting their stems. The seagrasses, whether found in large beds or in discreet patches, are enormously productive and contribute significantly to the nutrients and thus the food web of the archipelago. Fishes in particular benefit from associating with seagrass meadows. Many species found here are cryptic with their colouration in various shades of mottled green, such as the rabbitfishes, the young of several wrasse species, tobies, gobies, a few eel species, the young of several snapper species and most prominent the herbivorous marbled parrotfish. Seagrasses also provide refuge and shelter and in many cases species are equipped to hold on to, or shelter amongst the fronds, such as the pipefishes, seahorses and razorfishes. Although seagrasses provide the food source for many herbivores, few fish species actually consume the seagrass. Many “scrape” the epiphytic growth and other organisms off seagrass fronds to obtain their nutrition. However, all fishes that either eat seagrasses or that digest the growth on them, contribute to the food web by releasing nutrients into the surrounding water and ecosystems.

Snorkelling around the edges of a seagrass bed can be rewarding. So too the inspection of seine net catches made by artisanal fishermen around seagrass beds, invariably including a fascinating and colourful variety of fishes.

Mangroves

The tidal areas around mangrove forests provide an important refuge for numerous fishes. Sheltering amongst the prop roots of mangroves are the juveniles of many species, some remaining behind in shallow pools when the tide recedes while others migrate with the tides. These juvenile fish in turn provide a source of food for larger predatory species, such as the barracudas and the river snapper which can often be seen “patrolling” the edges of mangrove stands. Some fish found here are excellent mimics of fallen mangrove leaves, drifting with the tide so as not to be noticed by predators the best example of this is the juvenile of the triplefin.

Prominent amongst fishes of the mangroves are the mudskippers. Belonging to the goby family, these fascinating fishes are seen to hop from root to root or along the mudflats in between mangroves. Their “amphibious” antics are made possible by having modified pelvic and pectoral fins for movement and specially adapted eye lenses to aid sight in air. These agile fish form pairs and construct a tunnel in the mud, ending in a brood chamber where the couple protects and incubates their eggs. Mudskippers feed on a variety of small organisms, including small crustaceans, beetles, flies and worms.

Intertidal flats

The sand and muddy flats that make up much of the archipelago are rich in biota. Especially important are the benthic fauna that live on or burrow just below the surface of the substrate. These include numerous species of small crustacean, molluscs and worms, many of them a major source of food for fishes. Hence, the tidal ebb and flow of water over these intertidal flats sees a constant movement of fish that forage on these animals. Prominent are the mullets, pouters, grunters and small seabreams that forage over the muddy bottom during high tides. Some, like the grunter, can be seen “blowing” organisms from their burrows, at times with their tails protruding above the water as they feed. Feeding nearer the surface are halfbeaks, needlefish and garfish which are easily disturbed by small boats moving through the water and they will skip across the surface to escape the danger. Walking along the shore on the landward side of Bazaruto Island during high tide very often reveals large shoals of small fishes packed tightly together. These are hardheads, a common species of the silverside family. These shoals filter feed fine organisms from the water – but in turn represent a major source of food for larger gamefish which often rush into these shoals with great speed and splashing. Once the tide recedes, these fishes move to deeper water, only to return with the incoming tide and take the opportunity to forage on newly inundated areas.

Much of the bay on the landward side of Bazaruto Island does not dry during low tide, and here numerous species reside. Some may range wider to forage on inundated sandflats while others stay in deeper water. Common here are shoaling fishes of the sardine and anchovy families, all of which are filter feeding species, sifting planktonic organisms from the water columns. Besides being food for larger fish, seabirds also freely feed on these fishes, something that is clearly evident when travelling by boat on the landward side of Bazaruto.

Inshore coral reefs

The archipelago is endowed with fine coral reefs and a corresponding rich ichthyofauna. Snorkelling over shallow reefs, or SCUBA diving on the deeper reefs, will reveal a great and colourful diversity of fishes, most of them intimately associated with the reef ecosystem. This diversity is attributable to the variety of food sources available on the reef and also to the many complex and smaller habitats that occur within the coral ecosystem. Accordingly, many of the fishes are specially adapted to live in these diverse habitats. Some are mouth brooding or deposit their eggs on the reef so as to ensure their offspring are retained within the reef environment. Examples include the cardinal and anemone fishes respectively. Algae are common on reefs and they represent an important food source for herbivores such as surgeonfishes, some parrotfishes and rabbitfishes. Their constant grazing is clearly evident and plays an important ecological role in controlling algal growth so that it does not out-compete the corals. Several species feed directly on the coral polyps, such as some of the butterflyfishes. Others simply scrape the top layer of coral with their strong beak-like jaws, as in the case of parrotfishes. In doing so, the fish consume the finer types of algae that found on the surface of the reef. The sand between reef sections harbours many smaller crustaceans and worms. These too are consumed, especially by goatfishes which use their "prehensile" goat-like barbells to disturb and small food item just below the surface of the sand. Feeding goatfishes are commonly seen when diving around Bazaruto and present a fascinating insight into coral reef ecology. At times these goatfish are accompanied by other species which snatch the larger food items disturbed by the goatfish, not unlike a cattle egret does on land. Amongst the most diverse and fascinating fishes on the coral reef are the damselfishes. Some are solitary and cryptic while others form large shoals and are brightly coloured. Many have fascinating habits and behaviours, including commensalisms with other organisms as in the anemone fish and the domino which is often associated with sea urchins. Damselfishes may build nests for their eggs and young, which they protect. Most damselfishes are territorial and defend their patch of the reef, often aggressively.

A bluebarred parrotfish over the reef.
(Photograph by Camilla Floros)

The butterflyfishes are especially common and striking in the archipelago, with at least ten species commonly seen around the archipelago. Their deep bodies, bright yellow colours and agility gives rise to their common name. Most have bristle-like teeth, well suited to their omnivorous diet of small crustaceans and algae that are pecked from crevices in the reef. Although some form small shoals, most are found in pairs, suggesting fidelity between pairs.

One of the most diverse and colourful groups of fishes on Bazaruto's reefs are the wrasses. At least 34 species have been recorded in the archipelago, ranging from the diminutive cleaner wrasse to the endangered giant humphead wrasse. Similar to rock cods, sea breams and parrotfishes, wrasses undergo sex change, often associated with a change of colour and patterns. Thus the juveniles, females and males of one particular species may look completely different from each other. While some wrasses are confined to the deeper reefs, many of these agile species are common over the shallow corals and in the tidal pools, easily seen along the shoreline at low tide in a number of places. Snorkelling around Sailfish Bay is often a good place to sight wrasses. The small cleaner wrasse with its bright blue, black and white streaks is a particularly common and an interesting find. Single individuals or groups of these commensal fishes systematically clean the bodies of larger fish, removing both unwanted dead tissues as well as parasites. This cleaning service is endured by larger predators at no risk to the wrasse.

Equally bright are the angelfishes, some of which grow to a large size and add much colour to the reef. Examples from Bazaruto include both the spectacular emperor and the three spot angelfishes. Other common species of the coral include the triggerfishes, with their tough skin and strong dorsal fin that allows them to wedge firmly in reef crevices, and thus evade predation. Above the reef in deeper water there will be fusiliers, a group of brightly coloured shoaling species that filter and capture the small planktonic organisms that constantly drift over the reef.

The reef environment is one of survival and surviving. Predation is a key ecological driving force with resident reef predators including rockcods and snappers. Both groups are very well represented around Bazaruto and many of the species are also brightly coloured and patterned. While the rockcods are often cave dwelling and use ambush tactics to catch their prey by surprise, the snappers often hunt in groups and may target prey more directly. Sharks and rays also occur, some of them being resident. A common shark found hunting over reefs is the black tip reef shark. Notable also is the white tip reef shark which lives in caves on the reef and only emerges to hunt at night. The brightly coloured blue stingray often hides just below the sand next to reefs – and it too is a resident on Bazaruto's reefs.

Life on the reef is an intricate web of diverse physiological and ecological activities. Besides feeding there are important reproductive behaviours. Many fish aggregate at spawning time, thereby increasing the chances of fertilization and procreation. But this also makes them more vulnerable to exploitation and predation. Sex change is an important phenomenon amongst reef fishes, with some changing from male to female (protandrous), some from female to male (protogynous) and some change in response to needs driven by population structures.

Fishes of the open ocean

Much of the eastern side of the archipelago is washed by oceanic water, thereby allowing for a considerable influx of pelagic and larger species. Many of these are predators, such as the kingfishes, king mackerel, sharks and, quite commonly, also the billfishes such as marlin and sailfish. Bazaruto has a long history of marlin fishing, especially by tourist anglers based at Santa Carolina Island (erstwhile Paradise Island). The detailed records of billfish anglers have been maintained over many years, revealing that the archipelago is an area of special interest for these giant fishes- with at least five different species recorded. Barracuda are also often sighted or caught, including the giant barracuda with its distinctive black blotches near the tail. Slightly further away from the shore are true oceanic species, including the brightly coloured dorado, the tropical yellowtail and, not infrequently, the rainbow runner with its bright blue lateral band. There is also a considerable diversity of sharks that come inshore at Bazaruto. Most common are the Zambezi and Java sharks that may occur around all the islands. On the open side the blacktip, blackfin and dusky sharks occur. The open ocean also brings close inshore the large charismatic species such as the giant manta rays and the whale sharks. Both are commonly seen by divers over the deeper reefs – or at times simply at the surface from the side of a vessel.

But not all open ocean fishes are large predators. Shoals of smaller species belonging to the sardine and anchovy families are seasonally common. These species provide food for larger fish predators as well as whales and dolphins.

Fisheries

The rich diversity of marine life provides a basis for considerable fishing activities, probably the most important socio-economic activity in the archipelago. It provides food security and jobs to local residents and also represents a major draw card for tourists, many of whom are attracted to the archipelago by its fame as a sport fishing Mecca, thereby adding to local levels of income. Fishing collectively contributes 3% to the national GDP of Mozambique, a significant proportion of which is derived from informal fisheries (Afonso 2006). Different forms of fishing are recognised by Mozambique legislation, ranging from subsistence fishing for food security to industrial fishing on large vessels offshore. Most of these fishing types can be found at some time in the greater Bazaruto Archipelago.

Subsistence and artisanal fishing

It is impossible not to encounter local fishermen operating somewhere in and around Bazaruto on a daily basis. Some are resident in permanent fishing centres while others are more nomadic and move through the region as fish abundance changes with the seasons. Altogether, there are some 79 fishing centres and 1 425 informal fishing camps in the greater Bazaruto region, with 40 to 60 camps more closely related to the islands of the archipelago itself (IDPPE 2001; Sasol 2006). Each fishing centre is intended to have a Community Fishery Committee (CCP) that provides for co-management with the authorities through a process supported by the small scale fisheries development institute (IDPPE).

There is a rich history of traditional fishing activities. Middens of pearl oyster (mapalo, *Pinctada imbricata)* shells, turtle carapaces and clay pottery reveal a long history of subsistence harvesting. Traditional methods include the use of fishing line made from raffia and other plants, stake nets that allow for the passive capture of fish on the change of tides, the drying of fish on frames braided from indigenous vegetation and the use of canoes made from hollowed out tree trunks, most commonly the mango tree. However, modern technology has also been introduced and the use of monofilament line and gill nets, diving gear, outboard motors and fibreglass boats has enhanced fishing capacity but perhaps at the expense of sustainability. Traditionally, most of the catch was for local food security and dried to barter for grain products with communities from the mainland. But demand from hotels and tourist facilities as well as a previous non-sustainable crocodile farm, brought a new dimension to the marketing of local fish catches. Added to this was the sudden foreign demand for sea cucumbers (magajojo). This boom-and-bust fishery reported a catch of up to 40 tons of dried sea cucumbers in one year, but was short lived and resulted in the overexploitation of this valuable export resource (Dutton & Zolho 1990).

The most common fishing activity involves the simple gathering by women and children of marine life on the intertidal flats and in the seagrass meadows. Collections mostly include the pearl oysters or mapalo, *Pinctada imbricata*, an important food source consumed fresh or smoked. Although several tons are harvested each year, this oyster if highly productive and estimates of standing stock suggest resilience to fishing pressure. Other organisms taken include sea cucumbers, sea urchins, and especially crabs such as the blue swimming crab, *Portunis pelagicus, of* which up to five tons may be taken per annum. Ornamental shells are also collected and these are always popular with tourists. However, the improved conservation status of the MPA and the concern about overexploitation has discouraged this type of gathering. In the past there was considerable seasonal gathering of turtles and turtle eggs, but this too has largely ceased and nesting turtles are increasingly evident.

Beach seining is a common fishing activity, especially during spring tides on the sheltered western shores. Groups of men pull the 150 m-wide nets, known locally as gamboa, to shore or to an anchored vessel. The diversity of species caught by seine net is huge and inspecting the catch is always a fascinating experience with up to 180 species belonging to 58 families recorded. (Santana Afonso 2007). The catch normally comprises 90% fish with squid (5%) and other organisms also taken. There are three broad groups of fishes caught. One group includes productive small pelagic shoaling fishes such as scads, tropical sardines and juvenile kingfishes. The second group includes the fishes of the seagrass meadows, mostly greenish in colour and some herbivorous such as the rabbitfishes, pouters, green parrotfish, emperors and smelts amongst others. A third group are the smaller cryptic species, mostly not eaten by humans but of biological interest such as seahorses, pipefishes, razorfishes and others. Sometimes, seine netting is conducted along the eastern open shores, although coral reef habitat is normally avoided. Here, larger reef species are caught including kingfishes and parrotfishes. The total seine net catch varies seasonally and from year to year, but in excess of 100 tons are taken by seine nets in the greater archipelago annually (Dutton & Zolho 1990; Sasol 2006).

Stake nets are also evident in the area. Locally called Chicocota, they are an effective means of passive fishing and can take a wide range of species. Mullet are commonly caught as they move freely over the mudflats with the ebb and flow of the tides. Although the traps require considerable effort to construct and maintain, the actual fishing operation is passive as fish are “guided” into the small net-basket in the “V” of the trap system. At one stage there were almost 40 such Chicocota structures in place accounting for a considerable annual catch.

Some of the more energetic fishers have taken to diving and use spearguns to target gamefish on the seaward side. In addition, the demand for seafood by hotel visitors has created a regular market for lobsters. However, there is evidence that this demand can not be sustained as the fishers have to search further away over time to satisfy the demand.

Semi-industrial fishing

This form of fishing is defined by Mozambique law as industrial-type fishing but confined to motorised vessels of 10-20 m in length and port-based. Hence in the archipelago these vessels operate mostly from Vilankulos, although semi-industrial linefish vessels may also range from Inhassoro, Inhambane and even Maputo. Various types of fishing are undertaken, including linefishing, trawling and trap fishing. In recent years the size of the semi-industrial fleet has been substantially reduced as fish stocks declined.

Industrial fishing

Industrial fishing involves larger vessels, mostly those involved with offshore prawn trawling operations, trap fisheries for fish and lobster and tuna longlining. While these industrial fishing boats operate mostly over the Sofala Bank to the north, some do at times exploit fish resources in the general Bazaruto Archipelago area.

Recreational fishing

Most of the sport fishing is conducted by tourists, many from other countries. The Bazaruto Archipelago is considered to be one of the few “hot spots” for marlin fishing on the East African coast and there is a long history of billfishing at Bazaruto, most notably by anglers based at the resort that once flourished on Santa Carolina. Here a logbook of catches was kept for many years from 1960 onwards, providing a unique record of billfish in the region (van der Elst 1988). Analysis of these records indicates that most billfish are taken in summer and that sailfish and black marlin predominate in catches in approximately equal numbers. Unfortunately, equally diligent records of recent fishing activities have not been kept so current trends are less precise. A significant development has been the increased levels of tagging and release of billfish from Bazaruto encouraged by several of the tour operators, with an estimated 80% of all billfish caught being released alive. The joint Oceanographic Research Institute (ORI) and Instituto Nacional de Investigação Pesqueira (IIP) tagging project has recorded 1 000 sailfish and 100 black marlin tagged at Bazaruto over the last decade. Only two of these Bazaruto sailfish has been recaptured, one was re-caught locally but the other migrated to Sodwana Bay in South Africa. This low return rate is thought to reflect a relatively low fishing pressure on billfish in the region.

While billfish are popular, other gamefish are also caught and many tagged. Prominent amongst these is the giant kingfish with more than 1 000 tagged and close on 2% recaptured. While this does not suggest a high fishing mortality rate, it does contrast with the billfish in this species being more localised and semi-resident than the more nomadic behaviour of billfish.

Other types of recreational angling also take place. Rock and surf angling along the ocean beaches can yield a great diversity of excellent catches of gamefish. The tourist resorts also market a diversity of fishing opportunities, and increasingly include a focus on conservation such as tag and release.

Rules and regulations

Fisheries in Mozambique are controlled by the Decree 43 of 10 December 2003 which provides for comprehensive regulation of fishing activities. This legislation was considerably updated from the earlier Decree 51 of 1999 and provides for a wide range of management options applicable to all types of fishing in the maritime waters of Mozambique. This Act makes particular mention of participatory management and co-existence between the different fishery sectors. The legislation facilitates the creation of different types of marine protected areas with approval of the Ministry of Fisheries. Decree 51 of 1999 addresses the regulations applicable to recreational and sport fishing in considerable detail. In all cases of fishing a permit is required. Such permits place certain controls on the fishers to ensure sustainable development of the resources. The table below provides a synopsis of the current Mozambique permit conditions relating to linefish, although this is set to change in 2009.

Sector	Current Linefish regulations
Recreational and sport fishing	▪ Maximum number fish per fisher day = 10 ▪ Daily limit of slinger, soldier, trawl soldier and all species of rockcod is four of each per fisher-day. Limit for sharks is two per person per day. ▪ Species fully protected= brindle bass, potato bass, seventy-four, red steenbras and white shark. ▪ Maximum number of hooks used in surface fishing is three ▪ All regulations apply to national and foreign fishers ▪ A schedule of fines for certain transgressions exists ▪ A schedule of license fees exists, variable according to type of fishing and differs for foreigners and nationals. ▪ Trophy fish (e.g. billfish) command a higher license fee ▪ Fishing tournaments require authorization ▪ Recreational and game fishers may not sell their catch ▪ A cast net may be used only for personal live-bait purposes ▪ All catches must be available for scientific inspection if asked ▪ Fishers may be asked to submit catch returns
Artisanal	▪ A schedule of license fees exists ▪ Fishers may be asked to submit catch returns
Semi-Industrial	▪ Only accessible with a license ▪ May be required to provide access to catches for scientific inspection ▪ Must submit catch returns to Direcção Nacional de Administração Pesqueira (DNAP) ▪ Must submit daily catch record to Instituto Nacional de Investigação Pesqueira (IIP)
Industrial	▪ Only accessible with a license ▪ May be required to provide access to catches for scientific inspection ▪ Limited by annual catch quotas ▪ Must submit catch returns to Direcção Nacional de Administração Pesqueira (DNAP) ▪ Must submit daily catch record to Instituto Nacional de Investigação Pesqueira (IIP)
Spearfishing	▪ No explosives and no scuba ▪ No nocturnal spearfishing

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Table 13.1: Some of the fish species recorded from the Bazaruto Archipelago. Dominant habitats are indicated as well as those species of high fishery value.

	Common name	Inner Bay	Reefs	Sandy shore	Open ocean	High value
CLASS CHONDRICHTHYES						
ORDER CARCHARHINIFORMES						
CARCHARHINIDAE					*	
Carcharhinus amboinensis	Java shark		*		*	
Carcharhinus brevipinna	Spinner shark		*		*	
Carcharhinus leucas	Zambezi shark				*	
Carcharhinus limbatus	Blacktip shark				*	
Carcharhinus melanopterus	Blackfin reef shark				*	
Carcharhinus sealei	Blackspot shark				*	
Carcharhinus wheeleri	Shortnose blacktail shark				*	
ORDER RAJIFORMES						
RHINOBATIDAE						
Rhina ancylostoma	Bowmouth guitarfish			*	*	
Rhynchobatus djiddensis	Giant guitarfish				*	
ORDER MYLIOBATIFORMES						
MYLIOBATIDAE					*	
Aetobatus narinari	Spotted eagleray					
MOBULIDAE						
Manta birostris	Manta				*	
DASYATIDAE						
Dasyatis kuhlii	Bluespotted stingray		*			

Himantura uarnak	Honeycomb stingray			*		
Taeniura lymma	Bluespotted ribbontailray		*			
CLASS OSTEICHTHYES						
ORDER ELOPIFORMES						
ELOPIDAE						
Elops machnata	Ladyfish			*		*
MOBULIDAE						
Albula vulpes	Bonefish			*		
ORDER ANGULLIFORMES						
MURAENIDAE			*			
Echnidna nebulosa	Flower moray		*			
Gymnothorax favagineus	Honeycomb moray		*			
Gymnothorax meleagris	Guineafowl moray		*			
Siderea grisea	Geometric moray		*			
ORDER CLUPEIFORMES						
CLUPEIDAE						
Herklotsichthys quadrimaculatus	Blueline herring	*				*
Hilsa kelee	Kelee shad	*				*
Pellona ditchela	Indian pellona	*				*
ENGRAULIDAE						
Thryssa setirostris	Longjaw glassnose	*				*
Thryssa vitrirostris	Orangemouth glassnose	*				*
CHIROCENTRIDAE						
Chirocentrus dorab	Wolfherring	*				
ORDER SILURIFORMES						
PLOTOSIDAE		*	*			
Plotosus lineatus	Striped eel-catfish					
ORDER AULOPIFORMES						
SYNODONTIDAE						
Synodus variegatus	Redband lizardfish		*			
Trachinocephalus myops	Painted lizardfish		*			
ORDER LOPHIFORMES						
ANTENNARIIDAE						
Antennarius hispidus	Shaggy angler		*			
Antennarius striatus	Striped angler		*			
ORDER ATHERINIFORMES						
ATHERINIDAE		*		*		
Atherinomorus lacunosus	Hardyhead silverside					*
ORDER BELONIFORMES						
BELONIDAE						
Strongylura leiura	Yellowfin needlefish	*				
HEMIRAMPHIDAE						
Hemiramphus far	Spotted halfbeak	*				
EXOCOETIDAE						
Exocoetus volitans	Tropical two-wing flyingfish				*	
ORDER BERYCIFORMES						

HOLOCENTRIDAE						
Neoniphon argenteus?	Silver squirrelfish		*			
Sargocentron caudimaculatum	Tailspot squirrelfish		*			
Sargocentron diadema	Crown squirrelfish		*			
Sargocentron praslin	Dark-striped squirrelfish		*			
Myripristis berndti	Bigscale soldier		*			
Myripristis melanosticta	Pale soldier		*			
Myripristis murdjan	Blotcheye soldier		*			
ORDER SYNGNATHIFORMES						
PEGASIDAE		*				
Eurypegasus draconis	Seamoth	*				
AULOSTOMIDAE						
Aulostomus chinensis	Trumpetfish	*				
FISTULARIIDAE						
Fistularia commersonii	Smooth flutemouth	*				
Fistularia petimba	Serrate flutemouth	*				
SYNGNATHIDAE						
Hippocampus camelopardalis	Giraffe seahorse	*				
Syngnathoides biaculeatus	Alligator pipefish	*				
CENTRISCIDAE						
Aeoliscus punctulatus	Shrimpfish	*				
ORDER SCORPAENIFORMES						
SCORPAENIDAE						
Dendrochirus brachypterus	Shortfin turkeyfish		*			
Pterois antennata	Broadbarred firefish	*	*			
Parascorpaena mossambica	Golden scorpionfish		*			
Scorpaenopsis gibbosa	Humpback scorpionfish		*			
Taenianotus triacanthus	Paperfish		*			
TETRAROGIDAE						
Ablabys binotatus	Redskinfish		*			
PLATYCEPHALIDAE						
Papilloculiceps longiceps	Madagascar flathead	*				
Platycephalus indicus	Bartail flathead	*		*		*
Thysanophrys arenicola	Sand flathead	*				
DACTYLOPTERIDAE						
Dactyloptena orientalis	Helmet gurnard	*	*			
Dactyloptena peterseni	Starry helmet gurnard	*	*			
ORDER PERCIFORMES						
AMBASSIDAE						
Ambassis gymnocephalus	Bald glassy	*				
Ambassis productus	Longspine glassy	*				
KUHLIIDAE						
Kuhlia mugil	Barred flagtail	*	*			
SERRANIDAE						

Anthias evansi	Yellowtail goldie		*			
Anthias squamipinnis	Sea goldie		*			
Cephalopholis argus	Peacock rockcod		*			*
Epinephelus chloristigma	Brownspotted rockcod		*			*
Epinephelus faveatus	Bigspot rockcod		*			
Epinephelus malabaricus	Malabar rockcod		*			*
Epinephelus spilotoceps	Foursaddle rockcod		*			
Epinephelus tukula	Potato bass		*			*
Variola louti	Yellow-edge lyretail		*			*
PSEUDOCHROMIDAE						
Pseudochromis dutoiti	Dutoiti		*			
TERAPONIDAE						
Terapon jarbua	Thornfish	*		*		
PRIACANTHIDAE						
Priacanthus hamrur	Crescent-tail bigeye		*			
APOGONIDAE			*			
Apogon cookii	Blackbanded cardinal		*			
Apogon nigripinnis	Bullseye cardinal		*			
Apogon semiornatus	Threeband cardinal		*			
Apogon taeniatus	Twobelt cardinal		*			
HAEMULIDAE						
Plectorhinchus flavomaculatus	Lemonfish		*			*
Plectorhinchus gaterinus	Blackspotted rubberlip		*			*
Plectorhinchus gibbosus	Harry hotlips		*			*
Plectorhinchus plagiodesmus	Barred rubberlip		*			*
Plectorhinchus playfari	Whitebarred rubberlip		*			*
Pomadasys kaakan	Javelin grunter	*		*		**
Pomadasys multimaculatum	Cock grunter	*		*		**
LUTJANIDAE						
Aprion virescens	Green jobfish		*			*
Lutjanus argentimaculatus	River snapper	*	*			*
Lutjanus bohar	Twinspot snapper		*			*
Lutjanus fulvus	Yellow striped snapper		*			*
Lutjanus gibbus	Humpback snapper		*			*
Lutjanus kasmira	Bluebanded snapper		*			*
Lutjanus lemniscatus	Sweetlips snapper		*			
Lutjanus rivulatus	Speckled snapper		*			*
Lutjanus russelli	Russell's snapper	*	*			*
Lutjanus sanguineus	Blood snapper		*			*
Lutjanus sebae	Emperor snapper		*			*
CAESIONIDAE						
Caesio caerulaureus	Blue-and-gold fusilier		*			

SPARIDAE			*			
Acanthopagrus bifasciatus	Twobar seabream	*	*	*		
Rhabdosargus sarba	Natal stumpnose					*
LETHRINIDAE						
Gnathodentex aureolineatus	Glowfish		*			
Gymnocranius griseus	Grey barenose		*			
Lethrinus concyliatus	Redaxil emperor		*			
Lethrinus harak	Blackspot emperor	*	*	*		**
Lethrinus nebulosus	Blue emperor		*			**
Lethrinus sanguineus	Cutthroat emperor		*			*
Monotaxis grandoculus	Bigeye barenose		*			*
NEMIPTERIDAE						
Scolopsis ghanam	Paleband spinecheek	*	*			
KYPHOSIDAE						
Kyphosus bigibbus	Grey chub		*			
Kyphosus cinerascens	Blue chub		*			
Kyphosus vaigiensis	Brassy chub		*			
EPHIPPIDAE						
Tripterodon orbis	Spadefish	*	*	*		*
GERREIDAE		*		*		
Gerres acinaces	Smallscale pursemouth	*		*		*
Gerres filamentosus	Threadfin pursemouth	*		*		*
Gerres oblongus	Oblong pursemouth	*		*		*
Gerres oyena	Slenderspine pursemouth	*		*		*
MULLIDAE						
Mulloides flavolineatus	Yellowstripe goatfish		*			
Mulloides vanicolensis	Flame goatfish	*	*			
Parupeneus bifasciatus	Two-saddle goatfish		*			
Parupeneus indicus	Indian goatfish		*			
Parupeneus macronema	Band-dot goatfish		*			
Parupeneus rubescens	Blacksaddle goatfish		*			
MALACANTHIDAE						
Malacanthus latovittatus	Sand tilefish		*			
SILLAGINIDAE						**
Sillago sihama	Silver sillago	*		*		
POMACANTHIDAE						
Apolemichthys trimaculatus	Threespot angelfish		*			
Centropyge acanthops	Jumping bean		*			
Centropyge bispinosus	Coral beauty		*			
Centropyge multispinis	Dusky cherub		*			
Pomacanthus imperator	Emperor angelfish		*			
Pomacanthus semicirculatus	Semicircle angelfish		*			
Pomacanthus rhomboides	Old woman		*			
CHAETODONTIDAE						

Chaetodon auriga	Threadfin butterflyfish	*	*			
Chaetodon blackburnii	Brownburnie	*	*			
Chaetodon guttatissimus	Gorgeous gussy		*			
Chaetodon kleinii	Whitespotted butterflyfish		*			
Chaetodon lunula	Halfmoon butterflyfish		*			
Chaetodon meyeri	Maypole butterflyfish		*			
Chaetodon trifasciatus	Purple butterflyfish		*			
Chaetodon unimaculatus	Limespot butterflyfish		*			
Chaetodon vagabundus	Vagabond butterflyfish		*			
Forcipyger flavissimus	Longnose butterflyfish					
CARANGIDAE						
Carangoides ferdau	Blue kingfish		*	*		*
Carangoides fulvoguttatus	Yellowspotted kingfish		*	*		*
Carangoides gymnostethus	Bludger		*	*		*
Caranx ignobilis	Giant kingfish	*	*	*		**
Caranx melampygus	Bluefin kingfish		*			*
Caranx papuensis	Brassy kingfish		*	*		*
Caranx sexfasciatus	Bigeye kingfish	*	*	*		**
Decapterus russelli	Indian scad	*	*			*
Elagatis bipinnulata	Rainbow runner		*			*
Scomberoides commersonnianus	Talang queenfish		*	*	*	**
Scomberoides tol	Needlescaled queenfish		*	*		*
Trachinotus bolta	Largespotted pompano		*	*		**
CORYPHAENIDAE						
Coryphaena hippurus	Dorado				*	*
RACHYCENTRIDAE				*	*	
Rachycentron canadum	Prodigal son					
ECHENEIDAE		*		*	*	
Echeneis naucrates	Shark remora	*		*	*	
Remorina albescens	White remora					
CIRRHITIDAE			*			
Cirrhitichthys oxycephalus	Spotted hawkfish		*			
Paracirrhites arcatus	Horseshoe hawkfish		*			
Paracirrhites forsteri	Freckled hawkfish					
PEMPHERIDAE						
Pempheris adusta	Dusky sweeper		*			
POMACENTRIDAE						
Abudefduf notatus	Dusky damsel		*			
Abudefduf sexfasciatus	Stripetail damsel		*			
Abudefduf sordidus	Spot damsel		*			
Abudefduf sparoides	False-eye damsel		*			

Abudefduf vaigiensis	Sergeant major		*			
Chromis dimidiata	Chocolate dip		*			
Chromis weberi	Darkbar chromis		*			
Chrysiptera annulata	Footballer		*			
Chrysiptera leucopoma	Blueribbon damsel		*			
Chrysiptera unimaculata	Onespot damsel		*			
Dascyllus aruanus	Zebra humbug		*			
Dascyllus trimacullatus	Domino	*	*			
Neopomacentrus cyanomos	Crescent damsel		*			
Plectroglyphidodon dickii	Narrowbar damsel		*			
Plectroglyphidodon lacrymatus	Jewel damsel		*			
Pomacentrus caeruleus	Blue pete		*			
LABRIDAE						
Anampses caeruleopunctatus	Bluespotted tamarin		*			
Anampses lineatus	Lined tamarin		*			
Anampses meleagrides	Yellowtail tamarin		*			
Bodianus diana	Diana’s hogfish		*			
Cheilinus bimaculatus	Two-spot wrasse		*			
Cheilinus chlorourus	Floral wrasse		*			
Cheilinus oxycephalus	Snooty wrasse		*			
Cheilinus trilobatus	Tripletail wrasse		*			
Cheilio inermis	Cigar wrasse		*			
Coris aygula	Clown coris		*			
Coris caudimacula	Spottail coris		*			
Coris formosa	Queen coris		*			
Coris gaimard africana	African coris		*			
Cymolutes praetextatus	Knife wrasse		*			
Gomphosus caeruleus	Birdfish	*	*			
Halichoeres hortulanus	Checkerboard wrasse		*			
Halichoeres lapillus	Jewelled wrasse		*			
Halichoeres scapularis	Zigzag sandwrasse		*			
Hologymnosus doliatus	Ringed wrasse		*			
Labroides dimidiatus	Bluestreak cleaner wrasse	*	*			
Novaculichthys macrolepidotus	Seagrass wrasse		*			
Novaculichthys taeniourus	Rockmover wrasse		*			
Pseudocheilinus hexataenia	Sixstripe wrasse		*			
Pseudochilinus moluccanus	Chiseltooth wrasse		*			
Pteragogus flagellifer	Cocktail wrasse		*			
Stethojulis albovittata	Bluelined wrasse		*			
Stethojulis interrupta	Cutribbon wrasse		*			
Stethojulis strigiventer	Three-ribbon wrasse		*			
Thalassoma hardwicke	Sixbar wrasse	*	*			
Thalassoma hebraicum	Goldbar wrasse	*	*			*
Thalassoma lunare	Crescent-tail wrasse		*			*

Thalassoma purpureum	Surge wrasse		*			*
Thalassoma trilobatum	Ladder wrasse		*			
SCARIDAE						
Leptoscarus vaigiensis	Marbled parrotfish	*				**
Scarus ghobban	Bluebarred parrotfish		*			*
Scarus rubroviolaceaus	Ember parrotfish		*			*
Scarus sordidus	Bullethead parrotfish		*			*
Scarus tricolor	Tricolour parrotfish		*			*
MUGILIDAE						
Mugil cephalus	Fringelip mullet	*		*		**
Valamugil buchanani	Bluetail mullet	*	*	*		**
POLYNEMIDAE				*		
Polydactylus plebeius	Striped threadfin					*
SPHYRAENIDAE						
Sphyraena barracuda	Great barracuda	*	*	*	*	*
Sphyraena flavicauda	Yellowtail barracuda	*	*	*		**
Sphyraena jello	Pickhandle barracuda	*	*	*	*	**
BLENNIIDAE						
Aspidontus taeniatus tractus	Mimic blenny		*		*	
Ecsenius midas	Golden blenny		*			
Istiblennius impudens	Impspringer		*			
Plagiotremus rhinorhynchos	Twostripe blenny		*			
Plagiotremus tapeinosoma	Piano blenny		*			
TRIPTERYGIIDAE						
Helcogramma fuscopinna	Blackfin triplefin		*			
GOBIIDAE						
Amblygobius albimaculatus	Butterfly goby		*			
Valenciennea strigata	Pennant glider		*			
ACANTHURIDAE			*			
Acanthurus dussumieri	Pencilled surgeon		*			
Acanthurus leucosternon	Powder-blue surgeonfish	*	*			
Acanthurus lineatus	Bluebanded surgeon		*			
Acanthurus mata	Elongate surgeon		*			
Acanthurus nigricauda	Epaulette surgeon		*			
Acanthurus nigrofuscus	Brown surgeon		*			
Acanthurus tennenti	Lieutenant surgeonfish	*	*			*
Acanthurus triostegus	Convict surgeon	*	*			
Ctenochaetus strigosus	Spotted bristletooth		*			
Zebrasoma scopas	Twotone tang		*			
Naso unicornis	Bluespine unicorn	*	*			
ZANCLIDAE						
Zanclus canescens	Moorish idol		*			
SIGANIDAE						
Siganus sutor	Whitespotted rabbitfish	*	*			

SCOMBRIDAE						
Acanthocybium solandri	Wahoo				*	*
Euthynnus affinis	Eastern little tuna				*	*
Katsuwonus pelamis	Skipjack tuna				*	*
Scomberomorus commerson	King mackerel		*		*	**
Scomberomorus plurilineatus	Queen mackerel		*		*	**
Thunnus albacares	Yellowfin tuna				*	**
ISTIOPHORIDAE						
Istiophorus platypterus	Sailfish				*	*
Makaira indica	Black marlin				*	*
Makaira nigricans	Blue marlin				*	*
Tetrapturus angustirostris	Shortbill spearfish				*	*
Tetrapturus audax	Striped marlin				*	*
ORDER PLEURONECTIFORMES						
BOTHIDAE						
Bothus pantherinus	Leopard flounder		*	*		
ORDER TETRADONTIFORMES						
BALISTIDAE						
Balistoides conspicillum	Clown triggerfish		*			
Balistoides viridescens	Dotty triggerfish		*			
Rhinecanthus aculeatus	Blackbar triggerfish		*			
Rhinecanthus rectangulus	Patchy triggerfish	*	*			
Sufflamen chrysopterus	Halfmoon triggerfish		*			
MONACANTHIDAE						
Paraluteres prionurus	Blacksaddle mimic		*			
Paramonacanthus barnardi	Wedgetail filefish		*			
OSTRACIIDAE						
Lactoria cornuta	Longhorn cowfish	*	*	*		
Ostracion cubicus	Boxy		*			
Ostracion meleagris	Whitespotted boxfish		*			
TETRADONTIDAE		*	*			
Amblyrhynchotes honckenii	Evileye blaasop	*	*			
Arothron hispidus	Whitespotted blaasop	*	*			
Arothron immaculatus	Blackedged blaasop		*			
Canthigaster janthinoptera	Honeycomb toby		*			
Canthigaster valentini	Model toby		*			

CHAPTER 14

MARINE MAMMALS AND REPTILES

Marine mammals

The greater Bazaruto area provides a highly suitable habitat for marine mammals. The combination of rich shallows and the close proximity of oceanic conditions contribute to this and at least three species of whales, five species of dolphin and the endangered dugong occur in this area.

One of the most easily identifiable species of whales, the southern right whale (*Eubalaena australis*), can be seen off the southern east African coast from June to December each year. Characteristics that aid identification are the absence of a dorsal fin and the presence of yellowish-white wart-like callosities that cover their heads. These whales are particularly active when at the surface which makes watching them an entertaining experience.

Humpback whales (*Megaptera novaeangliae*) are a threatened species known to migrate along the coasts of KwaZulu-Natal (South Africa), southern Madagascar and Mozambique. The positive and repeated sightings of humpback whales around the archipelago suggests their preference for the region, especially since they can be observed to be actively feeding, possibly on the blue-line herring (*Herklotsichths quadrimanculatus*).

Bottlenose dolphins (*Tursiops truncatus*), an inshore species, were observed on numerous occasions on the seaward edge of Bazaruto Island, usually close inshore. It is probable that these sightings were of the same school that is resident in the area.

One school of common dolphins (*Delphinus delphis*) was observed just off the southern tip of Bazaruto Island, apparently feeding. The presence of this more migratory species is a good indication of the region's attractiveness to dolphins.

On several occasions spinner dolphins (*Stenella longirostris*), small, more tropical dolphins, were observed "porpoising" behind the surf line. These usually timid species are not frequently reported. Nevertheless research revealed that strandings of this species had previously occurred on the island and they may, therefore, be more abundant than originally thought.

Humpback dolphins (*Sousa chinensis*), a shallow water species, are normally associated with river mouths and estuaries, often in turbid water. It was surprising and pleasing to observe healthy schools of this species in the bay area. These animals were amazingly tame and lived in exceedingly shallow water. The presence of this species is considered important, as its status in other regions is severely depressed and threatened.

Several dolphins species, such as the striped dolphin (*Stenella coeruleoalba*) and Frazer's dolphin (*Lagenodelphis hosei*), that are predominantly found offshore, venture, at times, inshore to the Bazaruto Archipelago.

A striped dolphin broaches out the water.
(Photograph by Peter van der Elst)

Bazaruto is one of the region's main sanctuaries for dugongs (*Dugong dugon*), which occur in the sheltered bay between the islands and the mainland, grazing on the seagrass meadows. Individual animals have also been encountered close inshore on the open ocean littoral. They normally occur in small family groups but large aggregations of up to 70 animals have been encounted. Alhough dugong are difficult to count, recent surveys suggest that the population may be larger than previously believed, possibly numbering about 250 animals. It was also shown that more than one third of the dugong population occurs outside of the park boundaries, where the risk of net entanglement is higher. Although legally protected, inadequate controls are in place to enforce the law that prohibits the killing of dugongs.

Marine turtles

Hughes (1974) recorded the occurrence of five species of turtles in the vicinity of the Bazaruto Archipelago. These were the green turtle (ihasi) *Chelonia mydas*, the hawksbill turtle (xihambamutwitwi) *Eretmochelys imbricata*, the loggerhead turtle (xinholo) *Caretta caretta*, the olive ridley turtle *Lepidochelys olivacea* and the leatherback turtle (mukololo) *Dermochelys coriacea*. The response of local fishermen to photographs of the different turtles indicates that, with the exception of the olive ridley turtle, the other four species all nest on Bazaruto Island. Donald Broadley of the Biodiversity Foundation for Africa (Bulawayo, Zimbabwe) described these four species as follows:

Family CHELONIIDAE

The loggerhead turtle (*Caretta caretta*) has a uniform red-brown head and carapace, the plastron is yellow and the skin pale olive. The carapace may exceed 1 m in length. Adults feed in shallow coastal waters, using their powerful jaws to crush crabs, molluscs and sea urchins. This species nests on the eastern coasts of the archipelago. The female comes ashore at night and excavates a hole above high water mark before laying 50-160 eggs. These take almost two months to hatch. Predators (particularly ghost crabs) take a heavy toll of the hatchlings on their way down to the sea.

Ghost crabs feast on baby turtles at hatching time.
(Photograph by Rudy van der Elst)

The hawksbill turtle (*Eretmochelys imbricata*) has thick, keeled, carapacial shields that overlap like the tiles on a roof. Its long narrow head is equipped with a hooked beak for extracting prey from crevices. The carapacial shields are yellow, heavily streaked with red-brown and black, these are the source of commercial "tortoise shell". These turtles feed largely on sponges along coral reefs. Their main nesting areas are on the coast of northern Madagascar.

The green turtle (*Chelonia mydas*) is a large species, attaining a length of nearly 1½ m. The head is blackish, each shield bordered with white, the olive carapace may be streaked or spotted with black. Adults are largely herbivorous, grazing in the sea grass (*Zostera*) beds between the mainland and the archipelago, but juveniles feed on fish and floating marine animals. The principal local breeding site is Europa Island in the Mozambique Channel, but a few females nest on the east coast of Bazaruto Island, laying about 80 to 180 eggs at a time.

<u>The leatherback turtle (family DERMOCHELYIDAE)</u>

The leatherback turtle (*Dermochelys coriacea*) is the largest of the marine turtles, attaining a length of 1.7 m. The elongate carapace lacks horny shields, but the rubbery-textured skin forms five longitudinal ridges. The head is equipped with a hooked, bicuspid beak and the front flippers are very long. Adults are black above with scattered white spots, the underside is white. This is a deep sea pelagic species that feeds exclusively on jellyfish, so it is vulnerable to floating plastic bags, which can block the digestive tract and cause heavy mortality. It breeds on the Maputaland coast and the east coast of Inhaca Island.

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PART V

MANAGEMENT

CHAPTER 15

MANAGEMENT OF THE BAZARUTO ARCHIPELAGO

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It is not surprising that Bazaruto is a popular tourist destination. The outstanding combination of climate, tropical-island setting and rich and diverse marine life provides near-unique opportunities for tourist development. Already thousands of tourists visit the archipelago annually, accommodated in 9 resorts with a total of 260 beds. Cruise ships also call regularly at Bazaruto, placing several thousand additional day-visitors on the islands. But, significantly, the island is also home to about 3 500 local residents who have inherent rights to their resources, privacy and a healthy environment. The setting of environmental vulnerability and human pressures, such as growing tourism, prospecting for oil and industrial fishing, makes for considerable management challenges. The only way in which these can be addressed is on the basis of a scientifically defensible and integrated management plan.

Legal status

The ecological value of the Bazaruto Archipelago was first formally recognised pre-independence in 1971, when it was provided with Marine Protected Area (MPA) status by the Portuguese authorities, with the aim of protecting species of high conservation value, such as dugongs, dolphins, and sea turtles. Acting on recommendations made by ecologist Ken Tinley, in 1970, and a subsequent visit by the Conselho de Protecção da Natureza the three southern islands of Bangué, Magaruque and Benguérua were proclaimed National Parks. The area of sea bounded by the 100 m bathymetric line east of the islands and 5 km to the west was included in the Legislative Diploma No. 46 of 1971. Bazaruto and Santa Carolina islands were defined simply as areas designated for “special monitoring activities” (Zonas de Vigilância). Parts of Inhaca and Portuguese islands off Maputo were also proclaimed at that time (Sousa 1998).

While this 1971 proclamation provided considerable protection to the archipelago, on paper at least, it failed in providing more holistic protection of ecosystems, their services and external factors. Thus, in 2001, a much larger Bazaruto Archipelago National Park was proclaimed, including much more extensive marine areas and creating a natural park to its current designation with adjusted boundaries to include all the islands that are ecologically, socially and economically interrelated, thus promoting an integrated management approach. Two years later, the Cabo de São Sebastião peninsula was given statutory protection that now protects the natural resources of the nearby peninsula and adjacent waters.

One year after the Bazaruto Archipelago was proclaimed, the 7 500 km² Quirimbas National Park, was gazetted, which includes a suite of small islands and their marine habitats. Together with protection planned for the Machingulu area in the south and Palma in the north, Mozambique is contributing significantly to attaining the World Summit on Sustainable Development (WSSD) and Durban Accord targets for MPA development.

Management approaches

Considering the diverse challenges and pressures prevalent at Bazaruto, it is imperative that a fully integrated management plan is developed and supported. World Wide Fund for Nature (WWF) first initiated the preparation of elements towards a management plan with the brief to formulate a Master Plan, based on conservation principles, which would safeguard the ecological integrity of the Bazaruto Archipelago but, at the same time, permit the Mozambique Government to maximize social and financial benefits from tourism on a sustained development basis (Dutton and Zolho 1990). This called for protection, and where possible restoration, of the diversity of landscapes, ecosystems, species and ecological processes of the archipelago, recognising and harmonising with the traditional lifestyle of the island people.

In 2000, the protected areas mandate was transferred from the National Directorate for Forestry and Wildlife (DNFFB) to the Ministry of Tourism (MITUR), under the National Directorate for Conservation Areas (DNAC), as tourism was seen as one way of financing protected areas management. The Bazaruto Archipelago is today thus managed by DNAC, but with direct involvement from other partners. These include the National Directorate for Environmental Management, including the Department for Coastal Management and the Centre for Sustainable Development for Coastal Zones (CDS), within the Ministry for Co-ordination of Environmental Affairs (MICOA) the National Fisheries Research Institute (IIP) and the Institute for Development of Small Scale Fisheries (IDPPE). This multi-departmental strategy has many potential benefits. CDS contributes to aspects of Coastal Zone Management, MITUR helps to develop ethical principles for the sound development of tourism as a sustainable development activity intended to conserve the environment, IDPPE provides a link between fisheries and communities while IIP contributes on the conservation status of marine resources. Administratively, there is close collaboration with the Inhassoro District Administration structures to ensure that public affairs are adequately dealt with on the islands. Non-governmental support is especially relevant, such as the skills and resources contributed by WWF.

Following the proclamation of 2001, a larger and more formal management plan was developed, again largely supported by WWF. This plan: the five-year (2001-2006) Bazaruto Archipelago National Park Plan, specifically addresses livelihoods with a reference to "the improvement of social well-being through sustainable management systems". As communities reside within the Bazaruto Park, implementation of any plan involves extensive consultation. Accordingly, Bazaruto has several management structures, including an overall Management Committee with representation from government, stakeholder communities, NGOs, and the private sector. There are also interest-specific Community Management Committees and private sector committees, from which representatives are selected for the main Management Committee. It is envisaged that the management model developed for Bazaruto will be used and adapted for Quirimbas.

The Plan identified five different types of management zone:

Zone	Permissible activities
I	Wilderness- no activity at all
II	Total Protection – strictly a no-take zone
III	Limited Community Resource Use- set aside for sustainable exploitation by local people
IV	Multiple-Use- available for carefully managed and sustainable harvesting of resources by local communities and tourists is permitted
V	Extensive Use - in which a range of activities including exploitation are permitted.

The Bazaruto Archipelago Management Plan (BAMP-2002-2006) provides a five year plan to initiate serious management initiatives in Bazaruto and draws on considerable scientific information to underpin a zonation plan. A total of 15 specific use zones are identified: five terrestrial and ten maritime use areas, based on current usage, available resources and related ecological and socioeconomic factors. Totally protected marine and land areas are also defined, as well as areas for community use and areas for intensive use such as for tourism activities. The plan is supported by regulations defining the procedures and restrictions on activities permitted in the BANP. These comprehensively cover the administration and community management norms, the norms governing the use of income derived from visitors to the park, norms on scientific activities, environmental education, concessions, future development including tourism, diving, boats, fishing, professional photography and filming among others.

Management capacity

For Bazaruto to become a conservation success story there needs to be adequate management capacity. Trained staff, facilities, patrol vessels and other logistic support are minimum requirements. This can only happen with support from a diversity of sources and stakeholders. The Mozambique government provides funds for the warden and associated support but this is inadequate and a fee system for National Parks and Reserves exists. Resorts, lodges and other tourist facilities pay an annual fee based on the land they use; tourists pay an entry fee, while cruise ships pay a daily passenger-landing fee. These funds are collected into the Bazaruto Conservation Fund, from which 40% is allocated to park management and the remainder used to support community development projects. However, low overall visitor numbers, some problems with management and coordination of the Fund have limited its impact, so that several of the hotels have instigated their own community initiatives. Nevertheless, a huge contribution is made by WWF, which sees the Bazaruto Archipelago as a key conservation site in the Eastern African Marine Ecosystem region.

Benefits and threats to conservation

The continental shelf off Mozambique is believed to hold considerable mineral resources, such as oil, gas and heavy metals. While their exploration and subsequent exploitation will hold significant benefits for the country, they could also threaten the environment and the services it delivers. Poor management over such activities must be prevented and detailed environmental assessment studies have been underway for some time. These resources are allocated in Blocks, some of which are in proximity to Bazaruto but exclude key sensitive areas, such as the coastal area between the shoreline and the Park itself.

Fishing is a great attraction and indirectly contributes to the park and its people but fishing can also pose a potential threat if uncontrolled. All fishers require a fishing permit and strict conditions exist, especially for visiting sport fishers. Illegal fishing has been reported in proximity to Bazaruto, but increased vigilance by the authorities is having a positive effect. Many of the resorts in the park implement their own standards of conservation and generally do not support the killing of fish, except for modest quantities for food. Artisanal fishing is important and at times can have a negative effect. However, studies by Instituto Nacional de Investigação Pesqueira (IIP) are underway to understand the impact and the improve management if necessary.

Tourism is clearly a potential driver for success. The tropical island setting, coral reefs, sport fishing, whale migrations, turtle nesting, unique crocodile population, dolphins, dugongs and seafood are some of the attractions. The local economy benefits from sale of goods and services, such as nature guides, boat crew and sale of curios. Tourism also creates job opportunities and some 25% of the island's population benefit from tourism through the hotels structures. However, tourism has limits and excessive numbers of tourists and non-sustainable activities need to be strongly controlled. Most of the resorts, supported by WWF, implement sustainable activities. This ranges from special care with SCUBA diving on coral reefs to the non-interference with dolphins, dugongs and nesting turtles. However, the balance between large scale tourist operators, the Park's management authorities, active conservation NGOs and the communities needs to be carefully managed to ensure an integrated and balanced approach to the islands conservation future. Competition for fish resources between tourists and local fishers, marketing of the artisanal catch and zoning that favours tourists, are potential areas of tension. Communities need to be seen to benefit from tourism on their islands if they are to contribute to the island's continued attraction and tourist potential.

The prevailing tourism policy is aimed at high end / low impact tourism, thereby attracting foreign visitors to the exclusive hotels. Although this infers that absolute numbers will be modest, plans are underway to increase the number of resorts and beds, to enlarge the airport and to provide more anchorage. This could double the tourist numbers, which may require careful assessment to establish sustainability, especially in terms of waste management, water supply and excessive pressure on local populations.

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