BORANG PENGESAHAN STATUS THESIS

JUDUL : THE CONSERVATION BIOLOGY OF THE DUGONG
(Dugong dugon) IN SABAH, MALAYSIA : A BASIS FOR
CONSERVATION PLANNING

IJAZAH : Doctor Falsafah

SESI PENGAJIAN: 2008/2009 SESI II

Saya Leela Rajamani A/P Ramnath Rajamani mengaku membenarkan tesis
doctor falsafah ini disimpan di perpustakaan Universiti Malaysia Sabah
dengan syarat-syarat kegunaan berikut:

1. Thesis adalah hak milik Universiti Malaysia Sabah
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan
   untuk tujuan pengajian sahaja
3. Perpustakaan dibenarkan membuat salinan tesis sebagai bahan
   pertukaran antara institusi pengajian tinggi.
4. TIDAK TERHAD

Disahkan oleh:

Penulis : Leela Rajamani
A/P Ramnath Rajamani
Alamat:
B-4-4 Kondominium Abadi Villa,
Jalan 2/109C, Taman Abadi Indah,
58100 Kuala Lumpur.
W. Persekutuan.

Penyelia: Prof Dr. Ridzwan Abdul Rahman

Penyelia bersama : Prof. Dr. Helene Marsh

Penyelia Bersama : Dr. Mabel Bernadette Manjaji Matsumoto

Tarikh : 19/03/09
Catatan : @ Tesis dimaksudkan SEBAGAI THESIS ijazah Doctor falsafah dan
Sarjana secara penyelidikan atau desertasi bagi pengajian secara kerja
cursus dan penyelidikan, atau laporan Projek Sarjana Muda (LPSM).
THE CONSERVATION BIOLOGY OF THE DUGONG (*Dugong dugon*) AND ITS SEAGRASS HABITAT IN SABAH, MALAYSIA: A BASIS FOR CONSERVATION PLANNING

LEELA RAJAMANI A/P RAMNATH RAJAMANI

PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

THESIS SUBMITTED IN FULFILLMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
2009
DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

19th March 2009
LEELA RAJAMANI A/P RAMNATH RAJAMANI
PS2000-004-230
ACKNOWLEDGEMENTS

My Ph.D. journey has been an exhilarating one, in the quest for knowledge and experience. I would not have made it without the help of the following organisations and people:

The Ministry of Science, Technology and Environment, WWF Malaysia and Ocean Park Conservation Foundation, Hong Kong for providing me with the funding for research and training. Also because of the Prince Bernhard Scholarship, WWF-Switzerland, I was able to undergo training in Australia for dugongs and seagrasses.

The villagers at Banggi Island and Mantanani Island notably Encik Damsek and family who endured all those long seagrass and interview surveys.

My supervisors: Prof. Dr. Ridzwan Abdul Rahman thank for your thoughts and insights in solving conservation problems. Also thank you for providing significant funds to support my work. You inspired me to believe that anything could be done however impossible; Prof. Helene Marsh, it was a privilege to work with you and share your knowledge and enthusiasm for research and dugongs. I believe my writing skills have improved significantly. Also thanks for providing unlimited access to journals at JCU; Dr. Mabel Manjanji Matsumoto for assisting me during thesis preparation especially towards the end of the Ph.D.

My professors, colleagues, researchers and volunteers at Borneo Marine Research Institute Universiti Malaysia Sabah you are numerous, I thank Ronald Phan, Dr. Saifullah Jaaman, Yuhana Lah-Anyi, Dr. Ejria Salleh, Rosliah Lawrence, Jabdar A. Sahar, Ajahar A. Sahar, Zarina Hafiz, Laura Khor, Julian Ransangan, Rahdi Ajam, Josephine Gumpil, Basarun, Ramlan, Prof. Dr. Saleem Mustapha, Julian Ransangan, Ismail Tajul, Siti Badrah, Amizam Salleh, Musa Rubin, Bujang Kadir, Alex Hastie, Robert Hastie and many more. Dr. Annadel S. Cabanban was a source of support and provided advice on my editing skills.

Assoc. Prof. Hasan Mat Nor introduced me to social science research that opened doors and provided many new insights to address community in dugong research.

The staff and lecturers at James Cook University especially Dr. Ivan Lawler and Dr. Donna Kwan who helped me in various aspects of the aerial survey training. Thanks to Sue Bird for assisting me in various administration matters. I would also like to thank Dr. Rob Coles, Dr. Stuart Campbell and Len Mackenzie from the Queensland Department of Primary Industries who helped me design my seagrass surveys. I’m especially grateful to Juanita Bite for your warm hospitality.

WWF-Malaysia for providing technical assistance pertaining to the GIS work. I’m especially grateful to Ms. Diane Anthony and Ms. Rebecca Jumin for assistance at times when you were extremely busy with other work commitments.

The Department of Wildlife Sabah, especially to the Director, Mr. Mahedi Andau, and Senior Wildlife Officer, Edward Tangon, for providing assistance pertaining to the aerial surveys and permit approvals.
The staff and pilots at Sabah Flying Club and Sabah Air who helped with the dugong surveys.

Mr. James Fernandez, from the Department of Mapping, Sabah for providing aerial photographs of Banggi Island and Mantanani Island for viewing to assist in seagrass mapping.

Especially to my parents Janet and Raji who supported me at all stages of my Ph.D. studies. Thank you for the financial help in completing this Ph.D. My typists, Georgina Wong, Felsy Sandi, and Elizabeth James who assisted me when I had RSI. Finally, I would like to thank some of my friends both overseas and here, Vani, Hana, Vangi, Clo, Tonya, Kennedy, Mary, Suzie, Beeda and Sharifah who made life more cheerful and helped me get through the rough patches.
ABSTRACT
THE CONSERVATION BIOLOGY OF THE DUGONG (Dugong Dugon) AND ITS SEAGRASS HABITAT IN SABAH, MALAYSIA: A BASIS FOR CONSERVATION PLANNING

Prior to 1999, dugongs were rarely observed in Malaysia. This first comprehensive study of dugongs and their related seagrass habitats in Sabah, investigated the local stakeholder environment, the abundance and distribution of dugongs, identified and monitored threats to dugongs, and mapped seagrass habitats relevant to dugongs. The study was conducted in two spatial scales namely, 1) Regional (to determine dugong distribution in Sabah) (excluding Tawau) 2) Local - to determine local dugong abundance, conduct seagrass mapping and community surveys at two study sites Banggi island and Mantanani island. Community surveys consisted of a census, interview surveys, a dugong monitoring programme and participant observation. This information was used to determine stakeholder characters, and their perceptions of the researcher, research project, dugongs and seagrasses. Local ecological knowledge (LEK) of dugongs and seagrasses was also sought. The abundance, composition and habitat area of seagrass was assessed using a method of visually estimating above-ground seagrass biomass at sites along one kilometre transects perpendicular to the coast. Biomass was estimated every 50 metres in shallow areas (up to 5 metres depth) and every 100 metres in deep areas (greater than 5 metres depth). These sites later form the basis of seagrass meadows using GIS applications. Standardised aerial surveys were conducted regionally for the coastal waters of Sabah to determine dugong distribution patterns. The communities of Banggi and Mantanani are economically disadvantaged, practise destructive fishing and have little understanding of ecological processes and concepts of conservation. However, the reasons for dugong decline are known. Appreciation of the aesthetic value of dugongs within the communities is varied. However, the community appears to have adequate local knowledge of the dugong having cultural linkages through a dugong myth. Approximately, 70% of the total population is young below the age of 30, who could be receptive to new ideas. Outside influences from the media is widely available to the community. The community is able to develop a relationship with the researcher and participate cordially in research activities. Dugong numbers are very low in Sabah. Fifty two dugongs were sighted in Sabah excluding Tawau. Based on these results, crude estimates of minimal count are between 688 and 1376 dugongs residing in coastal Sabah. Key dugong areas were identified to be Brunei Bay, Labuan Island, and Sandakan Bay. Banggi Island and Mantanani Island supports a small population of dugongs respectively. Based on this study, dugongs were subject to threats, which were mostly anthropogenic. They were 1) blast fishing, 2) incidental entangling in nets and 3) unsupervised tourism and vessel strikes. The number of mortalities in Sabah (especially in Banggi Island), are high compared to dugong abundance results obtained in this study. When Potential Biological Removal (PBR) estimates were compared to crude estimates of yearly mortality, it is confirmed that dugong populations are declining. Ten species of seagrass from two families were found in Banggi Island and Mantanani Island. These include Halophila ovalis, Halodule uninervis (broad and thin variety), Thalassia hemprichii, Cymodocea rotundata, Halophila decipiens, Halophila spinulosa, Cymodocea serrulata, Syringodium isoetifolium, and Enhalus acoroides. A new unidentified species of Halophila was collected in Molleangan Island, west of Banggi Island. Approximately, 415 ha and 112 ha of seagrass meadows were mapped in Banggi island and Mantanani island respectively.
giving a total of 527 ha of seagrass available for dugong consumption. The information obtained on the local communities, seagrass and dugong provided the basis to inform a comprehensive conservation plan in Sabah. Key conservation strategies include a dialogue and community education programme, provision of alternative livelihoods, improving enforcement to prevent illegal fishing methods, co-management of dugong and seagrass resources, stringent controls on ecotourism and vessel strikes, zoning of seagrass in marine protected areas and further research. As the dugong is a migratory species, conservation management at an international level with the neighbouring state of Sarawak, and countries of Brunei, the Philippines and Indonesia is necessary.
ABSTRAK

Mantanani. Oleh sebab itu, sejumlah 527 ha rumput laut adalah sesuai sebagai makanan dugong secara keseluruhannya. Maklumat mengenai komuniti dugong, dan rumput laut ini akan dijadikan asas bagi penyediaan pelan pemuliharaan dugong di Sabah. Strategi pemuliharaan yang utama termasuklah program pendidikan masyarakat, pengurusan sumber dugong dan rumput laut; penguatkuasaan akta bagi membanteras penangkapan ikan secara membinasakan, memperketatkan system pelancongan dan kejadian pertembungan dengan kapal pelancong, penzonan kawasan rumput laut di kawasan yang dilindungi, dan meneruskan penyelidikan. Memandangkan dugong adalah spesies yang bermigrasi, pengurusan pemuliharaan pada tahap antarabangsa dengan kawasan bersebelahan seperti negeri Sarawak dan Negara Brunei, Filipina dan Indonesia adalah disyorkan.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE</td>
<td>i</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xvii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xxi</td>
</tr>
<tr>
<td>LIST OF PHOTOS</td>
<td>xxii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xxiii</td>
</tr>
<tr>
<td>LIST OF APPENDICES</td>
<td>xxvi</td>
</tr>
</tbody>
</table>

## CHAPTER 1: CONSERVATION STATUS OF THE DUGONG (*Dugong dugon*) IN SABAH, MALAYSIA

1.1 Introduction 1
1.2 Conservation History of Dugongs in Malaysia 1
1.3 Vulnerability of the Dugong to Anthropogenic Threats 2
1.4 Conservation Efforts 3
1.5 Aims and Rationale of the Study 5
1.6 Thesis Outline 6

## CHAPTER 2: CONSERVING DUGONGS IN DEVELOPING COUNTRIES: CHALLENGE AND HOPE

2.1 Introduction 9
2.2 General Biology 9
2.2.1 Distribution and Abundance 9
2.2.2 Diet 12
2.2.3 Habitat 13
2.2.4 Life History

2.2.5 Movements

2.3 Anthropogenic Threats to Dugongs

2.3.1 Fishing Pressure

2.3.2 Blast Fishing

2.3.3 Indigenous Hunting

2.3.4 Interference from Boats

2.4 Anthropogenic Threats to Seagrasses

2.4.1 Increased Nutrient Loads

2.4.2 Human-Induced increases in Sedimentation and Turbidity

2.4.3 Direct Mechanical Damage

2.5 Natural Threats to Seagrasses and Dugongs

2.6 Challenges Faced in Conserving Dugongs in Developing Countries

2.6.1 Institutional, Legislation and Enforcement issues

2.6.2 Research

2.6.3 Marine Park Management Issues

2.6.4 Cultural and Socio-Economic Factors

2.7 Conservation and Strategies Adopted in Developing Countries

2.8 Conservation Strategies Adopted in Australia: A Comparison

CHAPTER 3: THE STUDY AREA AND CONCEPTUAL FRAMEWORK FOR THE METHODOLOGY

3.0 Introduction

3.1 The Study Sites

3.1.1 Rationale for Selection of Study Sites

3.1.2 Banggi Island

3.1.3 Mantanani Island
3.2 Seasonality and Oceanographic Conditions 35

3.3 Development of Methodology 36

3.3.1 Aerial Surveys for Dugongs 37

3.3.2 Community surveys which include the Census, Focus Group Interviews, Dugong Monitoring Programme and Participant Observation 37

3.3.3 Seagrass Mapping Surveys 38

3.4 Research Approach 39


4.1 Introduction: Involving Stakeholders in the Conservation Process. 41

4.2 Background 43

4.2.1 Banggi Island 43

4.2.2 Mantanani Island 45

4.3 METHODS 45

4.3.1 Ethical and Cultural Considerations 45

4.3.2 Community Surveys 46

   a. Interview Surveys 46

   b. Monitoring programme 49

4.3.3 Community Survey Area 49

4.3.4 Validation of the Interview Responses 50

4.3.5 Scope and Limitations of the Study 51

4.4 RESULTS 52

4.4.1 Community Attitudes towards the Researcher and the Research Project 52

   a. Approaches Used to Communicate and Develop a Relationship with the Community 52

   b. Initial Interactions with the Community in Banggi Island 53
CHAPTER 5: COMPOSITION, DISTRIBUTION AND ABUNDANCE OF THE SEAGRASS COMMUNITIES IN BANGGI ISLAND AND MANTANANI ISLAND, MALAYSIA

5.1 Introduction: Status of Seagrass in Sabah
5.1.1 Description of the Seagrass Areas in Sabah
5.1.2 Seagrass Habitat Suitable for Dugongs

5.2 METHODS
5.2.1 Focus Group Interviews
5.2.2 Mapping of Seagrass in Banggi Island and Mantanani Island
5.2.3 Mellors’s Method, Standardisation and Preparation of Seagrass Standards
5.2.4 Preliminary Seagrass Surveys
a. Manta Tow and Spot Sampling of Seagrass
5.2.5 Transect Surveys at Banggi and Mantanani Island
a. Grab Sampling
5.2.6 Methods of Seagrass Analysis
5.2.7 Scope and Limitations of the Study

5.3 RESULTS
5.3.1 Focus Group Interviews - Local Ecological Knowledge of Seagrass in Banggi Island
a. Distribution of Seagrass
b. Seasonality of the Seagrass
c. Threats to Seagrass
5.3.2 Focus Groups Interviews - Local Ecological Knowledge of Mantanani Island
5.3.3 Seagrass Mapping - Banggi Island
a. Description of the Subtidal Meadows in Banggi Island
b. Description of the Intertidal Meadows in Banggi Island 114

5.3.4 Seagrass Mapping - Mantanani Island 121

5.3.5 Biomass of the Individual Seagrass Species and Depth Distribution 125

5.4 DISCUSSION 129

5.5 CONCLUSION 131

CHAPTER 6: THE DISTRIBUTION OF DUGONGS IN SABAH, MALAYSIA 132

6.1 Introduction 133

6.2 METHODS 133

6.2.1 Aerial Survey Methodology 133

a. Transect Aerial Surveys 133

b. Shoreline Aerial Surveys 136

6.2.2 Focus Group Interviews and Dugong Monitoring Programme 138

6.2.3 Scope and Limitations of the Study 138

6.3 RESULTS 138

6.3.1 Aerial Surveys - Distribution of Dugongs in Sabah as a Whole 138

6.3.2 Focus Group Interviews - Observing dugongs at Banggi and Mantanani Island 143

6.3.3 Abundance and Distribution of Dugongs in Banggi Island 144

a. Focus Group Interviews 144

b. Monitoring Programme in Banggi Island 145

6.3.4 Abundance and Distribution of Dugongs in Mantanani Island 147

a. Focus Group Interviews 147

b. Monitoring Programme in Mantanani Island 148

6.3.5 Estimating the Size of the Coastal Dugong Population in Sabah Waters 151

6.4 DISCUSSION 154
CHAPTER 7: THREATS, INDIGENOUS USE AND TRADE OF DUGONG (Dugong dugon) IN SABAH, MALAYSIA

7.1 Introduction

7.2 METHODS

7.2.1 Focus Group Interviews, Dugong Monitoring Programme and Participant Observation

7.3 RESULTS

7.3.1 Threats to Dugongs

7.3.2 Illegal Blast Fishing

a. Blast Fishing at Banggi Island

7.3.3 Incidental Entangling in Nets

a. Reports of Incidental Catch

7.3.4 Indigenous Use and Trade of the Dugong in Banggi Island

a. Dugong Preparation and Consumption

b. Indigenous Use of Dugong Products

c. Dugong Trade

7.3.5 Unsupervised Tourism and Vessel Strikes in Mantanani Island

7.4 DISCUSSION

7.5 CONCLUSION

CHAPTER 8: A CONSERVATION STRATEGY FOR SABAH, MALAYSIA

8.1 Introduction

8.2 BACKGROUND

8.2.1 Legislation

a. The Wildlife Conservation Enactment 1997 (Sabah)

b. The Fisheries Act 1985
8.2.2 Organisations Involved in the Conservation of Dugongs in Sabah
   a. Department of Wildlife, Sabah
   b. The Board of Trustees of Sabah Parks
   c. Department of Fisheries, Sabah

8.2.3 Facilitation of Laws relevant to Protecting Dugongs in Sabah

8.3 Conservation Issues

8.4 Conservation Strategies for Dugongs and Related Seagrasses in Sabah

8.4.1 EDUCATION
   a. Dialogue and Community Education Programme

8.4.2 MANAGEMENT
   a. Alternative Livelihoods
   b. Illegal Fishing Methods and Enforcement
   c. Co-management of Dugong and Seagrass Resources
   d. Zoning of Seagrass in Marine Protected Areas (MPAs) and Marine Managed Areas (MMAs).
   e. Issues with Unsupervised Tourism and Vessel Strikes
   f. Is Establishing a Dugong Sanctuary Feasible and Necessary?
   g. Conservation at a Regional Level

8.4.3 Recommendations for Future Research

CHAPTER 9: WHAT NOW FOR THE DUGONGS OF SABAH?

REFERENCES
LIST OF FIGURES

Figure 1.1 Conceptual model of the thesis. 6
Figure 3.1 Map of Sabah showing study sites Banggi Island and Mantanani Island. 31
Figure 3.2 Banggi Island is located north of Kudat district in Sabah. 34
Figure 3.3 Map of Mantanani Island showing study area. 35
Figure 4.1 Villages surveyed in Banggi Island. 50
Figure 4.2 Origins of the surveyed communities in Banggi Island and Mantanani Island. 62
Figure 4.3 Ethnic background of the surveyed community in Banggi Island and Mantanani Island. 62
Figure 4.4 Age structure of the communities in Banggi Island and Mantanani Island. 63
Figure 4.5 Age structure of the fishermen in Banggi Island and Mantanani Island. 64
Figure 4.6 Comparison of the education levels of the fishermen, school children and housewives in Banggi and Mantanani Island. 66
Figure 4.7 Literacy level of the general community in Banggi Island and Mantanani Island. 67
Figure 4.8 Comparison of literacy levels of the fishermen, housewives and school children in Banggi Island and Mantanani Island. 67
Figure 4.9 Languages spoken in the community of Banggi Island and Mantanani Island. 68
Figure 4.10 Reading materials enjoyed by the community of Banggi Island and Mantanani Island. 69
Figure 4.11 Reading materials enjoyed by the fishermen, housewives and school children in Banggi Island and Mantanani Island. 70
Figure 4.12 Comparison of the percentage of fishermen, school children and housewives who watch television in Banggi Island and Mantanani Island. 71
Figure 4.13 Television programmes favoured by the fishermen, school children and housewives in Banggi Island.

Figure 4.14 Television programmes favoured by the fishermen, school children and housewives in Mantanani Island.

Figure 4.15 Categorization of the occupations of the populations in Banggi Island and Mantanani Island.

Figure 4.16 Number of years of fishing of the fishermen in Mantanani Island and Banggi Island.

Figure 4.17 Fishing vessels used by the fishermen in Banggi Island and Mantanani Island.

Figure 4.18 Percentage of number of boat crew per fishing vessel.

Figure 4.19 Fishing gear the fishermen used in Banggi Island and Mantanani island.

Figure 4.20 Estimated total catch per month in Banggi Island and Mantanani Island during good weather conditions.

Figure 4.21 Other catch besides usual species of fish caught by the fishermen in Banggi Island and Mantanani Island.

Figure 4.22 Views of the fishermen towards the extinction of the dugong in Banggi Island (number of interviews, percentage).

Figure 4.23 Views of the fishermen towards the extinction of dugong in Mantanani Island (number of interviews, percentage).

Figure 4.24 Reasons given for dugong numbers lowering in Banggi Island (number of interviews, percentage).

Figure 4.25 Reasons given for dugong numbers lowering in Mantanani Island (number of interviews, percentage).

Figure 4.26 Views of the fishermen to dugongs returning to Banggi Island after a long absence (number of interviews, percentage).

Figure 4.27 Views of the fishermen to dugongs returning to Mantanani Island after a long absence (number of interviews, percentage).

Figure 4.28 Views of the fishermen towards seagrass loss in Banggi Island (number of interviews, percentage).

Figure 4.29 Views of the fishermen towards seagrass loss in Mantanani Island (number of interviews, percentage).
Figure 5.1  Seagrass distribution in Sabah based on previous research.

Figure 5.2  Interview reports of the distribution of seagrass around Banggi area.

Figure 5.3  Interview reports of the areas in the vicinity of Banggi which contain seagrasses.

Figure 5.4  Perceptions of the interview groups on the shift in seagrass abundance over time in Banggi (number of interviews, percentage).

Figure 5.5  Seagrass survey sites in Banggi Island.

Figure 5.6  Seagrass Meadows in Banggi Island, Molleangan Island, Pagassan Island and Balak Island.

Figure 5.7  Seagrass survey sites in Mantanani Island.

Figure 5.8  Seagrass meadows in Mantanani Island.

Figure 5.9  Above-ground biomass (gDW/m²) for each meadow type in Banggi Island and Mantanani Island (mean and ± standard error displayed).

Figure 5.10  Above-ground biomasses of seagrasses (gDW/m²) in Banggi Island and Mantanani Island (mean and standard error displayed).

Figure 5.11  Depths (m) of occurrence of each seagrass species in Banggi Island and Mantanani Island (mean and standard error displayed).

Figure 6.1  Aerial strip transect surveys conducted in Sabah (drawn to scale).

Figure 6.2  Illustration of flight route of coastal aerial survey of Sabah (drawn to scale).

Figure 6.3  Dugong sightings during the aerial surveys in July 2003, December 2005 and September 2006.

Figure 6.4  Sightings of marine fauna besides dugongs during the transect surveys and the shoreline surveys.

Figure 6.5  Information on dugong occurrence obtained from interview surveys before 2002.

Figure 6.6  Information obtained from dugong monitoring programme in Banggi Island (2001-2003).
LIST OF TABLES

Table 4.1 Percentage of numbers of the general population who received an education. 64
Table 4.2 Education levels of the teenage fishermen (who were between the ages of 16-19). 65
Table 4.3 Comparison of the income levels of the Banggi and Mantanani communities with the current poverty line income (PLI) and food poverty level income (PLI). 75
Table 4.4 Frequency of fishing in Banggi Island and Mantanani Island. 76
Table 5.1 Description of the Subtidal Meadows in Banggi Island. 113
Table 5.2 Description of the Intertidal Meadows in Banggi Island. 119
Table 5.3 Algae Composition of the Intertidal and Subtidal Meadows in Banggi Island. 120
Table 5.4 Mean above-ground biomass, areas and mean depths of the seagrass meadows in Mantanani Island. 123
Table 5.5 Mean above-ground biomass, standard errors, ranges and numbers of samples of the individual seagrass species in Banggi Island and Mantanani Island. 126
Table 5.6 Depth below mean sea level, standard errors and numbers of samples of the individual seagrass species in Banggi Island and Mantanani Island. 128
Table 6.1 Dugongs observed per hour during the aerial surveys. 139
Table 6.2 Summary of dugong sightings obtained during the aerial surveys. 140
Table 6.3 Responses of the interviewees regarding seasonality for sighting dugongs. 143
Table 6.4 Summary of dugong observations reported by the villagers from the interview surveys and the monitoring programme. 151
Table 6.5 Crude estimates of the annual sustainable human induced mortality for dugongs in Sabah based on extrapolations from the aerial survey data. 154
<table>
<thead>
<tr>
<th>Photo</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo 4.1</td>
<td>Educational posters shown during the presentation at Banggi and Mantanani Island.</td>
<td>54</td>
</tr>
<tr>
<td>Photo 4.2</td>
<td>Interviewing villagers for the monitoring programme in Mantanani Island.</td>
<td>59</td>
</tr>
<tr>
<td>Photo 4.3</td>
<td>Common pump boats in Banggi and Mantanani Island.</td>
<td>78</td>
</tr>
<tr>
<td>Photo 4.4</td>
<td>Monofilament gillnets used in Mantanani Island (mesh size 1-4 inches).</td>
<td>80</td>
</tr>
<tr>
<td>Photo 5.1</td>
<td>Seagrass beds of <em>Halophila</em> sp. unidentified in Molleangan Island.</td>
<td>111</td>
</tr>
<tr>
<td>Photo 5.2</td>
<td>Close up of <em>Halophila</em> sp. unidentified in Molleangan Island.</td>
<td>112</td>
</tr>
<tr>
<td>Photo 5.3</td>
<td><em>Halophila decipiens/Halophila ovalis</em> meadows at depths above 10 m.</td>
<td>114</td>
</tr>
<tr>
<td>Photo 5.4</td>
<td>Shallow seagrass of <em>Halodule uninervis</em> (thin)/<em>Halophila ovalis</em> in Wak-Wak bay.</td>
<td>116</td>
</tr>
<tr>
<td>Photo 5.5</td>
<td>Dugong feeding trails of <em>Halodule/Halophila</em> meadows in Molleangan Island, south-west of Banggi Island.</td>
<td>116</td>
</tr>
<tr>
<td>Photo 6.1</td>
<td>Adjustment of tape in the window to establish field of view for survey observer before flight.</td>
<td>134</td>
</tr>
<tr>
<td>Photo 6.2</td>
<td>Areas where the villagers sight the dugong in Kg. Siring Bukit, Mantanani island.</td>
<td>149</td>
</tr>
<tr>
<td>Photo 6.3</td>
<td>Conducting interviews for the monitoring programme in Mantanani Island.</td>
<td>150</td>
</tr>
<tr>
<td>Photo 7.1</td>
<td>The dugong 'Nicky' which has been observed consistently in Mantanani Island.</td>
<td>170</td>
</tr>
<tr>
<td>Photo 7.2</td>
<td>Dugong showing mating-like behaviour when approaching the dive boat.</td>
<td>171</td>
</tr>
</tbody>
</table>
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACF</td>
<td>Availability Correction Factor</td>
</tr>
<tr>
<td>AIM</td>
<td>Amanah Ikhtiar Malaysia</td>
</tr>
<tr>
<td>AREAS</td>
<td>Asian Rhino and Elephant Strategy</td>
</tr>
<tr>
<td>CITES</td>
<td>Convention on International Trade in Endangered Species of Wild Flora and Fauna</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetre</td>
</tr>
<tr>
<td>CMP</td>
<td>Conservation and Management Plan</td>
</tr>
<tr>
<td>CMS</td>
<td>Convention on the Conservation of Migratory Species of Wild Animals</td>
</tr>
<tr>
<td>dbMSL</td>
<td>Depth Below Mean Sea Level</td>
</tr>
<tr>
<td>DPA</td>
<td>Dugong Protected Area</td>
</tr>
<tr>
<td>EEZ</td>
<td>Exclusive Economic Zone</td>
</tr>
<tr>
<td>EPU</td>
<td>Economic Planning Unit</td>
</tr>
<tr>
<td>FELCRA</td>
<td>Federal Land Consolidation and Rehabilitation Authority</td>
</tr>
<tr>
<td>$F_R$</td>
<td>Recovery Factor</td>
</tr>
<tr>
<td>GBRWHA</td>
<td>Great Barrier Reef World Heritage Area</td>
</tr>
<tr>
<td>gDW/m²</td>
<td>Gram Dry Weight per square metre</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information Systems</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Position System</td>
</tr>
<tr>
<td>GRT</td>
<td>Gross Register Tonnage</td>
</tr>
<tr>
<td>ha</td>
<td>Hectare</td>
</tr>
<tr>
<td>IUCN</td>
<td>International Union for Conservation of Nature</td>
</tr>
<tr>
<td>JKKK</td>
<td>Jawatankuasa Kebajikan dan Keselamatan Kampung</td>
</tr>
<tr>
<td>kg</td>
<td>Kilogramme</td>
</tr>
<tr>
<td>kg.</td>
<td>Kampung (village)</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre</td>
</tr>
</tbody>
</table>
REFERENCES


Heinsohn, G.E. & Spain, A.V. 1974. Effects of a Tropical Cyclone on Littoral and Sub-Littoral Biotic Communities and on a Population of Dugongs (Dugong dugon (Müller)). Biological Conservation. 6(2):143-152.


