

**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

**BORNEO MARINE RESEARCH INSTITUTE  
UNIVERSITI MALAYSIA SABAH  
2009**

**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

UMS  
UNIVERSITI MALAYSIA SABAH

**THIS THESIS SUBMITTED IN  
FULFILLMENT FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY**

**BORNEO MARINE RESEARCH INSTITUTE  
UNIVERSITI MALAYSIA SABAH  
2009**

# UNIVERSITI MALAYSIA SABAH

## 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

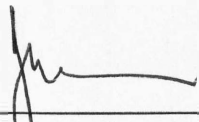
Saya Leela Rajamani A/P Ramnath Rajamani mengaku membenarkan tesis doctor falsafah ini disimpan di perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan berikut :

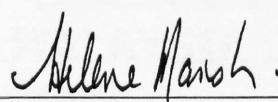
1. Thesis adalah hak milik Universiti Malaysia Sabah
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja
3. Perpustakaan dibenarkan membuat salinan tesis sebagai bahan pertukaran antara institusi pengajian tinggi.
4. TIDAK TERHAD

  
Penulis : Leela Rajamani  
A/P Ramnath Rajamani

Disahkan oleh:

  
TANDATANGAN PUSTAKAWAN

  
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 kursus dan penyelidikan, atau laporan Projek Sarjana Muda (LPSM).

## 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.

19<sup>th</sup> March 2009

  
LEELA RAJAMANI A/P RAMNATH RAJAMANI  
PS2000-004-230



UMS  
UNIVERSITI MALAYSIA SABAH

## 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, Zarinah Waheed, 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.



UMS  
UNIVERSITI MALAYSIA SABAH

## 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.



UMS  
UNIVERSITI MALAYSIA SABAH



## ABSTRAK

Sehingga tahun 1999, dugong jarang diperhatikan di Malaysia. Kajian secara menyeluruh ke atas dugong dan rumput laut yang menjadi habitat kepada dugong, mengkaji keadaan persekitaran pihak yang berminat, taburan habitat dugong, mengenalpasti dan memantow ancaman kepada dugong, kepadatan dan pemetaan habitat rumput laut dugong. Kajian ini telah dijalankan pada dua skala iaitu, 1) peringkat bahagian (bagi mengetahui taburan dugong di Sabah) (kecuali Tawau), dan 2) peringkat tempatan - untuk mengetahui taburan dugong, menjalankan pemetaan rumput laut dan tinjauan komuniti di dua kawasan kajian iaitu Pulau Banggi dan Pulau Mantanani. Tinjauan komuniti (termasuk bancian, soal selidik, pemantauan dugong, dan tinjauan ke atas peserta program) telah digunakan bagi mengenalpasti ciri-ciri pihak yang berminat dan untuk mendapatkan pendapat mereka terhadap penyelidik, projek penyelidikan, dugong dan rumput laut. Pengetahuan ekologi tempatan (LEK) mengenai dugong dan rumput laut turut dikaji. Kepadatan, komposisi, serta luas kawasan rumput laut telah dinilai secara visual untuk menganggar biojisim rumput laut. Garis tegak sepanjang 1 kilometer telah digunakan dimana ia diletakkan secara tegak dari pantai, dan penganggaran biomas rumput laut dilakukan setiap 50 meter di air cetek (sehingga kedalaman 5m) dan setiap 100 meter (bagi kedalaman melebihi 5m). Lokasi tersebut kemudiannya dijadikan sebagai asas pemetaan padang rumput menggunakan aplikasi GIS. Tinjauan piawai udara dilaksanakan pada peringkat bahagian bagi seluruh Sabah untuk menentukan corak taburan dugong. Komuniti di Pulau Banggi dan Pulau Mantanani merupakan golongan yang terbelakang dalam arus pembangunan ekonomi Negara, menggunakan kaedah perikanan yang membinasakan dan kurang memahami proses ekologi dan konsep pemuliharaan. Bagaimanapun, faktor pengurangan dugong adalah diketahui. Penghargaan nilai estetik dugong di kalangan komuniti adalah pelbagai. Namun demikian, pengetahuan mereka mengenai dugong boleh dikatakan memadai atas sebab perkaitan erat cerita dongeng mengenai dugong kepada budaya tradisional mereka. Lebih kurang 70% daripada jumlah populasi diwakili populasi muda yang berada di lingkungan umur bawah 30 tahun, dan adalah kumpulan yang mudah menerima idea baru. Bahkan, pengaruh luar dari media massa adalah mudah didapati. Komuniti didapati mudah menjalinkan hubungan mesra dengan penyelidik dan giat menyertai aktiviti-aktiviti penyelidikan. Bilangan dugong adalah amat kurang di Sabah. Sejumlah 52 ekor dugong telah diperhatikan di Sabah kecuali Tawau. Berdasarkan maklumat ini, anggaran kasar kiraan minima adalah diantara 688 dan 1376 ekor dugong yang menetap di kepantaian Sabah. Kawasan dugong didapati adalah Teluk Brunei, Pulau Labuan, dan Teluk Sandakan. Pulau Banggi dan Mantanani turut menampung populasi dugong yang kecil. Merujuk kepada kajian ini, dugong adalah dibawah ancaman. Antara sebabnya termasuklah 1) pengeboman ikan 2) penangkapan yang tidak disengajakan, dan 3) pelancongan dan kejadian pertembungan dengan kapal pelancong. Jumlah kematian melebihi catatan jumlah dugong yang dilihat. Pengurangan populasi dugong disahkan daripada 'Potential Biological Removal' (PBR), yang berdasarkan anggaran kasar kematian tahunan. Sepuluh spesies rumput laut daripada 2 famili dijumpai di Pulau Banggi dan Pulau Mantanani. Spesies-spesies tersebut adalah *Halophila ovalis*, *Halophila uninervis* (jenis kurus dan juga jenis lebar), *Thalassia hemprichii*, *Cymodocea rotundata*, *Halophila decipiens*, *Halophila spinulosa*, *Cymodocea serrulata*, *Syringodium isoetifolium*, dan *Enhalus acoroides*. Satu spesies baru dari genus *Halophila* telah dijumpai di Pulau Molleangan, berdekatan Pulau Banggi. Lebih kurang 415 ha rumput laut telah dipetakan di Pulau Banggi, manakala sejumlah 112 ha pula di Pulau

*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, pengusahaan cara hidup alternatif, 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.*



UMS  
UNIVERSITI MALAYSIA SABAH

# TABLE OF CONTENTS

	Page
<b>TITLE</b>	i
<b>DECLARATION</b>	ii
<b>ACKNOWLEDGEMENTS</b>	iii
<b>ABSTRACT</b>	v
<b>ABSTRAK</b>	vii
<b>LIST OF FIGURES</b>	xvii
<b>LIST OF TABLES</b>	xxi
<b>LIST OF PHOTOS</b>	xxii
<b>LIST OF ABBREVIATIONS</b>	xxiii
<b>LIST OF APPENDICES</b>	xxvi
<b>CHAPTER 1: CONSERVATION STATUS OF THE DUGONG (<i>Dugong dugon</i>) IN SABAH, MALAYSIA</b>	1
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
<b>CHAPTER 2: CONSERVING DUGONGS IN DEVELOPING COUNTRIES: CHALLENGE AND HOPE</b>	9
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	14
2.2.5	Movements	14
2.3	Anthropogenic Threats to Dugongs	15
2.3.1	Fishing Pressure	16
2.3.2	Blast Fishing	16
2.3.3	Indigenous Hunting	18
2.3.4	Interference from Boats	18
2.4	Anthropogenic Threats to Seagrasses	19
2.4.1	Increased Nutrient Loads	19
2.4.2	Human-Induced increases in Sedimentation and Turbidity	20
2.4.3	Direct Mechanical Damage	20
2.5	Natural Threats to Seagrasses and Dugongs	21
2.6	Challenges Faced in Conserving Dugongs in Developing Countries	22
2.6.1	Institutional, Legislation and Enforcement issues	22
2.6.2	Research	23
2.6.3	Marine Park Management Issues	24
2.6.4	Cultural and Socio-Economic Factors	25
2.7	Conservation and Strategies Adopted in Developing Countries	25
2.8	Conservation Strategies Adopted in Australia: A Comparison	27
<b>CHAPTER 3:</b>	<b>THE STUDY AREA AND CONCEPTUAL FRAMEWORK FOR THE METHODOLOGY</b>	<b>30</b>
3.0	Introduction	30
3.1	The Study Sites	30
3.1.1	Rationale for Selection of Study Sites	32
3.1.2	Banggi Island	32
3.1.3	Mantanani Island	35

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
<b>CHAPTER 4:</b>	<b>THE COMMUNITY, THE DUGONG AND THE RESEARCHER: SETTING THE STAGE FOR THE SOCIAL ENVIRONMENT</b>	<b>41</b>
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	<b>METHODS</b>	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	<b>RESULTS</b>	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

c.	Responses of the Communities in Banggi Island	56
d.	Responses of the Communities in Mantanani Island	57
e.	Impact of Monitoring Programme on the Community	59
f.	Impact of Monitoring Programme on the Research Project and the Researcher's Abilities to Carry Out Other aspects of the Research	60
4.4.2	Census Information	61
a.	Community Origins and Ethnic Background	61
b.	Age Structure	63
c.	Education	64
d.	Literacy Levels, Languages and Reading Interests	66
e.	Media Sources	70
f.	Occupation and Income	74
4.4.3	Fishing Practices	76
a.	Fishing Vessels	77
b.	Boat Crew	78
c.	Fishing Grounds	79
d.	Fishing Gear	79
e.	Fishing Catch	81
4.4.4	Fishermen's Attitudes and Knowledge of the Dugong	82
a.	The Link Between the Community and the Dugong	82
b.	Local Knowledge of Dugong and Seagrass	83
c.	Knowledge and Perceptions towards the Conservation of the Dugong	84
d.	Views of the Fishermen towards the Decline of Seagrass	88
4.5	DISCUSSION	89

4.6	CONCLUSION	93
<b>CHAPTER 5:</b>	<b>COMPOSITION, DISTRIBUTION AND ABUNDANCE OF THE SEAGRASS COMMUNITIES IN BANGGI ISLAND AND MANTANANI ISLAND, MALAYSIA</b>	94
5.1	Introduction: Status of Seagrass in Sabah	94
5.1.1	Description of the Seagrass Areas in Sabah	94
5.1.2	Seagrass Habitat Suitable for Dugongs	97
5.2	METHODS	98
5.2.1	Focus Group Interviews	98
5.2.2	Mapping of Seagrass in Banggi Island and Mantanani Island	98
5.2.3	Mellors's Method, Standardisation and Preparation of Seagrass Standards	99
5.2.4	Preliminary Seagrass Surveys	100
	a. Manta Tow and Spot Sampling of Seagrass	100
5.2.5	Transect Surveys at Banggi and Mantanani Island	101
	a. Grab Sampling	103
5.2.6	Methods of Seagrass Analysis	103
5.2.7	Scope and Limitations of the Study	104
5.3	RESULTS	104
5.3.1	Focus Group Interviews - Local Ecological Knowledge of Seagrass in Banggi Island	104
	a. Distribution of Seagrass	104
	b. Seasonality of the Seagrass	107
	c. Threats to Seagrass	108
5.3.2	Focus Groups Interviews - Local Ecological Knowledge of Mantanani Island	108
5.3.3	Seagrass Mapping - Banggi Island	108
	a. Description of the Subtidal Meadows in Banggi Island	113

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
<b>CHAPTER 6:</b>	<b>THE DISTRIBUTION OF DUGONGS IN SABAH, MALAYSIA</b>	<b>132</b>
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



6.5	CONCLUSION	158
<b>CHAPTER 7:</b>	<b>THREATS, INDIGENOUS USE AND TRADE OF DUGONG (<i>Dugong dugon</i>) IN SABAH, MALAYSIA</b>	160
7.1	Introduction	160
7.2	METHODS	161
7.2.1	Focus Group Interviews, Dugong Monitoring Programme and Participant Observation	161
7.3	RESULTS	161
7.3.1	Threats to Dugongs	161
7.3.2	Illegal Blast Fishing	163
	a. Blast Fishing at Banggi Island	163
7.3.3	Incidental Entangling in Nets	164
	a. Reports of Incidental Catch	165
7.3.4	Indigenous Use and Trade of the Dugong in Banggi Island	166
	a. Dugong Preparation and Consumption	166
	b. Indigenous Use of Dugong Products	166
	c. Dugong Trade	167
7.3.5	Unsupervised Tourism and Vessel Strikes in Mantanani Island	169
7.4	DISCUSSION	171
7.5	CONCLUSION	174
<b>CHAPTER 8:</b>	<b>A CONSERVATION STRATEGY FOR SABAH, MALAYSIA</b>	176
8.1	Introduction	176
8.2	BACKGROUND	176
8.2.1	Legislation	177
	a. The Wildlife Conservation Enactment 1997 (Sabah)	177
	b. The Fisheries Act 1985	177

8.2.2 Organisations Involved in the Conservation of Dugongs in Sabah	177
a. Department of Wildlife, Sabah	177
b. The Board of Trustees of Sabah Parks	178
c. Department of Fisheries, Sabah	178
8.2.3 Facilitation of Laws relevant to Protecting Dugongs in Sabah	179
8.3 Conservation Issues	181
8.4 Conservation Strategies for Dugongs and Related Seagrasses in Sabah	181
8.4.1 EDUCATION	183
a. Dialogue and Community Education Programme	183
8.4.2 MANAGEMENT	187
a. Alternative Livelihoods	187
b. Illegal Fishing Methods and Enforcement	188
c. Co-management of Dugong and Seagrass Resources	188
d. Zoning of Seagrass in Marine Protected Areas (MPAs) and Marine Managed Areas (MMAs).	190
e. Issues with Unsupervised Tourism and Vessel Strikes	191
f. Is Establishing a Dugong Sanctuary Feasible and Necessary?	191
g. Conservation at a Regional Level	192
8.4.3 Recommendations for Future Research	193
<b>CHAPTER 9: WHAT NOW FOR THE DUGONGS OF SABAH ?</b>	<b>195</b>
<b>REFERENCES</b>	<b>203</b>

## LIST OF FIGURES

		Page
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.	72
Figure 4.14	Television programmes favoured by the fishermen, school children and housewives in Mantanani Island.	73
Figure 4.15	Categorization of the occupations of the populations in Banggi Island and Mantanani Island.	74
Figure 4.16	Number of years of fishing of the fishermen in Mantanani Island and Banggi Island.	76
Figure 4.17	Fishing vessels used by the fishermen in Banggi Island and Mantanani Island.	77
Figure 4.18	Percentage of number of boat crew per fishing vessel.	78
Figure 4.19	Fishing gear the fishermen used in Banggi Island and Mantanani island.	80
Figure 4.20	Estimated total catch per month in Banggi Island and Mantanani Island during good weather conditions.	81
Figure 4.21	Other catch besides usual species of fish caught by the fishermen in Banggi Island and Mantanani Island.	82
Figure 4.22	Views of the fishermen towards the extinction of the dugong in Banggi Island (number of interviews, percentage).	85
Figure 4.23	Views of the fishermen towards the extinction of dugong in Mantanani Island (number of interviews, percentage).	85
Figure 4.24	Reasons given for dugong numbers lowering in Banggi Island (number of interviews, percentage).	86
Figure 4.25	Reasons given for dugong numbers lowering in Mantanani Island (number of interviews, percentage).	86
Figure 4.26	Views of the fishermen to dugongs returning to Banggi Island after a long absence (number of interviews, percentage).	87
Figure 4.27	Views of the fishermen to dugongs returning to Mantanani Island after a long absence (number of interviews, percentage).	87
Figure 4.28	Views of the fishermen towards seagrass loss in Banggi Island (number of interviews, percentage).	88
Figure 4.29	Views of the fishermen towards seagrass loss in Mantanani Island (number of interviews, percentage).	89

Figure 5.1	Seagrass distribution in Sabah based on previous research.	96
Figure 5.2	Interview reports of the distribution of seagrass around Banggi area.	106
Figure 5.3	Interviewee reports of the areas in the vicinity of Banggi which contain seagrasses.	107
Figure 5.4	Perceptions of the interview groups on the shift in seagrass abundance over time in Banggi (number of interviews, percentage).	108
Figure 5.5	Seagrass survey sites in Banggi Island.	110
Figure 5.6	Seagrass Meadows in Banggi Island, Molleangan Island, Pagassan Island and Balak Island.	118
Figure 5.7	Seagrass survey sites in Mantanani Island.	122
Figure 5.8	Seagrass meadows in Mantanani Island.	124
Figure 5.9	Above-ground biomass (gDW/m <sup>2</sup> ) for each meadow type in Banggi Island and Mantanani Island (mean and $\pm$ standard error displayed).	125
Figure 5.10	Above-ground biomasses of seagrasses (gDW/m <sup>2</sup> ) in Banggi Island and Mantanani Island (mean and standard error displayed).	127
Figure 5.11	Depths (m) of occurrence of each seagrass species in Banggi Island and Mantanani Island (mean and standard error displayed).	128
Figure 6.1	Aerial strip transect surveys conducted in Sabah (drawn to scale).	135
Figure 6.2	Illustration of flight route of coastal aerial survey of Sabah (drawn to scale).	137
Figure 6.3	Dugong sightings during the aerial surveys in July 2003, December 2005 and September 2006.	141
Figure 6.4	Sightings of marine fauna besides dugongs during the transect surveys and the shoreline surveys.	142
Figure 6.5	Information on dugong occurrence obtained from interview surveys before 2002.	145
Figure 6.6	Information obtained from dugong monitoring programme in Banggi Island (2001-2003).	146

Figure 6.7	Information obtained on dugongs from interview surveys in Mantanani Island before 2002.	147
Figure 6.8	Information obtained on dugong sightings and incidental catch from the monitoring programme in Mantanani Island (2001 – 2003).	148
Figure 6.9	Reports of mortalities and sightings in Banggi Island from interview surveys and the monitoring programme in relation to seagrass habitats mapped.	157
Figure 6.10	Reports of mortalities and sightings in Mantanani Island from interview surveys and the monitoring programme in relation to seagrass habitats mapped.	157
Figure 7.1	Fishermen's perception of the frequency of dugong sightings in Banggi Island (number of interviews, percentage).	162
Figure 7.2	Fishermen's perception of the frequency of dugong sightings in Mantanani Island (number of interviews, percentage).	162
Figure 7.3	Size of the fishing nets in relation to size of catch in Banggi Island (number of interviews, percentage).	165
Figure 7.4	Possible dugong trade routes compared to known fishing routes (obtained from census data) within Banggi Island to neighbouring areas.	168
Figure 8.1	Marine protected areas of Sabah, Malaysia.	180
Figure 8.2	Conceptual framework of a dugong conservation strategy for Sabah.	182

## LIST OF TABLES

		Page
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

## LIST OF PHOTOS

		Page
Photo 4.1	Educational posters shown during the presentation at Banggi and Mantanani Island.	54
Photo 4.2	Interviewing villagers for the monitoring programme in Mantanani Island.	59
Photo 4.3	Common pump boats in Banggi and Mantanani Island.	78
Photo 4.4	Monofilament gillnets used in Mantanani Island (mesh size 1-4 inches).	80
Photo 5.1	Seagrass beds of <i>Halophila</i> sp. unidentified in Molleangan Island.	111
Photo 5.2	Close up of <i>Halophila</i> sp. unidentified in Molleangan Island.	112
Photo 5.3	<i>Halophila decipiens</i> / <i>Halophila ovalis</i> meadows at depths above 10 m.	114
Photo 5.4	Shallow seagrass of <i>Halodule uninervis</i> (thin)/ <i>Halophila ovalis</i> in Wak-Wak bay.	116
Photo 5.5	Dugong feeding trails of <i>Halodule</i> / <i>Halophila</i> meadows in Molleangan Island, south-west of Banggi Island.	116
Photo 6.1	Adjustment of tape in the window to establish field of view for survey observer before flight.	134
Photo 6.2	Areas where the villagers sight the dugong in Kg. Siring Bukit, Mantanani island.	149
Photo 6.3	Conducting interviews for the monitoring programme in Mantanani Island.	150
Photo 7.1	The dugong 'Nicky' which has been observed consistently in Mantanani Island.	170
Photo 7.2	Dugong showing mating-like behaviour when approaching the dive boat.	171