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White, Alan Tyler

MARINE PARKS AND RESERVES: MANAGEMENT FOR PHILIPPINE, INDONESIAN AND MALAYSIAN COASTAL REEF ENVIRONMENTS

University of Hawaii Ph.D. 1984

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MARINE PARKS AND RESERVES: MANAGEMENT FOR PHILIPPINE, INDOONESIAN AND MALAYSIAN COASTAL REEF ENVIRONMENTS

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN GEOGRAPHY
DECEMBER 1984

By
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ACKNOWLEDGMENTS

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This project has been supported by a field study grant from the Environment and Policy Institute of the East-West Center. In addition, some internal travel to study sites and scuba diving expenses have been offset by the Natural Resource Management Center (NRMC) of the Ministry of Natural Resources of the Philippines, one tour company, and the Silliman University Marine Laboratory. While in the Philippines the author coordinated the Silliman University component of the United Nations Environmental Program (UNEP) coral reef-monitoring project. This involvement covered expenses to three Visayan study sites. Field assistants in all cases were generous with their time.

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ABSTRACT

Marine parks and reserves are observed and evaluated as management techniques for coral reef and associated reef environments. The problems of coral reef depletion, overexploitation of reef resources, and destructive fishing, indicate the need for management. These problems are contrasted with the benefits provided by coral reefs including high calcium deposition, nutrient cycling, and concentrated fishery yields. Since coral reefs are among the most productive ecosystems and supply a significant quantity of edible protein to island and coastal people, sustainable yield management is an important long-term goal. Seven reserve management and two control areas in the Philippines are discussed in detail and compared with two similar management areas in Indonesia and two in Malaysia.

This study undertakes three objectives: 1) to document the status of various reefs in the Philippines, Indonesia and Malaysia in terms of reef biology, management approaches, patterns of human exploitation, and the larger environmental settings of the reefs; 2) to examine the effects of various factors, including formal management schemes, human exploitation, and general setting on the reef environments; and 3) to investigate generalities between sites in terms of environmental conditions, management and use by humans.

Coral reef parameters are used to evaluate reef condition. These parameters include: substrate cover; density of coral genera, Acanthaster, and Tridacna; chaetodontid diversity; topographic relief; and noticeable damage. Sites are ranked in terms of reef quality and
are compared as to remoteness, human exploitation, destructive uses and management types. Municipal and national management approaches are contrasted and the effects of local education, scientific and tourist interests are noted at each site.

All sites where some form of management exists, except one, show an apparent positive impact and potential for sustainability. Control sites and those proposed for management without protection show some form of degradation. Two Philippine sites, Apo Reef and Tubbataha Reefs, have historically been preserved by their relative remoteness, but are now vulnerable and are recommended as national or regional protected areas.

Management recommendations emphasize education and participation of local communities in reserve planning and implementation. Integration of national or municipal reserve management plans with local resource use patterns and needs is discussed. "Core" and "buffer" zones are shown to be effective for integrating ecological reserve design constraints with traditional fishing, tourism, scientific research and environmental education. Implementation of a core reserve area or sanctuary zone is shown to 1) maintain species richness of fishes; 2) provide undisturbed breeding grounds; and 3) export fish biomass. These benefits are associated with acceptance of reserve management schemes by local residents dependent on reef resources and by national policy makers.
# TABLE OF CONTENTS

**ACKNOWLEDGEMENTS** .................................................. iv  
**ABSTRACT** ............................................................... vi  
**LIST OF TABLES** ....................................................... x  
**LIST OF FIGURES** ..................................................... xii  
**LIST OF ABBREVIATIONS** ............................................... xiv  
**PREFACE** ................................................................. xvi

## CHAPTER I. PURPOSE AND SCOPE OF THE STUDY

1.1 Introduction ......................................................... 1  
1.2 Value of Coral Reefs ................................................ 2  
1.3 Problems ............................................................. 3  
1.4 Marine Reserves ..................................................... 4  
1.5 Purpose of the Study ............................................... 6  
1.6 Benefits of the Study ............................................... 8  
1.7 Organization of the Thesis ......................................... 9  

## CHAPTER II. BACKGROUND ON CORAL REEF CONSERVATION IN THE PHILIPPINES, INDONESIA AND MALAYSIA

2.1 Introduction ......................................................... 11  
2.2 Ecosystems ............................................................ 11  
2.3 Ecosystem Interaction ............................................... 22  
2.4 Significance of Coral Reef Resources ................................ 23  
2.5 Status of Coral Reef Resources ...................................... 28  
2.6 Coral Reef Resource Degradation ................................... 30  
2.7 Regional and International Concern .................................. 37  
2.8 Marine Reserves for Protection and Management .................. 38  
2.9 Reserves in Southeast Asia .......................................... 43  
2.10 Local, National and Regional Management .......................... 45

## CHAPTER III. METHODOLOGY

3.1 Introduction .......................................................... 50  
3.2 Research Setting ...................................................... 51  
3.3 Data Collection ...................................................... 52  
3.4 Logistics, Changes and Problems .................................... 59  
3.5 Site-specific Data Analysis .......................................... 60  
3.6 Comparative Analysis Between Sites .................................. 62
CHAPTER IV. SITE-SPECIFIC EMPIRICAL FINDINGS AND ANALYSIS

4.1 Introduction—Philippines ..... 63
4.2 Apo Island, Negros ..... 64
4.3 Sumilon Island, Cebu ..... 75
4.4 Balicasag Island, Bohol ..... 92
4.5 Bantayan Beach, Cebu ..... 104
4.6 Moalboal, Cebu ..... 115
4.7 Sombrero Island, Batangas ..... 124
4.8 Apo Reef Island, Mindoro ..... 136
4.9 Tubbataha Reefs, Sulu Sea ..... 147
4.10 Cala veut Island, Palawan ..... 159
4.11 Introduction—Indonesia ..... 170
4.12 Bali Barat, Bali ..... 171
4.13 Kepulauan Seribu, Java Sea ..... 182
4.14 Introduction—Malaysia ..... 189
4.15 Pulau Perhentian Besar and Kecil ..... 193
4.16 Pulau Redang ..... 205

CHAPTER V. COMPARISON OF SITES AND PROGRAMS

5.1 Introduction ..... 209
5.2 Environmental Comparisons Among Study Sites ..... 209
5.3 Effect of Management, Exploitation and Setting on Reef Quality ..... 212
5.4 Effect of Different Management Approaches on the Environment ..... 220
5.5 Evidence for Environmental Sustainability ..... 225

CHAPTER VI. RELEVANCE FOR REGIONAL MARINE CONSERVATION

6.1 Introduction ..... 229
6.2 Standardized Data Collection ..... 229
6.3 Criteria and Methods for Selecting and Ranking Management Areas ..... 232
6.4 Important Regional Sites for Management ..... 236
6.5 Shared National Management Problems ..... 238

CHAPTER VII. FINAL INTERPRETATIONS AND RECOMMENDATIONS

7.1 Introduction ..... 242
7.2 Marine Reserve/Park Defined ..... 242
7.3 Traditional and Modern Management ..... 246
7.4 Site Specific Planning and Management ..... 249
7.5 National Planning and Management ..... 252

APPENDIX

Survey Forms ..... 256

BIBLIOGRAPHY ..... 259
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary Productivity of Some Major Marine Communities</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>Mangrove Coverage for Indonesia, Malaysia and Philippines</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>Coral Reef Resource Products and Uses</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Coral Reef Area, Calcification and Fishery Potential in World and Philippine Perspective</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>Human Activities and Their Impacts on Coral Reefs</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>Priorities Given to the Different Objectives of Marine Conservation in Various Types of Protected Areas</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>Number and Status of Marine Reserves in Southeast Asia</td>
<td>44</td>
</tr>
<tr>
<td>8</td>
<td>Summary of Sites Surveyed and Data Collected</td>
<td>53</td>
</tr>
<tr>
<td>9</td>
<td>Reef Quantitative Data (Percent Substrate Cover, Abundances, Depth Range, Noticeable Damage and Topographic Diversity for each Transect), Apo Island, Negros (1983)</td>
<td>68</td>
</tr>
<tr>
<td>10</td>
<td>Community Interview Summary (Demographic Information, Local Perceptions of Changes in Marine Resource Abundance and Fishing Capacity), Apo Island, Negros</td>
<td>72</td>
</tr>
<tr>
<td>11</td>
<td>Reef Quantitative Data, Sumilon Island, Cebu (1983)</td>
<td>81</td>
</tr>
<tr>
<td>12</td>
<td>Reef Quantitative Data, Balicasag Island, Bohol (1983)</td>
<td>98</td>
</tr>
<tr>
<td>13</td>
<td>Reef Quantitative Data, Bantayan Beach, Dumaguete (1981-1983)</td>
<td>109</td>
</tr>
<tr>
<td>14</td>
<td>Reef Quantitative Data, Moalboal (Pangasama Beach and Pescador Island) Cebu (1983)</td>
<td>120</td>
</tr>
<tr>
<td>15</td>
<td>Reef Quantitative Data, Sombrero Island Batangas (1983)</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>16</td>
<td>Reef Quantitative Data, Apo Reef Island, Mindoro (1983)</td>
<td>141</td>
</tr>
<tr>
<td>17</td>
<td>Reef Quantitative Data, Tubbataha Reefs, Sulu Sea (1984)</td>
<td>152</td>
</tr>
<tr>
<td>18</td>
<td>Reef Quantitative Data, Calait Island, Palawan (1983)</td>
<td>165</td>
</tr>
<tr>
<td>19</td>
<td>Reef Quantitative Data, Menjangan Island, Bali Barat (1984)</td>
<td>177</td>
</tr>
<tr>
<td>20</td>
<td>Reef Quantitative Data, Pulau Perhentian Besar and Kechil (1984)</td>
<td>198</td>
</tr>
<tr>
<td>21</td>
<td>Summary of Reef Quantitative Data (Percent Substrate Cover, Abundances, Noticeable Damage, Topography and Indicators of Management, Exploitation and Remoteness) for All Study Sites</td>
<td>210</td>
</tr>
<tr>
<td>22</td>
<td>Impact and Frequency of Human and Natural Influences on Reefs at All Study Sites</td>
<td>218</td>
</tr>
<tr>
<td>23</td>
<td>Composite Frequency and Negative Impact of Reef Uses and Natural Events at All Study Sites</td>
<td>219</td>
</tr>
<tr>
<td>24</td>
<td>Management Types and Their Relative Effectiveness at All Study Sites</td>
<td>222</td>
</tr>
<tr>
<td>25</td>
<td>Valuation of Ecological and Practical Criteria for All Study Sites</td>
<td>234</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Muro-ami Fishing Operation</td>
</tr>
<tr>
<td>2</td>
<td>Basic Reserve System</td>
</tr>
<tr>
<td>3</td>
<td>Study Sites</td>
</tr>
<tr>
<td>4</td>
<td>Transect Survey Methods</td>
</tr>
<tr>
<td>5</td>
<td>Apo Island, Negros, Fringing Reef, Reserve and Transects</td>
</tr>
<tr>
<td>6</td>
<td>Reef Profiles Showing Topographic Diversity, Depth Contour, Percent Substrate Cover and Hard Coral Diversity, Apo Island, Negros</td>
</tr>
<tr>
<td>7</td>
<td>Sumilon Island, Cebu, Fringing Reef, Reserve and Transects</td>
</tr>
<tr>
<td>8</td>
<td>Reef Profiles, Sumilon Island, Cebu</td>
</tr>
<tr>
<td>9</td>
<td>Balicasag Island, Bohol, Fringing Reef and Transects</td>
</tr>
<tr>
<td>10</td>
<td>Reef Profiles, Balicasag Island, Bohol</td>
</tr>
<tr>
<td>11</td>
<td>Bantayan Beach, Dumaguete, Fringing and Patch Reefs, and Transects</td>
</tr>
<tr>
<td>12</td>
<td>Reef Profiles, Bantayan Beach, Dumaguete</td>
</tr>
<tr>
<td>13</td>
<td>Moalboal (Panagsama Beach and Pescador Island), Cebu and Fringing Reefs</td>
</tr>
<tr>
<td>14</td>
<td>Sombrero Island, Batangas, Fringing Reef and Transects</td>
</tr>
<tr>
<td>15</td>
<td>Reef Profiles, Sombrero Island, Batangas</td>
</tr>
<tr>
<td>16</td>
<td>Apo Reef Island, Mindoro, Fringing Reef, Core and Transects</td>
</tr>
<tr>
<td>17</td>
<td>Reef Profiles, Apo Reef Island, Mindoro</td>
</tr>
<tr>
<td>18</td>
<td>Tubbataha Reefs, Sulu Sea, Fringing and Atoll Reefs, Sites and Transects</td>
</tr>
<tr>
<td>19</td>
<td>Reef Profiles, Tubbataha Reefs, Sulu Sea</td>
</tr>
<tr>
<td>Figure</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>20</td>
<td>Calauit Island, Palawan, Fringing Reef and Transects</td>
</tr>
<tr>
<td>21</td>
<td>Reef Profiles, Calauit Island, Palawan</td>
</tr>
<tr>
<td>22</td>
<td>Bali Barat, Bali. Coastline, Park Boundaries and Zones</td>
</tr>
<tr>
<td>23</td>
<td>Menjangan Island, Bali, Fringing Reef, Park Zones and Transects</td>
</tr>
<tr>
<td>24</td>
<td>Reef Profile, Menjangan Island</td>
</tr>
<tr>
<td>25</td>
<td>Repulauan Seribu, Java Sea, Patch Reefs, Sand Cays, and Park Boundaries and Zones</td>
</tr>
<tr>
<td>26</td>
<td>Peninsular Malaysia and Offshore Islands</td>
</tr>
<tr>
<td>27</td>
<td>Marine Protected Areas, Sabah</td>
</tr>
<tr>
<td>28</td>
<td>Pulau Perhentian Besar and Kechil, Trengganu, Fringing Reefs, Bays and Transects</td>
</tr>
<tr>
<td>29</td>
<td>Reef Profiles, Pulau Perhentian Besar and Kechil, Trengganu</td>
</tr>
<tr>
<td>30</td>
<td>Site Reef Habitat Richness Ranked by Coral Cover as Compared with Hard Coral Genera Density, Chaetodontid Species Diversity and Topographic Relief, Management, Exploitation and Remoteness</td>
</tr>
<tr>
<td>31</td>
<td>Site Reef Habitats Ranked by Total Sediment Cover and Coral Rubble as Compared with Noticeable Damage, Exploitation, Tridacna Density and Remoteness</td>
</tr>
</tbody>
</table>
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
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<td>ANR</td>
<td>Apo Island, Negros, Non-Reserve Area</td>
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<td>AR</td>
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</tr>
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<td>ARI</td>
<td>Apo Reef Island, Mindoro</td>
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<tr>
<td>ARR</td>
<td>Apo Reef Island, Reserve Area (Core)</td>
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<tr>
<td>ASEAN</td>
<td>Association of Southeast Asian Nations</td>
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<td>BAL</td>
<td>Balicasag Island, Bohol</td>
</tr>
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<td>BAN</td>
<td>Bantayan Beach, Dumaguete</td>
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<td>BB</td>
<td>Bali Barat, Bali</td>
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<tr>
<td>BFAR</td>
<td>Bureau of Fisheries and Aquatic Resources, Philippine Ministry of Natural Resources</td>
</tr>
<tr>
<td>CAL</td>
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</tr>
<tr>
<td>C</td>
<td>Celsius</td>
</tr>
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<td>F</td>
<td>Field Management</td>
</tr>
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<td>FAO</td>
<td>Food and Agriculture Organization, United Nations</td>
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<td>ICLARM</td>
<td>International Center for Living Aquatic Resources Management</td>
</tr>
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<td>IUCN</td>
<td>International Union for the Conservation of Nature and Natural Resources</td>
</tr>
<tr>
<td>K</td>
<td>Kepulauan (Archipelago)</td>
</tr>
<tr>
<td>km</td>
<td>Kilometers</td>
</tr>
<tr>
<td>L</td>
<td>Legal Management</td>
</tr>
<tr>
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</tr>
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<td>MSC</td>
<td>Marine Science Center, University of the Philippines</td>
</tr>
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<td>m</td>
<td>Meters</td>
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<tr>
<td>msa</td>
<td>Meters Additional Surface Area</td>
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<tr>
<td>MP/RTF</td>
<td>Marine Park/Reserve Task Force</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>MSY</td>
<td>Maximum Sustainable Yield</td>
</tr>
<tr>
<td>P</td>
<td>Pulau (Island)</td>
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<tr>
<td>PANAMIN</td>
<td>Presidential Assistant on National Minorities, Philippines</td>
</tr>
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<td>HBK</td>
<td>Pulau Perhentian Besar and Kechil, Trengganu</td>
</tr>
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<td>PCSSD</td>
<td>Philippine Commission on Sports Scuba Diving</td>
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</tr>
<tr>
<td>PCCT</td>
<td>Presidential Committee for the Conservation of the Tamaraw</td>
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<td>PD</td>
<td>Presidential Decree</td>
</tr>
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<td>PN</td>
<td>Philippine Navy</td>
</tr>
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<td>Directorate of Nature Conservation, Indonesia</td>
</tr>
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<td>Pulau Seribu</td>
</tr>
<tr>
<td>PTA</td>
<td>Philippine Tourism Authority</td>
</tr>
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<td>SDM</td>
<td>Sombrero, Island, Batangas</td>
</tr>
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<td>SNR</td>
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</tr>
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<td>SS</td>
<td>Systematic Snorkeling</td>
</tr>
<tr>
<td>SU</td>
<td>Silliman University, Dumaguete, Philippines</td>
</tr>
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</tr>
<tr>
<td>T</td>
<td>Transect</td>
</tr>
<tr>
<td>TFP</td>
<td>Task Force Rawikan</td>
</tr>
<tr>
<td>TUB</td>
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</tr>
<tr>
<td>UPM</td>
<td>Universiti Pertanian Malaysia</td>
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<td>WWF</td>
<td>World Wildlife Fund</td>
</tr>
</tbody>
</table>
PREFACE

WHY THIS TOPIC

Marine conservation and the plight of coral reefs have been strong interests since I went to the Philippines in January 1978. My job as a Smithsonian Peace Corps Volunteer with the Philippine Ministry of Natural Resources allowed me to visit and document many coastal areas. From the outset I was impressed with the incredible beauty of Philippine coral reefs and saddened by the extent of damage caused by human activities. Those feelings prompted a longer term involvement.

I have chosen the coral reef ecosystem because of its natural and theoretical attractions, as well as its economic importance to the countries of Southeast Asia. I have not regretted this decision. Since the beginning of the project, no matter how routine the day, I have been refreshed by a glimpse of the reef during an afternoon snorkel. This has helped me keep my focus and has repeatedly reaffirmed my commitment to the protection of coral reefs.

Marine reserves were new to the Philippines, and the world, when I went to the Philippines in 1978. Although Hundred Islands National Park was legislated in 1940, the marine habitat was not adequately protected. Other examples of this exist in the Philippines. In 1978 the Ministry of Natural Resources once again decided to choose coastal management areas and it selected three national priority sites. Ironically, at this writing the only national marine reserve in existence is not one of those original sites. The development of this
reserve, Sumilon Island, involved me personally and was another
important stimulus to this study.

As I began my graduate degree work in fall 1980, my concept of
"marine reserve" was based on the traditional notion of a coral reef
area where no destructive activity is allowed. Since that time, my
definitions of "marine reserve" have broadened. The connotations of
marine reserve/park have become more dynamic and variable. Rather
than a certain entity, I now see a marine reserve as a flexible tool
to meet management goals. This dynamic, functional type of reserve
is the subject of this dissertation, and many examples from the
Philippines, Indonesia and Malaysia are elaborated in detail here.
1.1 Introduction

Coral reefs constitute one of the earth's most productive and diverse ecosystems. They benefit man directly by providing food, medicine, construction materials and other valuable items. More importantly, coral reefs provide support and sustenance to the other coastal ecosystems upon which man depends.

Humans have always used reefs, although until recently their exploitation has been tempered by traditional tenures and taboos. As coastal populations in Southeast Asia have grown, they have brought increased pressure to bear on the reefs. At the same time traditional management strategies have been discarded. The result is that large areas of coral reef throughout Southeast Asia have been seriously depleted (Yap and Gomez 1983). This process will continue until new ways are found to protect and manage coral reefs.

This study is concerned with the viability of one management strategy, the marine reserve. Reserves are being used as a way of maintaining the longevity of coral reefs themselves and the yields of fish and other resources from the reefs. Currently a few functioning reserves exist in Southeast Asia and there are plans to set aside many more reserves. The time is opportune for an examination of the conditions under which marine reserves constitute an effective coastal management technique.
This dissertation evaluates the usefulness of marine reserves in various coral reef sites throughout Southeast Asia. Because the special mix of ecological, biological and socio-cultural variables in each site creates different management problems, this study moves from an examination and comparison of individual sites to an evaluation of the marine reserve as a general ecological strategy.

1.2 Value of coral reefs

Coral reefs serve as sources of food, coastline protection, medicines, aquarium fish, decorative shells, construction materials, sponges, jewelry, recreation sites, and scientific laboratories for the study of population dynamics, community interactions, species diversity, and ecosystem stability.

In terms of food, coral reef fishes constitute a significant portion of the recorded catch in most Southeast Asian countries. In the Philippines an estimated 10 percent of the country's fishery production is reef associated (Murdy and Ferraris 1980; Carpenter 1977), and for western Sabah the figure is 20 percent (Mathias and Langham 1978). Thirty-two out of the 132 economically important fish species in Indonesia are reef-associated (Soegiarto and Polunin 1982). In addition, reefs harbor mollusks, crustaceans, echinoderms, and algae, and they supply food for fishes harvested in nonreef areas.

Coral reef ecosystems are among the most productive natural ecosystems (Grigg 1979; Marten and Polovina 1981) due to their ability to use phosphorus, cycle energy efficiently, and fix nitrogen. Since coral reef ecosystems supply a significant quantity of edible protein to island and coastal people, provide coastal protection
through calcification, and produce many nonfood products, reef management on a sustainable yield basis is desirable for long-term use by humans.

1.3 Problems

In the Philippines, as well as in other countries of Southeast Asia and the western Pacific, coral reef areas have been seriously depleted by human activities (Gomez 1980a; Salvat 1974, 1979). Many reef resources traditionally used by local peoples are now becoming scarce as they are overexploited for local and export markets (Salvat 1979; McManus 1980).

Human impacts on coral reefs can be broadly defined as physical damage, changes in the deposition/erosion environment, overexploitation, and chemical pollution. Siltation and sedimentation are quickly becoming the largest threats. This has been well documented in the Philippines (Gomez 1980a) and is being observed in Indonesia (Soegiarto and Poluin 1982) and Malaysia (DeSilva 1982a and b). Often damage from siltation and sedimentation is irreversible.

A "tragedy of the commons", in the sense of Hardin (1968), is evident as reef fisheries are overexploited by individuals who focus only on short-term gain. An example is the fisherman who attempts to increase his short-term income by using fishing techniques which destroy the reef itself. Muro-ami (Carpenter and Alcala 1977) (see chapter 2), and similar reef fishing techniques contribute substantially to increased fisheries production in the Philippines while at the same time damaging the coral reef environment and the future fisheries.
Pacific islanders have traditionally depended on reef fisheries for about 90 percent of their animal protein (Johannes 1977) and have recognized for centuries that their marine resources were limited. Various reef and lagoon tenure and taboo systems may be interpreted as methods of conservation and management. Johannes (1977) points out, however, that these systems are currently falling into disuse because of increasing population and migration.

In the Philippines and Indonesia most traditional systems have disappeared, leaving a haphazard assortment of approaches toward reef management and use (Soegiarto and Polunin 1982). People's awareness of their impact on the environment has declined as their exploitation of it has increased (White 1980).

1.4 Marine reserves

A marine reserve constitutes a defined space to which some form of management and limited entry is applied. Resources, habitat, ecosystems, species and the space required for their interactions are common criteria used for selecting boundaries. Management may range from functional, where resource use occurs, to preservational, where entry is prohibited (see chapter two).

Some coastal communities in the southern Philippines and elsewhere are beginning to set guidelines for local coral reef fishery use and habitat protection (White 1981; Castañeda 1980). These local management attempts provide useful examples of potentially workable solutions for reef maintenance.

One management strategy adopted by these communities is the "municipal marine park" (Castañeda 1980). This basic reserve system
is simple (White 1980) and potentially effective as a fish breeding ground (Alcala 1981). In the Philippines this reserve concept is being attempted at various governmental levels (see chapter two). Goals for the reserves include arresting the current degradation of the reef, augmenting fishery yields, and preserving reefs for scientific research, education, aesthetic reasons, recreation, and tourism. National government reserves which consider local needs are currently being implemented in Indonesia with similar goals (Robinson, et al. 1981; see chapter two).

With the advent of extended maritime jurisdictions, much previously international ocean area has come under national jurisdiction. Most of the Southeast Asian seas are now under national jurisdiction. The Convention on the Law of the Sea provides that:

...states bordering enclosed or semi-enclosed seas should cooperate with each other in the exercise of their rights and duties, under this Convention. To this end they shall endeavour to (1) coordinate the management, conservation, exploration, and exploitation of the living resources of the sea; and (2) coordinate the protection and preservation of the marine environment.

Nationally-implemented marine reserves may be a means of achieving these and additional objectives set by the Convention for management of larger ocean areas.

It is now well established by the IUCN (1981), ASEAN (1980) and government policy reports from the Philippines, Indonesia, and Malaysia that marine reserves are being seriously considered as a viable means of ocean resource management. The themes of regional and national importance, functional management, benefits to local population and protection of endangered species and ecosystems are common. It is also clear that each country has little experience in reserve application and lacks alternative approaches to management.
1.5 **Purpose of the study**

This study is concerned with the effectiveness of marine reserves as a coastal management technique in Southeast Asia. Its purpose is to observe, evaluate and compare various management schemes in small island and coastal sites in the Philippines, Indonesia and Malaysia. It documents the biological and socio-cultural factors pertinent to each site in order to present a comprehensive picture of site-specific management problems. Consideration of a sample of sites differing in key variables (e.g., management approaches, exploitation patterns, environment, local and national governments) permits a broad comparative examination of the marine reserve concept.

This thesis has three major objectives:

1. First, the status of various reefs throughout Southeast Asia is documented. Those variables considered in the determination of reef status include reef biology, management approaches used in the area, patterns of human exploitation, and the general environmental setting of the reef. Reef condition is determined by simple surveys and a reef monitoring technique which quantifies reef quality by measuring substrate composition and selected organism abundance, dominance and diversity. This standardized monitoring technique permits the determination of major differences between sites and changes over time.

Various methods, including formal interviews with key informants, informal interviews with local fishermen, and observation, are used to determine reef use patterns, management approaches, and
environmental setting of the reef. These are discussed in more detail in chapter three.

2. Second, the effects of various factors, including formal management schemes, human exploitation, and general environmental setting, on the reef environment are examined. It is assumed that interactions of these factors produce high quality reefs in some cases and low quality reefs in others. The environmental impacts of human use of the reef, whether "managed" or not, are noted in particular. This is especially important insofar as these impacts contribute to reef longevity and fishery yields. The social and cultural problems of implementing reserves among local populations are observed. All variations in management are of interest, with the common denominator being environmental impact as quantified by reef monitoring at the study sites.

3. Third, commonalities between sites in terms of environmental conditions, management, and use by humans are investigated. The study isolates and compares similar environments and management approaches to determine the benefits and problems associated with a particular approach. Various options for management are identified and evaluated. The potential of the community-based, semi-traditional reserve, for example, can be assessed by drawing generalities from observations of site-specific successes and problems in various locales. Throughout the study, management techniques are observed for site-specific differences and commonalities which help in applying such techniques to other sites with similar conditions.
Regional, national and community perspectives on management in the Philippines, Indonesia and Malaysia are compared and transferability of the reserve concept among Southeast Asian countries is addressed.

1.6 Benefits of the study

The observation and evaluation of marine reserves in small island and coastal reef systems can lead to improved management models. By combining the perceptions of the people in each community with qualitative and quantitative environmental data, answers can be obtained for the following questions:

1) In the socio-economic, political context of lesser developed countries such as the Philippines, Indonesia and Malaysia, what constitutes a marine reserve or park from regional, national and community perspectives?

2) What are the advantages and disadvantages of the various management schemes currently being implemented?

3) What administrative differences may exist between community-based reserves and those instituted at national or regional levels of government?

4) What potential exists to augment management awareness among local communities by the integration of a semi-traditional reserve concept into a changing culture?

5) How does the reserve as a management tool affect coral reef longevity and fishery yield?

6) What coral reef environmental parameters may be significantly correlated with reserve management?
7) What historical customs may be relevant for current success in a marine reserve model? and,
8) What potential do the various reserve concepts have for application in similar national or international settings among nations of Southeast Asia?

1.7 Organization of the thesis

The scope and purpose of the study as defined in chapter one provides an introduction to this dissertation. Chapter two, "Background on coral reef conservation in the Philippines, Indonesia and Malaysia," supplies many of details necessary to complete the arguments given in chapter one justifying the topic. It presents a comprehensive introduction to the major coastal marine ecosystems and the human activities which affect them, and it summarizes the various forms of management applied to coral reef areas.

Chapter three presents the study methodology in three parts: environmental data, data on human use of the reefs, and management observations. It lists the research sites and explains why they were chosen.

Chapter four contains all of the data collected at the thirteen field sites. The data are presented by study site in the order of 1) overview, 2) marine environment, 3) human interaction with the environment, and 4) summary and management recommendations. Tables and figures for each site present the bulk of the data. Analysis in this chapter is limited to each site and only a few site comparisons are made.
Chapter five analyzes the site data in relation to other sites. Comparison of all sites is made by means of environmental parameters, human impacts, management schemes and the country in which they occur. Generalizations about coral reef management are made in this chapter and the discussion follows in chapters six and seven.

Chapter six presents the relevance of the study results for regional coastal management in Southeast Asia and the western Pacific area. It discusses those findings which are important in more than one country and how they may be implemented. Chapter seven summarizes the overall findings of the study in relation to marine reserve/park management. It addresses those goals which the study was designed to ultimately meet and answer.
CHAPTER TWO
BACKGROUND ON MARINE CONSERVATION IN THE
PHILIPPINES, INDONESIA AND MALAYSIA

2.1 Introduction

The marine environment of Southeast Asia is the richest and most diverse biogeographic region in the world (Ekman 1953). Most shallow-water marine biota reach the peak of their species diversity here, and the various ecosystems interact in complex ways. This complexity is compounded by the fact that humans in the region live close to the coast and interact intensively with the sea. The three countries under study here, for example, depend on the seas for marine resources, transportation, ports, waste disposal, and defense. Management of Southeast Asian marine ecosystems thus requires a comprehensive grasp of the interaction of humans with a complex marine environment. This chapter presents an overview of the marine ecosystems and their conservation-related problems.

2.2 Ecosystems

The currents in Southeast Asian seas show regular seasonal reversals over large areas because of the monsoonal winds (Morgan and Valencia 1983). Typical of much of the region are two monsoonal winds: from May through September southeasterly winds prevail; from October or November through April northeasterly winds prevail. The
monsoons also cause rainy and dry seasons which together with the winds, currents, and geographical complexities, lead to changes in salinity of the surface water and turbidity from coastal runoff. The relationship of currents, wind, and runoff combined with gentle coastal plains causes turbid conditions on the continental shelves. The run-off also brings with it inorganic and organic nutrients which enhance biological production in the coastal areas (Morgan and Valencia 1983; Soegiarto and Polunin 1982).

Southeast Asian waters typically show a marked stratification of temperature, density and chemical constituents (Wyrski 1962). Generally an upper layer of water (20 to 200 m) overlies a layer of higher density, lower temperature and greater concentration of nutrients. This deeper layer seasonally reaches the surface in a few places of upwelling caused by monsoonal winds. Examples of upwelling areas include the waters south of Java, west of Sulawesi, and in the eastern Molluccas in Indonesia. Upwelling waters bring nutrients (such as nitrates, phosphates and silicates) necessary for photosynthesis to offshore surface waters usually deficient in nutrients (Soegiarto and Polunin 1982). Open ocean fisheries are dependent on these nutrients from upwelling or from continental shelf and inshore waters.

The inshore coastal zone tropical ecosystems of Southeast Asia have a high diversity of species. They also display high primary productivity and fishery yields. Productivities of ocean and coastal systems are given in table 1.
Table 1
Primary Productivity of Some Major Marine Communities

<table>
<thead>
<tr>
<th>COMMUNITY TYPE</th>
<th>PRIMARY PRODUCTIVITY (g carbon/m²/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mangroves</td>
<td>430-5000</td>
</tr>
<tr>
<td>algal, sea-grass beds</td>
<td>900-4650</td>
</tr>
<tr>
<td>coral reefs</td>
<td>1800-4200</td>
</tr>
<tr>
<td>estuaries</td>
<td>200-4000</td>
</tr>
<tr>
<td>upwelling zones</td>
<td>400-3650</td>
</tr>
<tr>
<td>continental shelf waters</td>
<td>100-600</td>
</tr>
<tr>
<td>open ocean</td>
<td>2-400</td>
</tr>
</tbody>
</table>


Estuaries. Estuaries exist at the interface between the land and ocean, where sea water is diluted with fresh water from land drainage and contain a mixture of organisms and nutrients from both sides. They are generally formed by a high-rainfall watershed draining into a low coastal flood plain (Maragos et al. 1983a).

Large estuarine systems are found in the deltas of major rivers. Intermediate and small estuaries occur along all the continental and larger island coasts. Only small islands lack estuarine systems completely since fresh water is not sufficient to form an estuary. Many estuaries are found in the western Malay Peninsula, the low, north-eastern coast of Sumatra, southern and eastern Borneo, and scattered areas in Java and Sulawesi. The Philippines and small islands elsewhere have few major estuaries (Morgan and Valencia 1983).

Compared to the adjacent open sea, estuaries produce large amounts of organic matter (see table 1). Associated plant and animal
communities are often rich (Whittaker 1975), and estuaries serve as nursery grounds for many important organisms, thus extending their influence beyond the vicinity of river mouths and coastal lagoons. Estuaries in the Philippines, Indonesia and Malaysia are lined with mangrove forests and tend to attract human settlements. Increased sedimentation from soil erosion is probably the most important human impact on estuaries in the region. Sedimentation increases the likelihood of floods and shoreline changes, and it affects filter-feeding fishes and other organisms. Increases in salinity may result from decreased river discharge. Since estuaries are commonly considered "free" waste disposal sites, chemical pollution is becoming significant in many estuaries near cities and industrial sites, such as Manila Bay (NEPC 1981) and Jakarta.

**Beaches.** Beaches serve as an abrupt transition zone between marine and terrestrial habitats. A dynamic area of constant fluctuation, the beach promotes mobility in organisms. Many crustaceans, mollusks, and some worms are specially adapted to survive in sandy and rocky subtidal to supratidal zones. Sea turtles nest exclusively on undisturbed sandy beaches. Numerous strand plants protect the supratidal zone from erosion and provide a habitat for salt-adapted terrestrial organisms (Maragos et al. 1983a).

The beach absorbs wave energy and thus protects the shoreline behind it, the accompanying flora and fauna, and contiguous human settlements (Hayden et al. 1978). Beaches have traditionally provided convenient access to the sea because of their gradual decline to the water and their wave-absorbing morphology.
Beaches are important in tourism. The most important coastal tourist sites are on white sand beaches, often near coral reefs. Beaches attract tourists because of the aesthetically pleasing natural setting and the opportunities for snorkeling, swimming and surfing.

The large sand beaches of the region occur on coasts exposed to high wave energy, that is, the south-facing coasts of the Sunda Archipelago, the eastern coast of the Malay Peninsula, exposed coasts on the eastern and western shores of the Philippines, and northern Borneo (Morgan and Valencia 1983). Less developed beaches are widely distributed throughout these countries. These smaller beaches are associated with coral reef formations, small islands, particular coastal geomorphology, longshore currents and sediment sources. Beaches near rivers occur commonly on one or both sides of river mouths, depending on the predominant currents.

Mangroves. Mangrove forests are found on tidal flats at the mouths of streams and on the shores of sheltered bays. They do well on accreting silt-laden shores in high rainfall areas, and their distribution is limited to warm areas above 20-degrees C.

Mangroves represent one of the world's most biologically fertile ecosystems in terms of both gross primary productivity and leaf litter production (Snedaker and Brown 1981) (see table 1). They may provide more than half of the organic matter available to estuaries by trapping inorganic nutrients carried down from river watersheds and converting them into organic compounds (Snedaker and Brown 1981).
Because of the high productivity and physical structure of mangroves, many edible land and marine animals use mangroves as a source of food and shelter (Snedaker and Brown 1981). Such organisms include penaeid prawns, crabs, sergestid shrimp and various species of fish. Mangroves are also sources of firewood, charcoal, medicinal extracts, roof thatching, minor foods, tannin and animal feeds. In their natural state mangroves help stabilize coastal zones by reducing wind damage and wave energy and by checking soil erosion. Mangroves build land through slow, long-term sedimentation.

Table 2 gives estimates of mangrove coverage by country as of 1981. The largest concentration of mangrove forest remaining in Southeast Asia is an estimated 3.6 million hectares in Indonesia. Three-quarters of this is in Irian Jaya and Sumatra. Other major mangrove forests are found along the southwest coast of the Malay Peninsula and at various places along the coast of Borneo.

Mangrove forests are often viewed as undesirable because of their association with swampy areas, and there has been little control over their exploitation. In Southeast Asia mangroves are damaged by: cutting for use as wood and charcoal; reclamation for agriculture; aquaculture; urban development; dumping sites or other construction; and various forms of pollution (Chansang 1979). The major adverse economic impact of mangrove removal is on those nearshore fisheries highly dependent on mangrove-produced nutrients (Foo and Wong 1980).
### Table 2

Mangrove coverage for Indonesia, Malaysia and Philippines

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>AREA (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>3,627,000</td>
</tr>
<tr>
<td>Malaysia</td>
<td></td>
</tr>
<tr>
<td>(Peninsular)</td>
<td>113,348</td>
</tr>
<tr>
<td>(eastern)</td>
<td>538,959</td>
</tr>
<tr>
<td>Philippines</td>
<td>106,133</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4,385,440</td>
</tr>
<tr>
<td>TOTAL FOR THE REGION</td>
<td>6,749,712</td>
</tr>
<tr>
<td>TOTAL FOR THE WORLD</td>
<td>43,700,000</td>
</tr>
<tr>
<td>PERCENT OF REGION</td>
<td>65</td>
</tr>
<tr>
<td>PERCENT OF WORLD</td>
<td>10</td>
</tr>
</tbody>
</table>

**Sources:** Snedaker and IUCN 1981. Umali 1980.

**Coral reefs.** The coral reef ecosystem is noted for its diversity of species and its high productivity. Calcareous rock forms its framework and immediate foundation. Conditions favoring the development of reefs include water temperature above 20-degrees C; water depth shallower than 50 m; constant salinity greater than 30 parts per thousand; low sedimentation rates; sufficient circulation of pollution-free water; and pre-existing substrate (Goreau et al. 1979).

Coral reefs serve humans as sources of food production, coastline protection, nonfood products, aesthetic and related economic benefits, and scientific and educational benefits (Gomez 1980a). Coral reefs are among the most productive ecosystems (see table 1) and...
this productivity is enhanced by the ability to use phosphorus and cycle energy efficiently and to fix nitrogen (Lewis 1981). As a result of their high productivity and varied physical structure, reefs are inhabited by many organisms of economic value as noted below in section 2.4.

Fringing coral reefs occur throughout Indonesia, Malaysia, and the Philippines, and are usually found near small to medium-sized coastal islands (Morgan and Valencia 1983). Larger islands and continental coasts have less reef area because of sedimentation, turbidity and low salinity near river outlets. Coastal islands of the Malay Peninsula, for example, support coral reefs but the peninsular coast generally lacks coral.

The most extensive coral reef area for any single country in the world occurs in Indonesia, reflecting its 81,000 km coastline and 13,000 islands. Coral reefs are found in the Mentawai Archipelago, along many coasts in the Sunda Archipelago, in islands in the Java and Banda Seas, and in north central Indonesia. The Philippines also has extensive reef growth along its 18,000 km coastline and 7,000 islands. The better quality and more extensive reefs are found on the more remote, small islands. The Sulu Archipelago, the Sulu Sea islands, Palawan, Cuyo Islands, some smaller Visayan islands, and some eastern Pacific-facing coasts support much reef area. The best developed Malaysian reefs occur along the coasts and islands of Sabah and Sarawak. Offshore islands of eastern and western Peninsular Malaysia also support some reefs.
Human impacts on coral reefs may be broadly characterized as physical damage, change in deposition/erosion patterns, overexploitation and chemical pollution. Section 2.5 below summarizes the various threats to reefs.

**Sea-grass algal beds.** Seagrasses grow on sandy substrates while larger algae develop on rocky or rubble substrates. Both flourish only in shallow, well-lit waters, often constituting a distinct zone on reef flats. Seagrass and algal beds are common along Southeast Asian coasts, especially on protected shorelines inside coral reefs or near mangrove stands.

Many invertebrates and fishes use seagrass-algal communities at some stage in their life cycle as both communities commonly fix large amounts of carbon and nitrogen (Maragos et al 1983a). Leaf litter or finer particulate matter from seagrass-algal beds may moderate fluctuations in food availability in neighboring communities. Some seagrasses excrete phosphorus absorbed from sediments, which is then used by corals (Soegiarto and Polunin 1982).

Plant biomass in seagrass beds is grazed by sea turtles, Dugong, or smaller herbivores, and in some areas seagrass beds are important nurseries for penaeid prawns. Seagrass and adjacent habitats also serve as feeding grounds for wading seabirds.

Seagrass and algal communities are vulnerable to over-exploitation, changes in hydrological environment, and pollution. Some macroalgae are collected to support industrial demand and some invertebrate species may over-graze seagrass-algae, causing
instability. Activities such as dredging, which increase the turbidity and sedimentation, can damage light-dependent algae and seagrasses. Eutrophication caused by sewage or other pollution can dramatically change community composition (Johannes 1975).

Islands. Islands support ecosystems which are isolated from comparable ecosystems elsewhere. Although more than ninety percent of the land area of Southeast Asia is made up of continental and large island land masses, the many thousands of small islands in the Philippines and Indonesia create a significant coastline. Remote island populations of marine organisms are genetically distinct even if actual speciation has not yet taken place. Endemism of fishes is associated with remote islands such as the Hawaiian Islands (Randall 1976). There is also substantial geographical variation in community structure within certain groups of organisms (Soegiarto and Polunin 1982). The acanthurid fish family, for example, is almost totally absent from peninsular Malaysia east coast island reefs and plentiful on Philippine reefs across the South China Sea (pers. obs.).

Genetic variability maintained by remote island ecosystems contributes to the overall species richness of Southeast Asia. Because of their smallness and ecosystem variability, islands are useful to science for understanding processes of colonization, succession, competition, and evolution and the problems of management. Such environments also have special recreational, educational and tourist value.

The relative remoteness of certain islands provides a habitat devoid of large land reptilian and mammalian predators, including
hunans. These islets are thus nesting sites for seabird colonies and sea turtles (Feare 1978).

**Offshore seas.** About half of the offshore seas of these three countries lie over continental or archipelagic shelves less than 200 m deep. The remaining ocean area lies over continental slopes and abyssal plains (Morgan and Valencia 1983). Highly stratified offshore waters vary with depth and season. The euphotic layer, where there is enough light for significant primary production, is usually less than 50 m deep (Soegiarto and Polmin 1982).

The deeper offshore waters have less biological productivity and lower species richness than the coastal ecosystems discussed above (Whittaker 1975). Organisms in the offshore seas depend heavily on phytoplankton for their food. Productivity is about 2 g carbon/m²/day, or more, in shallow shelf waters (Whittaker 1975). Coastal and upwelling communities are more productive (see table 1) and are likely to be more efficient at using available food. The ratio of fish yield to primary productivity is .005-.013 for upwelling areas and only .00001-.0002 for the open ocean (Marten and Polovina 1981). Since primary productivity is confined to surface layers less than 50 m deep, most important fisheries are in shallow water.

Offshore seas provide a medium for ocean shipping, a base for offshore fisheries, and a site for the extraction of oil and other minerals. Another important use of offshore seas is waste disposal.

Humans damage the offshore seas of Southeast Asia through pollution and the overexploitation of fish stocks and other ocean
resources. Management of offshore waters must consider pollution limits, sea traffic control, regulation of fishing, and control of mineral resources exploitation.

2.3 Ecosystem interaction

Ecosystems, although named and studied independently, are in reality mutually interdependent. Organisms, minerals, and organic matter move through the boundaries on a regular basis. This movement is enhanced in the fluid medium itself. Coral reefs, seagrass beds and mangroves are all exporters of nutrients and organic matter. Estuaries, with a well-defined flow of water, collect nutrients which are then distributed to surrounding coastal areas. Coral reefs provide conditions favorable for the development of mangroves, stable beach communities, and inshore seagrass algal beds.

Some organisms cross ecosystem boundaries during their life cycles. For example, although many prawns breed offshore, they are partially dependent on mangroves for habitat and food (Martosubroto and Naamin 1977; Maragos et al. 1983a). Many fishes typical of open waters feed over or on coral reefs or seagrass beds and spawn in these areas (Grandperrin 1978; Bray et al. 1981). The complexity of interaction between organisms and inshore ecosystems is far higher than in offshore areas, and in many ways offshore waters are dependent on inshore productivity (Maragos et al. 1983a). Thus the potential damage caused by ecological disruption in the coastal zone is greater than in the open sea.

In planning for management of marine areas, interdependent ecosystems cannot be treated individually. Whole areas comprising
inter-connected systems should be treated as functional units.

2.4 Significance of coral reef resources

Historical uses. Coral reef resources have been exploited by man since pre-history, as indicated by remains of marine shells and other marine species found in Palawan caves (Fox 1970). The Spaniards used corals for building houses in the Philippines in the 16th century, and observation suggests that corals have been used for construction since that time. The use of cement in the Philippines, Indonesia and Malaysia early in this century included stony corals in concrete mixtures. Live corals have been used in fishpond dikes since the early 1900's in the Philippines (Alcala et al. in press). More recently, coral tiles made from species which grow to massive size have been used in private homes and public buildings.

Until the early part of this century crude fishing methods were sufficient to catch enough food for local consumption from coral reefs with probable negligible impact on the environment. As populations grew, more efficient and destructive methods became common.

With the rise of the cash economy after World War II, certain reef resources (i.e., stony corals, shells, turtles and aquarium fish) have acquired importance as export items from the Philippines, Indonesia and Malaysia (see table 3).

Food production. Reef-related fisheries annually yield an estimated 9 percent of the world's total fishery of seventy billion kg (Smith 1978) (see table 4). The contribution of reef fish to the total fisheries of the Philippines ranges from 8 to 20 percent.
Table 3
Coral Reef Resource Products and Uses

A. Major Reef Export Products of Economic Importance

<table>
<thead>
<tr>
<th>RESOURCE</th>
<th>PRODUCT—USE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>story coral&lt;sup&gt;a&lt;/sup&gt;</td>
<td>building material, fish</td>
<td>primary reef frame builder</td>
</tr>
<tr>
<td>precious coral*</td>
<td>jewelry, decoration</td>
<td>enhances habitat</td>
</tr>
<tr>
<td>fish*</td>
<td>food, aquarium fish</td>
<td>link in metabolism</td>
</tr>
<tr>
<td>molluscs*</td>
<td>shell collection</td>
<td>calcification, food chain</td>
</tr>
<tr>
<td>Tridacna clams*</td>
<td>decoration, novelty</td>
<td>calcification</td>
</tr>
<tr>
<td>top shells, Trochus</td>
<td>mother-of-pearl</td>
<td>calcification, food chain</td>
</tr>
<tr>
<td>oysters*</td>
<td>pearls</td>
<td>calcification, food chain</td>
</tr>
<tr>
<td>lobsters*</td>
<td>gourmet food</td>
<td>scavenger</td>
</tr>
<tr>
<td>sea cucumbers</td>
<td>&quot;Trengang&quot;, food</td>
<td>detritus feeder, sand</td>
</tr>
<tr>
<td>sponges*</td>
<td>toiletry</td>
<td>borer</td>
</tr>
<tr>
<td>sea turtles*</td>
<td>shell, oil, meat, eggs</td>
<td>food chain</td>
</tr>
<tr>
<td>sea snakes*</td>
<td>skin, crafts</td>
<td>food chain</td>
</tr>
<tr>
<td>misc. invertebrates</td>
<td>antibiotics, drugs</td>
<td>varied</td>
</tr>
<tr>
<td>coral sand</td>
<td>concrete, building</td>
<td>substrate, beaches</td>
</tr>
<tr>
<td>ecosystem</td>
<td>tourism, aesthetic appeal, conservation, natural laboratory</td>
<td>genetic diversity</td>
</tr>
</tbody>
</table>

B. Subsistence Food Products Commonly Used

<table>
<thead>
<tr>
<th>ORGANISM GROUP</th>
<th>KIND</th>
</tr>
</thead>
<tbody>
<tr>
<td>fish**</td>
<td>large variety</td>
</tr>
<tr>
<td>bivalves</td>
<td>clams, mussels, oysters</td>
</tr>
<tr>
<td>gastropods</td>
<td>most large ones</td>
</tr>
<tr>
<td>cephalopods</td>
<td>squid, cuttlefish and octopus</td>
</tr>
<tr>
<td>crustaceans</td>
<td>crab and shrimp</td>
</tr>
<tr>
<td>echinoderms</td>
<td>sea cucumbers and sea urchins</td>
</tr>
<tr>
<td>coelenterates</td>
<td>jellyfish and anemones</td>
</tr>
<tr>
<td>sea turtles</td>
<td>all except Hawksbill, eggs</td>
</tr>
<tr>
<td>algae</td>
<td>many edible varieties</td>
</tr>
</tbody>
</table>

<sup>a</sup> McManus (1980) notes that 1,830,089 cubic meters were exported from the port of Zamboanga, Philippines in 1976.

* Seriously depleted on many reefs throughout Southeast Asia and the Western Pacific region.

** The most significant contribution of reefs to subsistence food consumption in all Southeast Asian countries.
Fish harvests from fringing reefs (60 m or less in depth) in the Philippines vary from 8.0 mt to 23.7 mt/km²/yr. These figures are comparable with those of western Samoa which range from 8.0 mt/km²/yr (Wass 1983) to 18 mt/km²/yr (Hill 1978). Reef fisheries in West Sabah contributed up to 20 percent of the total fishery as estimated by Mathias and Langham (1978).

Coastal people supplement fish intake by the consumption of sea turtles and invertebrates such as octopuses, bivalves (Tridacna and other clams), gastropods, shrimps, spiny lobsters, sea urchins and sea cucumbers. Hundreds of thousands of sea turtle eggs are harvested in the Sulu Islands, Philippines, eastern peninsular Malaysia, and Java, Bali, Sumatra and other Indonesian islands.

Non-protein food products from the reef include edible algae, jellyfish and sea anemones. Consumption of these items depends on particular traditional and cultural preferences.

**Coastline protection.** Fringing and barrier reefs are natural breakwaters which protect low-lying coastal areas from erosion and other destructive action by the sea. Coral reefs also contribute to terrestrial accretion by providing sand for beaches and low islands (Goreau et al. 1979). Calcification is responsible for reef structure formations and sediments. This major biogeochemical process on coral reefs contributes about 50 percent of the total calcium carbonate deposited in the world's oceans annually (Smith 1978) (see table 4).
Table 4
Coral Reef Area, Calcification and Fishery Potential in World and Philippine Perspective

A. Coral Reef World Contributions

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CONTRIBUTION</th>
<th>PERCENT OF WORLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>total ocean area</td>
<td>600,000 km²</td>
<td>0.17</td>
</tr>
<tr>
<td>0-30m area</td>
<td>600,000 km²</td>
<td>15.0</td>
</tr>
<tr>
<td>Philippine reef area</td>
<td>27,000 km²</td>
<td>4.9</td>
</tr>
<tr>
<td>calcification</td>
<td></td>
<td>50.0</td>
</tr>
<tr>
<td>fishery production</td>
<td></td>
<td>9.0</td>
</tr>
</tbody>
</table>

B. Philippine Reef Fishery Contributions

<table>
<thead>
<tr>
<th>DATA YEAR (BFAR)</th>
<th>CONTRIBUTION</th>
<th>PERCENT OF TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>126,300,000 kg</td>
<td>8.4</td>
</tr>
<tr>
<td>1976</td>
<td>137,200,000 kg</td>
<td>9.8</td>
</tr>
<tr>
<td>1975</td>
<td>200,600,000 kg</td>
<td>15.9</td>
</tr>
</tbody>
</table>

C. Potential Reef Contribution Using Different Estimates of Reef Productivity

<table>
<thead>
<tr>
<th>RESEARCHER</th>
<th>CONTRIBUTION</th>
<th>PERCENT OF TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcala (1979)</td>
<td>398,300,000 kg</td>
<td>29.8*</td>
</tr>
<tr>
<td>Stevenson and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marshall (1974)</td>
<td>135,000,000 kg</td>
<td>10.1*</td>
</tr>
</tbody>
</table>

* Based on estimates of potential coral reef fishery productivity from the cited studies and extended for the Philippines assuming 27,000 km² of reef area and using fishery production for 1975.

Non-food products. Coral reefs have traditionally served as sources of building materials as discussed above. Lime is extracted from many Indonesian reefs for use in cement (Soegiarto 1983; pers. obs.), and tiles are made from massive corals in the Philippines. Sand extracted from reefs serves as a fill material and is widely used in cement mixes.

Pharmaceutical and industrial products obtained from reefs include anti-cancer substances in sea hares, contraceptive chemicals derived from corals, and agar and carrageenan extracted from various algae (Alcala et al., in press).

In the late 1960's international trade in ornamental corals, shells, sea turtles and coral reef fish began to flourish. These items now support large industries and end up mainly as decorative pieces in various parts of the world (Wells 1982). Hydrophiid snakes have been exploited primarily for skins and secondarily for meat since the 1930's in the Philippines (Punay 1975). The Philippines exported 7,224 mt of coral and 4,000 mt of ornamental shells in 1974 (McManus 1980). Even though bans exist on coral and sea turtle collecting, these items continue to leave these countries in large quantities (Alcala et al., in press; Soegiarto 1983). The implications of removing ornamental shells from coral reefs have not yet been adequately evaluated.

The aesthetic appeal, biological richness, clear waters and relative accessibility of coral reefs make them popular recreation areas for local and foreign tourists. Skin and scuba diving, underwater photography, and amateur collecting are common activities on reefs in the region. Local scientific research on coral reef
ecology and fauna is increasing as field monitoring becomes necessary to answer new management questions. The conflict between rapid industrialization and long-term conservation is being addressed in the Philippines through coral reef research. Coral reefs also provide a laboratory for the study of basic biological processes by high school and college students in these countries (Gomez 1983b).

2.5 Status of coral reef resources

Coral cover. Out of 632 reef stations in the Philippines surveyed for relative coral cover by the Marine Science Center (MSC) as of 1982, only 5.5 percent were found to be in "excellent" condition (80 percent or more living hard coral cover). Twenty-four percent were rated "good", and the majority came in the "fair" and "poor" categories comprising 38.3 and 32.1 percent respectively (Gomez et al 1982). It may be inferred from these data that reefs in the country are generally stressed or disturbed. Informal reports from Indonesia and Malaysia indicate similar trends (Salm pers. comm.; DeSilva pers. comm.).

Fish. The current tendency is for fishermen to resort to increasingly efficient, exhaustive, often habitat-destructive fishing methods without consideration for maintaining yields. These practices include spearfishing with or without scuba, muro-ami, and dynamite blasting (see section 2.6). Informal reports and personal observation indicate that there are decreased fish catches within the last twenty years along coastlines subject to habitat destruction in all three countries (pers. obs.). Carpenter et al. (1981) link
reduced fish abundance to reduced substrate topographic diversity and coral cover.

The growth of aquarium fishing in remote islands in the Philippines and Indonesia indicates that fish populations in accessible islands are already depleted (Albaladejo and Corpuz 1981; Kvalvaagnaes 1982). Also, the use of sodium cyanide, a simple but destructive collection method, indicates scarcer resources.

Shells. No quantitative studies have been conducted on the effect of intensive exploitation of reef mollusks on the ecology of coral reefs and surrounding ecosystems. Wells and Alcala (1984) indicate significant perturbation of molluscan populations in a number of Philippine areas, as evidenced by localized depletion of certain species (e.g., top shell, *Trochus*; the giant clam, *Tridacna*; and the triton shell, *Charonia*). These species are generally depleted in Indonesian and Philippine waters (pers. obs.; Salm 1984; Soegiarto and Polunin 1982). *Tridacna gigas*, for example, although totally missing from Visayan Philippine reefs is common at the remote Tubbataha reefs in the Sulu Sea (pers. obs.; Munro 1983).

Turtles, sea snakes and lobsters. The Hawksbill turtle studied by Alcala (1980) had not laid eggs in two of three known nesting beaches in Negros Oriental, Philippines, during the preceding two years. This species and the Green turtle are rarely seen in Philippine waters except in remote areas (pers. obs.), and informal reports suggest a drastic decline during the past forty years. A similar trend has been recently observed for turtle nesting beaches of
east coast Peninsular Malaysia where Leatherback and Green nesting have decreased more than 50 percent since 1956 (Chan pers. comm.).

Populations such as the three species of Laticauda captured by the thousands prior to the 1970's in the vicinity of Gato Islet, Cebu, Philippines, have virtually disappeared (Punay 1975; Bacolod 1982).

The spiny lobster (Panulirus), once abundant on coral reefs and rocky coasts in all three countries, has become scarce in all heavily fished areas (pers. obs.; Salm pers. comm.; DeSilva pers. comm.).

2.6 Coral reef resource degradation

Natural causes. Shallow-water reefs along storm or monsoon paths often suffer physical damage which takes years to repair. Such damage normally includes uprooted coral heads and scattered broken corals (Woodley et al. 1981). Extreme low tides may expose corals directly to sunlight and to freshwater run-off, both of which are lethal during several hours of exposure (Goreau et al. 1979).

Interactions between different coral species and between corals and other reef organisms are significant in reef dynamics (Glynn 1977). Predation on hermatypic corals tends to accelerate bicerorsion. This may be more significant than the mechanical action of currents and waves in producing calcareous sediments on the reef (Glynn 1977).

Predation also modifies reef community structure. Two coral predators in the region are the Crown-of-thorns starfish (Acanthaster planci) and at least two species of muricid gastropods, Drupella spp. Both feed on the polyps of stony corals and leave a barren calcium skeleton which erodes or becomes encrusted with other organisms.
Although *Acanthaster* is present on most reefs in the Southeast Asian region, serious infestations of 100 or more per 1,000 m² (Endean 1973) have not been reported except on reefs of islands off east coast Peninsular Malaysia. Here the coral covers of Pulau Redang and Perhentian Besar and Kechil reefs were reduced by 90 percent during the 1978-80 *Acanthaster* infestation (DeSilva 1984). About ten individuals per 1,000 m² were reported for two small reefs in the central Philippines (Alcala 1976). Predation by the gastropod *Drupella* spp. has been reported at Mactan Island, Cebu, Philippines (Moyer et al 1982), although frequency in other areas is not known.

**Human causes.** Increasing population pressure has a direct effect on coastal resources. The 1980 Philippine population of 49 million is increasing by about 3.7 percent a year, and the population density of 159 per sq km is nearly double the Southeast Asian average. Since 87 percent of the population lives within fifty km of the coast, there is considerable pressure on marine resources (Umali 1980). A summary of human impacts on coral reefs is presented in table 5.

The most important single cause of reef degradation is sedimentation resulting from human terrestrial activities (Gomez 1980a). These include unsound agricultural and forest practices, mismanagement of watersheds, exploitation of mangroves, earth-moving for construction, oil drilling, and the dumping of terrestrial and marine mine tailings and effluents. Increased turbidity reduces the penetration of sunlight, thus inhibiting photosynthesis in primary producers, such as the symbiotic algae of coral polyps. This in turn slows coral growth. Coral communities in deeper waters are at the
Table 5

Human Activities and their Impacts on Coral Reefs

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) extraction of coral limestone</td>
<td>reef foundation degradation</td>
</tr>
<tr>
<td>2) extraction of coral sand</td>
<td>turbidity, water flow dynamics</td>
</tr>
<tr>
<td>3) explosive fishing techniques</td>
<td>habitat destruction</td>
</tr>
<tr>
<td>4) terrestrial sediments from human activity</td>
<td>turbidity, smothering</td>
</tr>
<tr>
<td>5) physically damaging fishing methods</td>
<td>habitat destruction</td>
</tr>
<tr>
<td>6) reef trampling by humans or anchors</td>
<td>habitat destruction</td>
</tr>
<tr>
<td>7) overfishing of fish and invertebrates</td>
<td>changes in ecosystem balance, lowers MSY</td>
</tr>
<tr>
<td>8) aquarium fish collection</td>
<td>selectively depletes population</td>
</tr>
<tr>
<td>9) urban-industrial pollution</td>
<td>biological degradation</td>
</tr>
<tr>
<td>10) oil spill</td>
<td>biological degradation</td>
</tr>
<tr>
<td>11) oil drilling</td>
<td>turbidity, habitat destruction</td>
</tr>
<tr>
<td>12) fish poisoning</td>
<td>biological degradation</td>
</tr>
<tr>
<td>13) spearfishing</td>
<td>selective depopulation of fish</td>
</tr>
<tr>
<td>14) tourism</td>
<td>collecting, minor habitat disturbance</td>
</tr>
<tr>
<td>15) thermal or salinity changes</td>
<td>detrimental to coral polyps and invertebrates</td>
</tr>
</tbody>
</table>

margins of light penetration, and may be the most vulnerable. Sedimentation also smothers living coral, and silt hinders the settling of planulae larvae (Johannes 1975).

Perhaps the most lethal form of sedimentation is from heavy concentrations of mine tailings (Lowrie et al. 1982; Aliño et al. 1981). Currents affect the rate and extent of their dispersal. In 1982 the Philippine National Environmental Protection Council (NEPC) reported that 371,644 mt of mine wastes and 190,896 mt of tailings were dumped daily by 110 mining companies (Lastimosa 1982).

Soil erosion caused by deforestation and agriculture eventually deposits large quantities of silt on coral reefs. As this is more geographically widespread than pollution from mine tailings, quantities and the associated effects tend to be more difficult to assess.

Coral mining and harvesting for local use and international trade directly contribute to coral reef degradation (Ross 1982; McManus 1980; Mathius and Langham 1978). Corals are commonly used for construction in Indonesia and many reefs near population centers are mined for limestone (Soegiarto 1983; pers. obs.). All removal of corals creates sedimentation and changes water movement and shoreline erosion.

Destructive fishing methods common in the Philippines, Indonesia and Malaysia include blasting, muro-ami, trawling over reefs, use of cyanide, use of small mesh nets and traps, traditional spearing, and spearing using scuba. Even though these deleterious fishing methods may not necessarily lead to overfishing, they may damage the reef itself and thus inhibit the potential fish yield.
Reef-front trawling and reef-front bottom trawling have caused damage to considerable tracts of coral. Because the fine mesh nets capture many juvenile fish, these methods probably cause the depletion of many fish stocks (Ruddle 1981).

Blasting is one of the most destructive fishing techniques in the region (Alcala and Gomez 1984). Although illegal, it is still common in many areas. Blasting shatters the coral reef for a radial distance of several meters, depending on blast depth and strength (Brever 1975). Damaged areas thereafter support little fish life, are slow to recover (up to thirty years for 50 percent recovery), and encourage infestation by some algae and other weedy species such as Crown-of-thorns starfish (Alcala and Gomez 1979).

Muro-ami and kayaks fishing techniques, common to the Philippines and reported in Indonesia and Sabah, are related to traditional Japanese methods of using swimmers to chase fishes into a net (Carpenter and Alcala 1977) (see figure 1). The swimmers bang the bottom substrate with poles (kayaks) and rocks (muro-ami) to make noise, scaring the fish out of hiding and herding them into nets. The consequence is many broken corals in a disturbed bottom habitat.

Fish traps are a legitimate fishing method when used judiciously. At times, however, coral is broken and used for trap weights, and abandoned traps continue to catch fish until the traps disintegrate. Sometimes large traps are dropped on reef ledges and retrieved by a line, both of which can smash sizeable coral formations.

Bait or aquarium trade fishing often involves breaking colonies
Figure 1. *Muro ami* Fishing Operation
Source: (Smith et al. 1980:20).
of branching and foliose corals in order to shake fish out of them. Fish toxicants are also used, some of which (e.g., sodium cyanide) are detrimental to the health of coral and other invertebrates (Gomez et al. 1984). Aquarium trade capture is frequently directed toward certain popular fish, such as cleaner wrasses, which serve a particular ecological role in the reef community (Gomez 1980). Their capture upsets the natural balance. This same principle applies in spearfishing for large, desirable species such as groupers, parrotfish, and acanthurids (Salm 1982).

Inshore fishing in reef environments normally involves the use of small to medium-sized boats whose anchors are designed to hook corals or other substrate. Frequent dropping and removal of such anchors damages heavily visited coral areas. Boats transporting tourists also drop anchors at popular snorkeling and diving areas and can cause significant damage (pers. obs. Davis 1977).

Reef gleaners break corals by walking over the reef at low tide, and swimmers damage corals with their fins (pers. obs.). Tourists sometimes remove live corals and reef animals from protected areas (pers. obs.). The extent of such damage is unknown but is usually concentrated near resorts or popular diving areas (Gomez 1983a).

Pollutants other than sediment which affect coral reefs include heavy metals, sewage, hydrocarbons and thermal discharge (Johannes 1975). Since these pollutants occur near populated, industrial areas, reefs bordering major cities in Indonesia, Malaysia and the Philippines are mostly destroyed. The cause is a combination of chemical and physical disturbance in most cases (Gomez 1980a).
Hydrocarbon pollution occurs near oil refineries, drilling platforms and in harbors where spillage occurs. Evidence shows that oil kills reef fish and has detrimental effects on the reproduction, growth rate, colonization, feeding and behavioral responses of corals (Maragos 1983b; Gettelsson 1980; Loya, in Press). Oil platforms shade corals and contaminate them by dumping drilling muds and drill cuttings into the sea. At a drill site off northwest Palawan Island, Philippines, drill cuttings caused a 79 percent reduction in the amount of living hard coral cover (Hudson et al. 1982).

The impact of thermal pollution is limited to hot water discharges from heavy industrial and power generating plants and some offshore oil sites. Since tropical organisms live at temperatures close to their upper lethal limits, the threat to reefs can be significant (Johannes 1975).

2.7 Regional and international concern

Because the 1970's was a period of increased consciousness about environmental problems (Johnston and Letalik 1980), the 1982 Convention on Law of the Sea includes much of ocean environmental importance. For example, coastal states are obligated to conserve and seek optimum use of living resources. Specifically, they must: 1) protect and preserve the marine environment; 2) prevent and control pollution; 3) cooperate in the development of scientific criteria and rules for the prevention, reduction and control of marine pollution; and 4) adopt and enforce laws to deal with pollution from land-based sources, sea-bed activities, activities in the area, dumping, or vessels (Johnston and Letalik 1980).
At the regional level the United Nations Environmental Programme (UNEP) has initiated an East Asian Seas Action Plan which will assess oil and non-oil pollutants, study pollution control and waste management, and collect data on coastal marine ecosystems. The action plan emphasizes environmental assessment and quality, and it plans to formulate a regional marine science program as a first step towards protection of the marine environment (UNEP 1981).

A Draft Action Plan for the Conservation of Nature in the ASEAN Region was formulated by the International Union for the Conservation of Nature in 1981. Priorities set by this plan include a network of ASEAN reserves, an information exchange, and a regional training program on conservation management (IUCN 1981). The need to maintain essential ecological processes, to preserve genetic diversity, and to ensure the sustainable use of species and ecosystems are unifying criteria of future projects (IUCN 1981). A network of reserves (nature, biosphere, or wildlife) is regarded as one of the most effective ways of conserving ecosystems and their constituent wildlife. Stress is placed on finding common criteria for establishing an adequate reserve system (ASEAN 1980).

2.8 Marine reserves for protection and management

Taken together, the Convention on the Law of the Sea, the UNEP program, and the IUCN plan reflect three overlapping but separate environmental concerns: 1) conservation of marine species, 2) marine pollution control, and 3) coastal zone management (Johnston and Letalik 1980). The concept of marine reserves has been used to address various aspects of these problems.
The first terrestrial reserve was set up early in the 19th century and moves were made from the 1870's onward to limit certain types of fishing on vulnerable marine coasts (Polunin 1980). Sixty years ago the first marine reserves were established by national governments (Bjorklund 1974).

A marine reserve constitutes a defined space which has some form of management and limited entry. The many types of protected areas defy simple categorization, but these various reserves represent a spectrum reflecting different degrees of control. Each type emphasizes different objectives (Polunin 1981) (see table 6).

When properly designed and enforced, a protected area constitutes a simple, efficient and logical means of serving various marine conservation needs. For example, reserves help maintain biotic and genetic diversity through habitat preservation (Polunin 1981). They protect endangered species and sub-populations, allow for management of fisheries, and maintain wild populations important to aquaculture. Restoration of depleted populations can occur. Reserves often serve educational and research functions compatible with strict biotic and genetic protection. Recreation and tourism areas may also be compatible with protected areas by facilitating education, providing cultural exchange, and generating revenue.

The following is a summary description of reserve types and their application.

**Sectoral reserves.** Sectoral reserves are based on specific uses. Coastal zone management areas, tourism management zones, and water quality management zones are examples (see table 6). These
Table 6
Priorities Given to the Different Objectives of Marine Conservation in Various Types of Protected Areas

<table>
<thead>
<tr>
<th>OBJECTIVE</th>
<th>PROTECTED AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>protect ecosystems</td>
<td>1 1</td>
</tr>
<tr>
<td>maintain biotic diversity</td>
<td>1 1</td>
</tr>
<tr>
<td>education, research</td>
<td>2 1</td>
</tr>
<tr>
<td>safeguard water quality</td>
<td>3 3</td>
</tr>
<tr>
<td>prevent shore erosion</td>
<td>3 3</td>
</tr>
<tr>
<td>produce fish protein</td>
<td>3 4</td>
</tr>
<tr>
<td>provide recreation, tourism</td>
<td>2 4</td>
</tr>
<tr>
<td>sustain yields</td>
<td>2 3</td>
</tr>
<tr>
<td>protect cultural sites</td>
<td>2 4</td>
</tr>
<tr>
<td>protect aesthetic qualities</td>
<td>1 3</td>
</tr>
<tr>
<td>maintain resource options</td>
<td>4 4</td>
</tr>
<tr>
<td>stimulate rational use</td>
<td>3 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>National Park</th>
<th>Biological Reserve</th>
<th>Wildlife Refuge</th>
<th>Resource Reserve</th>
<th>Sustained Yield Harvest Zone</th>
<th>Water Quality Control Zone</th>
<th>Tourism Management Zone</th>
<th>Cultural Monument</th>
<th>Coastal Zone Management Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Objective prevails in management of whole area.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Objective prevails in management of part of the area.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Objective is accomplished by other objectives.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Objective not relevant in area.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

reserves frequently span natural boundaries of ecosystems, species habitat, or the land-water interface because vulnerability to some general threat is the underlying rational for formation of the reserve. In the Philippines, for example, large sectoral fishing reserves have been initiated where commercial fishing has become too intense.

**Ecosystem, habitat, and species reserves.** Ecosystem, habitat, and species reserves are prompted by the need to protect certain vulnerable resources. The motivation for such reserves is the inherent value of the resource. Prime candidates would be the productive ecosystems of the coastal zone such as the coral reef, mangrove, seagrass, estuarine and upwelling areas indicated in table 1. These ecosystems and habitat areas are resources in themselves and provide habitat for commercially important and/or endangered species.

Ecosystem, habitat, and species reserves, as contrasted with sectoral reserves, are concerned with maintenance of specific resources. Such reserves are based on strict control of small areas. They may be combined with the resource, wildlife, and biological reserves of table 6 or the western idea of national parks. An example is Bali Barat National Park, Indonesia, which protects both a small island coral reef and a coastal mangrove habitat.

Because the effectiveness of reserves is closely tied to the traditional use patterns of the people who live nearby, any ecological analysis of a species must include ecological information about humans as well.
**Regional biosphere reserves.** Biosphere reserves are designed to protect biotic diversity. Criteria for selecting areas to serve as biosphere reserves include high species diversity, density and endemism, complexity of ecosystems, outstanding wilderness value, uniqueness in species composition, and the geographical variation of the species richness (IUCN 1981). Principles of island biogeography could be useful in providing estimates of the isolation of particular communities and the size of an area necessary to conserve a maximum diversity (Goeden 1979). Maximum uniqueness and/or diversity should determine geographical location (Polunin 1981). Regional biosphere reserves may well be congenial with well-maintained habitat, ecosystem and species reserves or with national marine parks.

Prime candidates for regional marine biosphere reserves in the Philippines, Indonesia and Malaysia include biologically rich areas such as:

1) the Aru Archipelago in eastern Indonesia where four species of turtles nest and Dugong and crocodile populations survive in an environment of relatively pristine mangrove forest and coral reefs;

2) one of several recently formed Indonesian national parks which include coastal areas with reef and mangrove habitat, some populations of sea turtles, Dugong, a few crocodiles, seabirds, and indigenous beach vegetation; these parks are Ujung Kulon in west Java, Baluran in east Java, Bali Barat in Bali, Komodo in Nusa Tenggara Province, and Manusela in central Seram;

3) parts of the east coast of the Malay Peninsula where dense sea turtle nesting occurs; and

4) Apo Reef and Tubbataha Reefs in the Philippines, two extensive, mostly intact coral reef atoll ecosystems (see Chapter 4).
National marine parks. A national marine park, while partly a biosphere reserve, is also designed for human accessibility, recreation and education. The various reserve types could all occur within a national marine park, but the park concept emphasizes use by people. Marine parks should follow international standards set by the IUCN. Variations on the zonation scheme of core and buffer as described by Ray (1976) may be appropriate in national marine parks. Examples in the Philippines, Indonesia and Malaysia are discussed below.

2.9 Reserves in Southeast Asia

Because the diverse and resource-rich coastal areas of Southeast Asia are necessary for the maintenance of fisheries and other uses, there is now great interest in marine parks and reserves as tools for management (see table 7). Many areas have been designated as marine parks or reserves. Few of these sites, however, are being managed in a manner consistent with long-term maintenance of coastal resources because of a lack of technical knowledge, money, and law enforcement on the part of national governments.

Table 7 summarizes the number of existing legislated and proposed reserves in the regional countries. To illustrate, Indonesia's thirteen existing reserves include:

- Bali Barat (P. Menjangan), a coastal, small island, reef complex in an area of developed international tourism with a potential for recreation and sanctuary zones and a buffer zone of traditional but regulated fishing (see Chapter 4); and

- Komodo National Park, an extensive marine area in a remote terrestrial island reserve with potential for zonation and multiple uses (Robinson et al. 1981).
Malaysia has four existing marine reserves, including:

- Dungun Beach in Trengganu, serving as a wildlife sanctuary for nesting sea turtles and a site for observation of sea turtle nesting;
- Muka Head State Park in Penang, serving primarily recreation and tourism needs;
- the Turtle Islands in Sabah, a legislated wildlife sanctuary for sea turtle nesting habitat (Bullock 1974).

The Philippines has nine existing marine reserves, including:

- Sumilon Island near southern Cebu Island, a fishery reserve legally; it is used as a marine park with a strict reserve for scientific research and viewing, and a buffer zone for regulated traditional fishing (see chapter 4); and
- Apo Reef near Mindoro Island; legislation is pending to make it the largest marine park in the Philippines with extensive reefs and a potential for a strict reserve, recreation areas and a sizeable buffer zone for traditional and sustainable levels of fishing activity (see Chapter 4).

Table 7
Number and Status of Marine Reserves in Southeast Asia

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>EXISTING*</th>
<th>LEGISLATED</th>
<th>PROPOSED</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Thailand</td>
<td>4</td>
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<td>14</td>
</tr>
</tbody>
</table>

* In a few cases in the Philippines and Indonesia, reserves have been implemented without national legislation.

**Only northern Australia, bordering on the Southeast Asian region, is represented.

2.10 Local, national, and regional management

Local management. In most coastal areas of Southeast Asia the disappearance of traditional management schemes has left a haphazard assortment of approaches toward reef use. National legislation is not usually enforced and local governments generally do not have jurisdiction over marine areas. Although public concern with protecting the marine environment has generally increased, increased rates of exploitation have counteracted conservation efforts (White 1980).

Nevertheless, as reef degradation has increased, a few communities in the Philippines and elsewhere have recognized the problem and have used the reserve as a method of conserving local marine resources. These reserves mandate strict protection for parts of the reefs, with no removal of organisms within a central core portion. Only traditional, non-destructive fishing methods are allowed in the buffer zone surrounding the central core area (Ray 1976).

This basic reserve system (see figure 2), referred to as the "municipal marine park" by Castañeda (1980), fits well with traditional reef tenure and community resource use systems which were in effect before western regulatory ideas became prevalent. The concept of community domain over nearby marine areas is well established in many local traditions. Johannes (1980) points out that municipal reserves and regulations, like older, local conservation customs, are devised by the villagers themselves and thus are tailored to fit specific local environmental and social conditions.
Figure 2. Basic Reserve System
The people of Moalboal, Philippines, for example, passed a municipal ordinance in May 1980 to protect the immediate beach-reef area and a small island, Pescador, about 2 km. offshore. The use of fish traps on the reef ledge was banned, since these systematically break corals. Other destructive practices were also prohibited, and the entire island of Pescador was set aside as a marine park (White 1981) (see chapter 4).

National. Marine conservation in the region has not been a matter of national priority until very recently. For example, although the creation of Hundred Islands National Park in 1940 in the Philippines was a first in marine conservation, it has not succeeded in preserving marine life because it has no field management or legal enforcement (Villadolid 1967). Other national reserves suffer similar fates.

National interest in resource management arises from economic considerations. There is national prestige in having pristine coastal areas for biotic preservation and for tourism. Fishery depletion caused by overfishing and destruction of coral reef, mangrove, sea grass and estuarine habitats has become significant. Local cultures may also be affected by dwindling populations of endangered species.

National government priorities may sometimes conflict with those of local governments. Where municipalities take initiative and designate reserved areas, it may be difficult for the national government to accept such areas. In the extreme, the national government could annul local management efforts by forbidding municipal jurisdiction over marine areas.
On the other hand, national governments could choose to support municipal efforts logistically and legally, thus shifting part or all of the burden of selection and management to the local community or municipality.

**Regional.** Regional reserve management puts the entire regional ocean-land regime in focus, with the sea and the land considered together. Such ecological processes as nutrient flow, species movement, siltation, energy transfer, and stream flow between land and sea are key factors in determining the boundaries of regions and potential reserves. Such processes must be integrated with social, economic and political factors to ensure that reserve selection is optimal for the marine resources concerned (IUCN 1979).

Just as community and national levels of reserve management are ideally complementary rather than mutually exclusive, the interplay of regional and national levels can also be complementary. Most small reserves will fall within national boundaries, but some large threats, such as oil spills, are best addressed on a regional basis. Moreover, since coastal development of one country may seriously affect another, arrangements are needed for bilateral regional agreements to negotiate the management of broad areas.

Regional planning lends itself to the establishment of a network of reserves, the institution of legal means to protect endangered species, and the establishment of mechanisms for information exchange, research and management (IUCN 1981). Emphasis might first be placed on workable, functioning local reserves as regional plans proceed so that what is practically possible is kept in sight.
To secure international support for national action in conservation, the nations of Southeast Asia are becoming parties to the global conservation conventions (IUCN 1981). The World Heritage Convention affirms the obligation of states to protect unique natural and cultural areas of international significance. The Wetlands Convention concerns the conservation of coastal and other wetlands critical to waterfowl, fish and species requiring aquatic habitats (IUCN 1981). The Migratory Species Convention obliges parties to protect endangered migratory species and to endeavor to conclude agreements for the conservation of migratory species whose status is "unfavorable." This convention would be particularly useful for conservation of transfrontier and specific migratory species in the region. An example is the marine turtle population inhabiting the islands of the Philippines, Malaysia and Indonesia.

International mechanisms that might be invoked to control trade are the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the proposed ASEAN plan for nature conservation. These are essential for the effective implementation of any regional action to control trade in highly endangered species.
3.1 Introduction

Data on environment, reef use, and management have been collected at each study site in order to answer the question "How can marine reserves best serve as management tools for coastal reef environments?" Reef environments were monitored qualitatively and quantitatively by collecting data on substrate cover, coral diversity, and selected species diversity and density. Reef use has been documented by interviewing local residents, fishermen, and key informants, and by personal observation. Management schemes have been documented and evaluated by site visits, interviews with officials and general observations.

Information on reef environment, reef use, and management is necessary to present a holistic picture of the ecological, socio-economic and management status of each site. An evaluation of reserve management is based on this complete picture. It is also essential to have a complete description of each site for comparison of reefs between sites and countries.

This study is composed of a literature review, a report on site monitoring, and the analysis of site-specific data. The literature pulls together information about the marine reserve concept, marine management, and coral reef ecology. The study began in the
Philippines in 1978 with the help of the Philippine Ministry of Natural Resources (MNR) and Silliman University. It was continued during 1981 and 1982 at the University of Hawaii and at the Environment and Policy Institute of the East-West Center. It was completed in 1983 in the Philippines at Silliman and during short visits to Indonesia and Malaysia in 1984.

3.2 Research setting

In the Philippines five small island sites and one coastal community area were selected because in each area some sort of reserve management scheme had begun. In addition, three control sites without management were chosen, two heavily exploited and the other in a remote, unexploited area. One site where management had begun and one without management were observed in Indonesia (Soegiarto and Polunin 1982). In Malaysia the study sites are two proposed island reserves off the eastern coast of Peninsular Malaysia, where both tourism and fishing interests are present (DeSilva 1982a; 1982b).

The Philippine study sites are:

1) Apo Island, Negros Oriental; managed, exploited
2) Sumilon Island, Cebu; managed, exploited
3) Balicasag Island, Bohol; no management, exploited
4) Bantayan Beach, Cebu, Negros Oriental; no management, exploited
5) Moalboal, Cebu; managed, exploited
6) Sombrero Island, Batangas; managed, exploited
7) Apo Reef, Mindoro Occidental; managed, not exploited
8) Tubbataha Reefs, Palawan; no management, not exploited, remote
9) Calauit Island, Palawan; managed, not exploited

The Indonesian study sites are:

1) Bali Barat, Bali; managed, not exploited
2) Seribu Archipelago, Java Sea; no management, exploited
The Malaysian study sites are:

1) Pulau Perhentian Besar and Kechil; no management, exploited
2) Pulau Redang Archipelago; no management, exploited

Table 8 presents a summary of the type and source of data collected at each site and figure 3 shows site locations.

3.3 Data collection

Monitoring reef environment. The three guidelines for choosing survey techniques were speed, simplicity and replication (Dahl 1977).

A terrestrial and marine overview delineated the boundaries of the study areas, allowed for general observations and measurement for maps, and insured comparability of sites. This included a general visual reef survey (Kenchington 1978) using snorkeling and an underwater slate to provide a descriptive picture of the entire reef. This completed site Survey Form I (see appendix). Obvious signs of damage from natural or human causes were noted. Broken and dead coral, siltation, unusual algal growth, accumulation of debris or other extraordinary conditions were also recorded. These preliminary survey observations acted as a check on transect accuracy and helped in making comparative qualitative evaluations.

All reef sites were monitored using a standard reef transect technique combining the methods described by Reed (1980) (see figure 4), Dahl (1977), and Johannes and Stoddart (1977). Observations were made along a 100-m transect line demarked at each end by reef features such as a coral head or rock. The transect was laid out by two scuba divers and/or snorkelers. One swam along the 5-m calibrated transect
<table>
<thead>
<tr>
<th>SITE</th>
<th>REEF SURVEYS</th>
<th>REEF USE</th>
<th>MANAGEMENT</th>
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<td>p</td>
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<td>p</td>
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<td>p</td>
<td>p</td>
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<td>p</td>
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<td>ps</td>
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<td>s</td>
<td>p</td>
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<tr>
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<td>s</td>
<td>p</td>
</tr>
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<td>p</td>
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<tr>
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<td>p</td>
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</tr>
<tr>
<td>Pulau Redang</td>
<td>PR</td>
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</tr>
</tbody>
</table>

p primary source of information—collected by the author
s secondary source of information—through field reports and published accounts
ps combination of primary and secondary sources of information
Figure 3. Study Sites (underlined)
line and estimated substrate covers in centimeters for each 5-m segment. For later diversity analysis, the other recorded coral genera in each 5-m transect segment in a meter wide band along the transect line and counted dominant organisms.

An index of topographic relief was obtained by measuring meters of additional surface area (masa) per 10 m of transect line. A calibrated, weighted nylon line was laid closely over the contour of the reef under 10-m sections of transect and the additional distance required to span the 10-m distance was measured. This information was transferred to Survey Form II (see appendix), derived from Dahl (1977).

Specific data on substrate cover, coral genera, selected invertebrate and vertebrate abundance, diversity and the index of topographic relief provided a basis for quantifying relatively small changes over time and for making comparative analyses between sites.

Two to four transects were laid at each site, depending on the size of the site. Their locations were equally spaced or placed randomly within the area of study. The transect lines were attached at 15 m depth and extended toward the shore (perpendicular to the shoreline), thus providing reef profiles with similar zones.

A few permanent transect sites were surveyed at periodic intervals of approximately one year to allow observation and quantification of environmental changes (Dahl 1977). These longitudinal comparisons were possible only at those sites surveyed originally in 1981 or 1982 (see table 8).
A. Substrate Cover:

Transect line for estimating substrate cover—surveyor swims along line and measures length of line over substrate types

B. Organism Density:

5 m x 1 m quadrats are approximated along transect line for estimating invertebrate organism density/100 m²

C. Topographic Relief:

Meters additional surface area (m²a)/10 meters is measured by laying a calibrated weighted line closely over reef contour under 10 m of transect line

Figure 4. Transect Survey Methods
A systematic snorkeling (SS) survey was used as a check on the transect data and to document sites where transects were not placed. In this technique a snorkeler recorded the same bottom cover parameters used in the transect method by stopping at stations spaced approximately 100 m apart. These were estimated by 100 swimming strokes. Because these stations normally extended the length of a study area, this method offered a wider view of the reef. The SS data are reported with the transect data for comparison.

1983 and 1984 snorkel and scuba surveys also included observations on the diversity of chaetodontidae (butterfly) fishes. These data serve as a supplemental indicator of reef condition because chaetodonid diversity reflects the richness of the coral habitat in terms of topographic relief and the diversity and condition of hard coral (Reese 1977; 1981). Chaetodontids were easy to learn to recognize so the data are complete for those reefs observed.

Monitoring reef use. For each site information was gathered on the community of people who use the particular reef area. When possible, a survey of neighboring fishermen was conducted. In other cases, observation and key informant interviews were used to obtain relevant data. Particular emphasis was placed on documenting those human activities which affected the marine environment. Specific questions dealt with fishing income, changes in reef environment and use, changes in the fishing community, the types of fishing methods used, and local perceptions of weather, marine organisms, management, and why there have been changes in resource abundance.
Interviewers fluent in the local dialect and nonobtrusive in their interview techniques conducted interviews with fishermen and older members of each community. Eliciting stories of past events and current topics of interest were standard methods of approach. It was not considered appropriate to use a formal sampling and questionnaire procedure as fishermen were willing to provide more information and be more spontaneous in a non-formal setting (pers. obs.).

Key informants were often important sources of specialized information and overall perspectives on history, perceptions of the environment, management, politics and the economic situation. These informants ranged from marine scientists, both foreign and local, to government leaders and resort owners. Information obtained in the course of these informal conversations is summarized in Survey Form III (see appendix), patterned after Hill (1978). Informal interview information was transferred to a standard questionnaire containing a list of the proposed questions. This reminded the interviewer of the data desired and helped standardize the accumulated data for later evaluation.

Observation of management. Reserve management by local communities was observed personally. Discrepancies between local and national approaches were analyzed by comparing local socio-economic data and interview information with national legislation, means of enforcement, management ideals and interviews with responsible national officials. Important sources were published accounts of reserves and their formation and management problems.
3.4 Logistics, changes and problems

Although the original intent of reef monitoring was preserved, several changes in the transect technique were made. Originally, a permanent transect with markers was envisioned. This was not possible because of the difficulty of installing markers on the reef and their subsequent removal by people. Because reef landmarks were substituted for permanent transect ends, those transects surveyed at yearly intervals could not be laid in exactly the same location. The line would inevitably move with currents and could not be laid over the identical substrate. As a result, periodic surveys give varying results because of slightly different (1-5 m) locations on the reef. These were not useful for discerning small changes over time. Changes over the three-year period have been discerned at only one site.

Although no diversity index was specified in the project proposal, field experience indicated that documentation of coral genera diversity was feasible. This became the prime diversity indicator for comparison of coral habitat richness between reefs. It was supplemented with Chaetodontidae (butterfly fish family) species diversity, which also reflects habitat richness.

A factor inhibiting the fishermen interviews was finding an eligible interviewer. The number of interviews suffered because qualified persons were not available for prolonged field trips to small islands. The interviews obtained, however, tend to be complete.

Information gathered on the management of the various research sites is variable. Some sites have many published reports documenting activities over time. Others have had no formal surveys or
implemented management schemes, so that limited data are available. Interviews with government officials were variable and/or not always possible. The best information was often obtained indirectly while working on other projects, in government offices, or by social conversations at unpredictable times.

From an overall project perspective, changes in the proposed design have been small. Practical discrepancies, mentioned above, include the difficulty of being totally consistent at all project sites and with all informants. Also, several inaccessible project sites were changed when others could be readily substituted.

3.5 Site-specific data analysis

Each study site is presented in chapter four as a unit. The data are summarized in four categories: site overview, marine environment, reef use, and a summary/discussion of management and organizational problems and recommendations. Methods of analysis and summary are discussed below.

Environmental data. Observations about the general condition of the marine environment and the immediate shore are summarized for each site. Reef substrate data, coral diversity, and other parameters are presented in tables showing the results of each transect and systematic snorkeling (SS) survey. The mean values of substrate percentages from yearly transects and all transects are included. A profile of each, or the most recent, transect gives a schematic view of the reef, topographic relief, coral diversity per 10 m, and relevant notes. A not-to-scale map of the site and reef shows
transect locations, important environmental features, and summarizes the reef quality as determined by the survey methods. The diversity of Chaetodontids is presented in the marine summary tables.

A discussion of the accumulated data presented in maps, tables and profiles provides a comprehensive synopsis of the area from an environmental perspective. This summarized data then becomes the basis for site comparisons in chapter 5.

Reef use data. The analysis of the reef use data is divided into three parts: 1) an overview of the community, its people, and their occupations, as derived from the interview forms (see appendix); 2) a discussion of the general area use by outsiders, i.e., fishermen, visitors, government, and tour companies, especially insofar as this use affects the environment; 3) relevant historical, socio-economic and political data and interviews with key informants. The emphasis throughout is on how use of the reef by the community and other parties affects the environment. Attitudes and perceptions about the environment and its management are discussed.

Management. Information about reef management is summarized and analyzed in a general discussion which focuses on links between environmental quality and management. At control sites, where management is non-existent or where only negative influences are important, the link between environmental quality and these influences is discussed. Since sources of management data vary, the quantity and quality of the data are also variable.
A brief discussion highlights the most important factors influencing each site from the environmental, socio-economic, and management perspectives. General factors not fully discussed in preceding sections are elaborated in the summary so that linkages are clear. Such a discussion might include political problems of management, cultural differences between the various parties involved at a site, or traditional perceptions of environment and/or management.

3.6 Comparative analysis between sites

Chapter five compares data on all the sites observed in the study. The environmental parameters (e.g., reef substrate cover, coral genera diversity, topographic index, and abundance of indicator species) are correlated with reef use data and with management observations.

The analysis seeks to uncover any trends or generalizations which appear from the holistic analysis of reefs, their use and management. Determination of successful or unsuccessful management is made and the advantages and disadvantages discussed. Major problem areas of management schemes are identified. The separation of successes, failures and problems, points out country-wide trends, if they exist. A country-by-country presentation is then made, noting lessons and distinctive traits of each country which leads to the regional perspectives and implications of chapter six.
CHAPTER FOUR
SITE-SPECIFIC EMPIRICAL FINDINGS AND ANALYSIS

4.1 Introduction-Philippines

The Philippines has many areas where marine reserves have either been proposed or partially implemented, and it thus offers a variety of study sites which meet the criteria of this study. The rationale for choosing Philippine study sites is discussed in detail in chapter three. The main criterion is that a site has been included in some kind of management plan, either proposed or actual. Two sites are used as controls. At one, Bantayan Beach, Dumaguete, heavy exploitation has occurred, and at the other, Tubbataha Reefs, Palawan, there has been relatively little exploitation.

Apo Island, Negros; Sumilon Island, Cebu; and Bantayan Beach, Dumaguete, have been the most intensively observed study sites and provide baseline data with which to compare other sites. Balicasag Island, Bohol, and Moolboal, Cebu, are influenced by Silliman University management, but as peripheral areas they have received less emphasis. Actual management in both cases has been local. Sombrero Island, Batangas; Apo Reef, Mindoro; and Tubbataha Reefs, Palawan, although not geographically close, have been selected because the rational government is proposing management in each place. Calauit Island, a special area protected by the President, was the subject of a Silliman University survey project and is included as a special case.
4.2 Apo Island, Negros

Overview. Apo Island impresses one with the relatively good condition of the fringing coral reef, the self-awareness and autonomy of its residents, and the efforts made by Silliman University and the community to apply a conservation ethic to marine resources.

Located off the southeast coast of Negros Island in Central Philippines (see figure 5), Apo Island is approximately 25 km south of Dumaguete City. The island community of 900 is under the jurisdiction of the Municipality of Dauin on Negros Island. Population growth on Apo during the last twenty-five years has been great due to immigration and high birth rates.

Apo is a small (72 ha) volcanic island about 150m high. It has five white sand beaches, the principal ones located on the southeast and southwest sides of the island (see figure 5). The southeast beach area and fringing reef were proposed as a marine reserve in 1980 by Silliman University.

Except for native growth in steep, rocky areas, little of Apo's original vegetation remains. Leguminous trees (Leucaena) and a screw pine (Pandanus) have been planted. Water is brackish during the dry season and people depend on stored rainwater or water transported from Negros Island. Cultivated plants include coconut trees, corn, sweet potatoes, and cassava. Animals include chickens, hogs, goats, and cattle. The milkfish (Chanos chanos) is raised in two brackish ponds.

Fishing on the reef occurs throughout the year and at different times of the day, depending on currents, winds, and local storms. The
Figure 5. Apo Island, Negros, Fringing Reef, Reserve and Transects
fishermen (80-100 total) use small, locally-built outrigger boats, called bancas. Their fishing methods include baited hand lines, bamboo traps, gill nets, and spearguns.

The island community political hierarchy is dominated by the barrio captain. In addition to marketing fresh and dried fish, people collect shells for sale to tourists and weave mats for Negros markets. Literacy among Apo residents is low and the general attitude is that education is not necessary.

From July 1979 to March 1980 Silliman University extension workers conducted intermittent marine conservation and education programs at Apo Island. Although the impact of the program could not be formally assessed due to lack of formal pre- and post-tests, the people of Apo Island seemed to gain some understanding of the importance of the reef ecosystem (Cabanban and White 1981). During the time of this program the concept of a "marine reserve" on the southeast side of Apo was introduced (see figure 5). Acceptance of this was mixed. The barrio captain supported the idea verbally, but not in practice. In 1982 a new barrio captain formally endorsed an agreement between the town of Dauin and the barrio. Guidelines for management were suggested by Silliman University, marker buoys designating a protected area were placed, and island residents were informed of the location and rationale for the reserve. Visits by the author in June 1982 revealed that the community had some knowledge of the reserve but that there was no actual enforcement. Some fishermen continued to fish inside the marker buoys.
Apo Island marine environment. Apo Island has a steep and rocky coastline surrounded by a fringing reef. The area of this reef to the 60m isobath is about 1.56 km². The east and southeast portions of the reef have the most extensive live coral cover. Volcanic rock boulders provide substrate for much of the fringing coral growth and allow for a topographically diverse reef, atypical of most Philippine, strictly coralline, island reefs.

Northeast and southwest monsoons affect wave action and fishing activity around the island. Currents are consistent throughout the year but vary daily with tidal changes. The strongest current comes from the north and northeast and passes along the east and west sides.

Transects were made at Apo Island in three consecutive years, 1981, 1982, and 1983 (see table 9). Data for transects 3 and 4, systematic snorkeling data, and chaetodontid diversity were collected only in 1983.

Table 9 and figure 6 summarize the results of these observations and show the general condition of the coral reef. Hard coral cover is greater than 30 percent and is in good condition. Coral rubble is not significant and there is little dead standing coral, except in the southeast reserve, where Acanthaster have decimated large colonies of branching coral. Acanthaster are generally not evident in other areas. Because massive coral is the dominant hard coral growth form, there is a high topographic index. Galaxea, the dominant genus, is common.

Soft corals also cover more than 30 percent of the substrate, giving an average total coral cover of 63.1 percent for the four transects. The high percent of soft coral may reflect the rocky
Table 9
Reef Quantitative Data (Percent Substrate Cover, Abundances, Depth Range, Noticeable Damage and Topographic Diversity for each Transect), Apo Island, Negros (1983)

<table>
<thead>
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<th>PARAMETERS</th>
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<th>NON-RESERVE</th>
<th>REEF</th>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Depth Range (m)</td>
<td>1/15</td>
<td>0.3/15</td>
<td>-</td>
</tr>
<tr>
<td>Noticeable Damage (1-10)</td>
<td>-</td>
<td>2.8</td>
<td>-</td>
</tr>
<tr>
<td>Topography (m)</td>
<td>2.3</td>
<td>2.6</td>
<td>2.5</td>
</tr>
</tbody>
</table>

* all corals (Phylum Cnidaria) with calcium carbonate skeletons of orders Scleractinia, Stolonifera, Coenostealia and Hydroidea (Millepora)
** all corals (Phylum Cnidaria) without calcium carbonate skeletons of orders Alcyonacea and Zoanthidea
*** sponges, algae and seagrasses
 t total for reef
Figure 6. Reef Profiles Showing Topographic Diversity, Depth Contour, Percent Substrate Cover and Hard Coral Diversity, Apo Island, Negros
substrate. Another hypothesis is that soft coral may grow over disturbed areas.

Twenty-five species of chaetodontids indicate a reef of good hard coral cover and high topographic relief. Transect measures do not change discernibly between 1981 and 1983, and any variation between years can be attributed to sampling variables. The main conclusion to be drawn from the longitudinal data is that coral cover is stable, with no signs of degradation in the past three years.

The relatively small number of hard coral genera (24.2) contrasts with the relatively large number of soft coral genera (9.4). Data obtained by systematic snorkeling around the island show a coral cover comparable to the transect sites. A higher general hard coral cover in the reserve area, as shown by transects one and three, reflects the bias of choosing that particular area for the reserve rather than any impact by the reserve itself. This is because the reserve is newly formed and not strictly enforced. The systematic snorkeling and T-4 (see figure 6) reveal general degradation on the southwest reef in front of the village. This area is affected by boat anchors, heavy fishing and collecting, and presumably, blast fishing in recent years (pers. comm.). Except for the southwest reef, there is little evidence for serious reef degradation unless the high soft coral cover is considered a sign of degradation. The percent cover of coral rubble, blocks, and dead standing coral are all low.

Alcala and Luchavez (1981) estimated the fish yield of the 1.56 km² fringing reef by interview-questionnaire and direct observation for a period of 11 months (May 1980-March 1981). The estimated annual yield ranged from 8.00 to 14.23 (mean 11.4) mt/km². Although
substantial, this figure is lower than some other small island reef estimates (e.g., Sumilon Island, Cebu; 14–20 mt/km²). A higher fish yield was noted during the southwest monsoon months. This may be due to the more extensive live coral cover on the east and southeast reefs, which are protected from this monsoon.

**Apo Island reef use.** Reef use has been documented through observations and open-ended interviews with eleven island residents in 1983 (see table 10). These respondents comprise about 10 percent of the fishermen on the island and the sample is biased toward older, longer-term residents. Visits by the researcher over a four-year period suggest that these interviews reflect representative views.

Although fishing has traditionally been allowed everywhere around Apo Island and neighboring islands, now a feeling of territoriality prevails. Some feel that fishing by outsiders should not be permitted. Ideas on modern management range from having a protected reserve to making certain fishing methods, such as dynamite fishing, illegal. There is a general bias against muro-ami fishing by outsiders. Several fishermen note that Silliman and local people worked hand in hand on the marine reserve and education conservation projects, and these are considered useful management approaches.

Changes in resource abundance are attributed to population increase, dependence on fish, and lack of alternative means of livelihood, all of which correlate with the author's observations.

Although most informants have knowledge of the marine protected area, reasons for the formation of the reserve aren't clear to some. Two express support of the marine reserve as a means of stabilizing
Table 10

Community Interview Summary (Demographic Information, Local Perceptions of Changes in Marine Resource Abundance, and Fishing Capacity), Apo Island, Negros

<table>
<thead>
<tr>
<th>Number of respondents: 11 (about 10 percent of total fishermen)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fishing ground:</strong> Apo Island reef only</td>
</tr>
<tr>
<td><strong>Home Community:</strong> Apo Island</td>
</tr>
<tr>
<td><strong>Years in vicinity:</strong> Range (7-60), Average 38 years</td>
</tr>
<tr>
<td><strong>Place of birth:</strong> 9-Apo, 1-Basilan, 1-Selinog Island</td>
</tr>
<tr>
<td><strong>Age:</strong> Range 27-65; Average 48 years</td>
</tr>
<tr>
<td><strong>Sex:</strong> 11-male</td>
</tr>
<tr>
<td><strong>Educational level:</strong> Average 4 years</td>
</tr>
<tr>
<td><strong>Occupation:</strong> 11-fishermen; 2-middlemen</td>
</tr>
<tr>
<td><strong>Share of income:</strong> fishing 80-100%; mat-weaving 0-4%; other</td>
</tr>
<tr>
<td><strong>Marketing:</strong> sell fish to local middlemen or market on Negros</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CHANGES</th>
<th>NOW</th>
<th>BEFORE (within memory)</th>
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</thead>
<tbody>
<tr>
<td>Number of fishermen:</td>
<td>more</td>
<td>less</td>
</tr>
<tr>
<td>Time fishing/week:</td>
<td>5-6 days</td>
<td>5 days</td>
</tr>
<tr>
<td>Catch/effort:</td>
<td>7 kg/day</td>
<td>11 kg/day</td>
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<tr>
<td>Meals/day with fish:</td>
<td>2.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Meals/day with other seafood:</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Fish:</td>
<td>10-less; 1-equal</td>
<td>10-more; 1-equal</td>
</tr>
<tr>
<td>Tridacna:</td>
<td>4-none; 6-rare</td>
<td>4-none; 6-rare</td>
</tr>
<tr>
<td>Sea turtles:</td>
<td>2-none; 8-rare</td>
<td>7-rare; 3-some</td>
</tr>
<tr>
<td>Acanthaster:</td>
<td>6-rare; 4-many</td>
<td>same</td>
</tr>
<tr>
<td>Sharks:</td>
<td>9-rare; 1-many</td>
<td>6-rare; 4-many</td>
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<tr>
<td>Groupers:</td>
<td>7-rare; 3-many</td>
<td>7-rare; 3-many</td>
</tr>
<tr>
<td>Tourists:</td>
<td>more (100-200/yr)</td>
<td>few</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FISHING CAPACITY</th>
</tr>
</thead>
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<tr>
<td><strong>Boat size:</strong></td>
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<tr>
<td><strong>Motors:</strong></td>
</tr>
<tr>
<td><strong>Number of people:</strong></td>
</tr>
<tr>
<td><strong>Methods:</strong></td>
</tr>
</tbody>
</table>
resources and attracting tourists. Another says that the Apo community should control the protected area without interference from outside agencies. The coming of tourists is attractive to those who would like to profit by renting resthouses on the beach, selling shells and mats, and catering food.

Several informants indicate that the protected area could serve as a means of legally preventing outside fishermen from using the area. Incidents of dynamite fishing by outsiders occur on Apo Island reefs. Violations are patrolled by the Philippine Constabulary, which could also guard the protected area against local poaching. Those who understand and support the concept of a protected area suggest that more education is needed among island residents to improve the implementation and acceptance of a marine reserve.

**Apo Island management and recommendations.** Several key points emerge from the above data and general observations. The Apo community is composed mostly of long-term residents for whom fishing is the most important economic activity. While population is increasing, resources per capita are decreasing. Fishing effort/unit catch is increasing, and the quantity of fish consumed per capita is decreasing. Nevertheless, the coral reef environment, as measured both by the perceptions of local people and by the environmental survey, has not noticeably deteriorated. Residents recognize the problem of blast fishing and *muro-ami*. Although most residents are aware of the marine reserve, they do not totally understand why it exists. They suggest better education is needed but do not mention the lack of enforcement of reserve rules as a problem.
A mood of territoriality prevails among Apo residents. Frustrated in preventing fishing by outsiders, they may see the protected area as a legitimate excuse to call in law enforcement authorities. In this instance the involvement of Silliman University in setting up the reserve would be considered beneficial, although several persons expressed a need for autonomy of management. However, the very fact that Silliman initiated the conservation program on Apo Island raises questions about local autonomy vs. management expertise from an outside institution. Silliman's goal is to enhance the awareness of Apo residents about sustainable use of their marine resources. Even though the community didn't, and still doesn't, entirely understand Silliman's management concepts, it has offered some support. Motivation among residents ranges from following an authority figure, seeing an opportunity for more control over "their" coral reef, bringing in more tourists, to establishing a fish breeding ground.

Cabanban and White (1981) maintain that non-formal education has played an important role in promoting marine conservation at Apo Island and should be continued. In June 1982 they proposed guidelines for the Apo Island-Silliman University joint management of the protected area. These guidelines suggest that:

1. Apo Island choose an administrator of the marine sanctuary who will be popularly chosen by all people concerned;

2. The chosen administrator shall:
   a. prohibit all exploitative activities, including collection of marine organisms, within the sanctuary boundaries; this applies to local residents or visitors to the island;

   b. encourage boats to anchor outside of the sanctuary and to refrain from dropping anchors on corals to protect coral cover from physical damage; and
c. promote the compliance of all people concerned with these rules and the periodic dissemination of information regarding the marine sanctuary and its purposes;

3. Apo Island shall permit scientific research, snorkeling, scuba diving and general viewing within the sanctuary as long as these are not harmful to the coral reef organisms or environment; and

4. Apo Island shall facilitate, with the help of Silliman University, as mutually agreed:
   
a. the development of the adjacent beach for purposes of tourism by maintaining several rest houses, a clean beach, an outhouse, and other simple facilities which can generate income for the local residents or community through rentals and collection of a small fee for diving and snorkeling in the sanctuary area; and
   
b. the installation and maintenance of boundary marker buoys for the sanctuary and the strategic placement of anchor buoys near shore and on the principal diving areas.

Continuing extension efforts by Silliman University or other outside agencies need to be directed toward the specific goals of marine conservation and reforestation of the island. Projects arising under these goals should be formulated in terms of the felt needs of the resident population. Ultimate control, as much as possible, should rest in local towns or barrios. Legal instruments at the community level, prepared with outside consulting, can then receive enforcement from national agencies if required.

4.3 Sumilon Island, Cebu

Overview. Sumilon Island reef is the first nationally protected marine park in the Philippines. It was formed by Silliman University in conjunction with Oslob, Cebu, in 1974 as a municipal marine reserve and was designated nationally in 1980 by the BFAR. For this reason it is a unique case of marine reserve management in the Philippines.
Sumilon Island is a low island of about 23 ha located near the southeast tip of Cebu Island, central Philippines (see figure 7). It is composed of uplifted volcanic rock with a land surface of coralline limestone rock, a thin layer of topsoil, some small hardwood forests, and beach vegetation. There is currently little agriculture. On the south end stands an abandoned tower built during the 18th century for the Spanish to watch for Muslim invaders. A modern, non-functioning lighthouse stands beside this tower today. The reef which surrounds the island has traditionally served as a fishing ground for Cebu residents from the towns of Oslob and Santander.

Since 1974 Sumilon has been managed by Silliman University in cooperation with the municipality of Oslob, Cebu, as a marine reserve (Council 1974). Fronting the 750m shoreline on the east side is a strictly protected area designated as a marine sanctuary. No fishing or collecting is allowed there (see figure 7). Non-destructive fishing is allowed in the remaining waters surrounding the island. The privately owned terrestrial portion of Sumilon is not included in the agreement, although the University has been gradually leasing parcels of land from the owners. Since 1974 the University has built two beach shelters and one field station. It also maintains a caretaker to monitor fishing activity and enforce regulations pertaining to the reserve area on the west side.

Although the above management scheme is still intact, in December 1980 a "National Fish Sanctuary" was established at Sumilon by the Bureau of Fisheries and Aquatic Resources (BFAR) (Administrative Order 128 within the Ministry of Natural Resources). The declared fish sanctuary was superimposed on the 750m reserved
Figure 7. Sumilon Island, Cebu, Fringing Reef, Reserve and Transects
area on the west shore and the remaining limited fishing area. This national law resulted from management problems between Silliman University and Oslob, Cebu, after a new mayor, Apolonio Abines, was elected in January 1980. The national law has since been used by Silliman University and the national police to enforce rule infractions by fishermen. In two cases these infractions were by the Mayor of Oslob himself. Although the BFAR has not been active in field management, it has legally supported the Administrative Order forming the fish sanctuary.

Silliman also sends faculty members, students, and foreign researchers to conduct marine research projects on the Sumilon reef. Fish populations are monitored to assess the effects of fishing on the east, north, and south sides in contrast to the protected west side. Other projects include monitoring coral reef secondary productivity; coral colony and species growth; the growth and mortality of transplanted stony and horny corals; some fish and invertebrate yields; the biology of several commercial fish; the growth of Tridacna clams; and algae studies.

Scuba diving and reef watching began at Sumilon in the early 1970's, and the formation of the protected reef area has made it an increasingly popular recreational destination. The protected west side now has a national reputation as a dive site for observing plentiful and tame fish.

Traditional, small scale artisanal fishing continues on the north, east and south sides of Sumilon at a level not significantly different from ten years ago. Approximately 100 fishermen frequent the reef in mostly non-motorized bancas. According to fish catch
assessments begun in 1976, they extract an increasing tonnage of reef fish (Alcala 1981).

**Sumilon marine environment.** Sumilon is an uplifted volcanic island capped with limestone and bordered by 3-to 5m cliffs on all sides except the northeast shore. Here there is a narrow carbonate sand beach with a small mangrove lagoon. Behind the lagoon are 20m high limestone cliffs. A shifting sandbar on the northwest corner is exposed at medium and low tides. The 100m wide shallow fringing reef on the west side drops off at about 60 degrees from the 2m deep reef crest. The remaining reef has a more gradual slope beginning closer to shore (see figure 7). The reef zones are classic in type but vary in proportion between the east and west sides. The west reef has a shallow 80m wide reef flat, a shallow reef crest, with a distinct fore reef and slope. On the east side is a very narrow 10-20m wide inner reef flat followed by an indistinct reef crest (20-40m) and a very gradual fore reef and slope (see figure 7). The latter becomes progressively more sandy with scattered large coral heads below the reef crest. The total reef area to 10m depth is approximately 328,000 m² and to 40m it is 491,000 m² (about 50 ha). The practical limit of coral growth is at 50m, which is not farther than 250m from shore. The composition of the reef to the 10m isobar was calculated in 1979 (White) to be: 20.2 percent hard coral; 10 percent soft coral; 28.9 percent sand; 16.3 percent coralline rock; 16.5 percent broken coral (small pieces); and 8.1 percent dead corals (heads and larger pieces).

Sumilon is exposed to both the northeast and southwest monsoons. The northeast monsoon, from October through April, often creates
choppy sea conditions on that side of the island. The west side receives occasional strong waves from the more erratic southwest winds during May through September. The pronounced drop-off on the west side is probably due to currents around the north and south ends and the original topography of uplifted limestone rock. Currents generally flow in a westerly direction around the island, and the west side is normally free of strong currents. Water visibility at Sumilon varies from 15-30m and the water temperature from 27 to 30 degrees C.

Most recent research has been done on the western protected side of Sumilon. For this study three transects were placed on the west reef, two on the east reef, and one on the north reef (see figure 7). These six transects were placed randomly. A systematic snorkeling survey around the island on the reef crest was done in August 1983, and chaetodontid species were checked. The six transects, the snorkeling data and the chaetodontid diversity are divided between the west reserve side and the northeast nonreserved and fished side of Sumilon (see table 11). A representative transect profile for each side of Sumilon is shown in figure 8.

The Sumilon substrates and diversity figures show no trends over the three-year observation period. Rather, the general state of the reef is well defined and a comparison can be made between the reserve and non-reserve sides. Transect substrate figures show that hard coral cover is slightly higher on the east side. This is because the reef crest is very narrow on the west side and wider on the east side (see figure 7). The inner reef flat on the west side has much sand and old rubble giving a high percent of sediment. In contrast to transect data, the snorkeling survey shows a marked difference between
<table>
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<td></td>
<td>T-2.4,6</td>
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<td>T-1.3,5</td>
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<td>24.2</td>
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<td>-</td>
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<td>-</td>
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<td>55t</td>
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<td>Soft Coral Genra/100m²</td>
<td>7.3</td>
<td>-</td>
<td>6.7</td>
<td>-</td>
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<td>Acanthaster/100m²</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
<td>14</td>
<td>-</td>
<td>23t</td>
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<td>-</td>
<td>2/4</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Noticeable Damage (1-10)</td>
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<td>4.7</td>
<td>3.3</td>
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<td>1.6</td>
<td>1.4</td>
<td>1.6</td>
<td>1.8</td>
</tr>
</tbody>
</table>

* t total for reef
Figure 8. Reef Profiles, Sumilon Island, Cebu
the reserve (45.6 percent) and the nonreserve (15.9 percent) in hard coral cover. This method compares the entire nonreserve reef crest (shallow), which includes much sediment, with the narrow but rich reserve reef crest of the west side (see figure 8).

The general condition of the Sumilon reef is only fair in every category except diversities of hard corals and fish, which are high. Thirty-six hard coral genera were noted in T-2 on the west side (1983) while the general surveys give total genera for the area of more than 50. This high diversity of coral reflects the rich reef crest and fore reef on the west side of the island. The east side has noticeably fewer genera (27).

Fish diversity gives a more striking comparison. The reserve area (less than 1/3 of the entire reef) has 22 chaetodontids and at least 142 total reef species (Carpenter and Tarr 1983). The non-reserved or fished area (2/3 of the entire reef) has only 14 chaetodontids and 118 total reef species. These numbers indicate richer coral habitat on the west side for the chaetodontids and probably reflects the lack of fishing on this side. Russ (1984) reports a mean standing crop of serranids in the reserve of 2.52 kg/750m² compared to 0.46 kg/750m² in the non-reserve. Differences in fishing pressure also probably explain the extreme variation of density in these prized food fishes.

The topographic relief is not great anywhere except along the western reef crest and fore reef. This helps to explain higher fish and coral diversity in this area.

Before 1974 the Sumilon reef was badly damaged. Observers during the 1970's report that the reef has been improving in
coral cover and now the west reef shows little obvious recent damage. It also has a low rating for noticeable damage as contrasted with a higher level of damage on the east side. Although little destructive fishing occurs on the east side, many boats anchor there and heavy collecting occurs. Anchoring has been replaced on the west side with mooring buoys. Noticeable damage on both sides is normally in the form of old coral rubble. Some corals broken by scuba diver fins are evident on the west drop-off, and although this damage has not been quantified, it may be significant (pers. obs.).

The high diversity and biomass of fish found in the protected area is the most readily apparent value of the Sumilon reserve. The reserve may be a breeding ground for numerous species, some of which circulate around the island, and it is the source of attraction to visitors to the island.

The Sumilon fishery has been monitored since 1976 in an attempt to document changes in fish catch attributed to the reserve formation (Alcala 1981). The weekly catch retrieved in bamboo fish traps is recorded by the island caretaker, and those fishermen using gill nets and hand lines have been interviewed.

Fish yields in Sumilon during 1977-1980 ranged from 14 to 24 tons/km²/yr for "reef" fish. Between 1976 and 1979, the catch more than doubled (Alcala 1981). Some of this increase may be due to methodological inconsistency, but some may be attributed to the effects of the reserved area. Also, the general yield is high compared to most other places, e.g., 12.1 metric tons/km²/yr for American Samoa (Smith et al 1980; Hill 1978). The high yields may be attributable to the naturally high productivity of a relatively small
coral reef and island which "concentrates" the fish biomass and increases yields over a small area. Other small Philippine islands also show high yields but the exact theoretical explanation is not known.

The most important reef fishes caught in the nonreserve area of Sumilon include caesionids, acanthurids, pomacentrids, labrids, scarids and epinephelids. Caesionids range from 47 to 76 percent of the monthly totals and are usually caught in bamboo traps. These fish school outside of the reef drop-off and seem to move around the island.

**Sumilon reef use.** Most of the 100 fishermen who frequent the Sumilon reef paddle from the Cebu coast in small outrigger bancas. They fish when the water is calm and the wind not too strong. Much fishing takes place at night and in the early morning. Methods used include hook and line, small gill nets, traps, and infrequently, hand spears. Shallow diving is done to collect mollusks, sea urchins, sea cucumbers, crabs and shrimps, and at low tide fishermen may wade onto the reef to collect these animals. Island beaches are used by fishermen to rest, clean fish, cook, store fish traps and nets, and occasionally, to collect wood and edibles from the island. Small amounts of sand are sometimes removed.

The marine reserve formed in 1974 curtailed traditional uses of the island on the west reef. Fishermen were told that this action would improve their fish catches over a three to five-year period.

The Sumilon reserve and nonreserve sides are regularly visited by foreign and national scuba divers and snorkelers. The most
Desirable diving is in the reserve area, which receives between 30 and 100 divers per month. Boats in the reserve anchor on mooring buoys, but they drop anchors on the east side in front of the beach shelters or at diver sites. Reef damage from visitors is limited to scuba coral breakage and anchor damage on the east side because collecting and spearing are strictly prohibited.

Several research projects mentioned above are ongoing on the Sumilon reef. Collecting is allowed only in the nonreserve area for limited purposes, and student groups, for example, do not generally collect specimens.

**Sumilon management and recommendations.** Sumilon Marine Park is the first protected area of its kind in the Philippines. Its protected status is 10 years old under municipal law and four years old under national law. It has attracted attention from government policy makers, local politicians, local artisanal fishermen, marine scientists, students, tourists, and others who have a stake in the issue of marine conservation. Sumilon is an intensely used area and its unique status sheds light on the complexity of marine management problems on a small island coral reef fishery. The problems of multi-use management of a rich fringing coral reef have surfaced in recent years in an arena of verbal and non-verbal battles.

The following account of the reserve formation and the reaction of various people is drawn from Dy-Liacco (1983) and the author's own observations.

In 1974 Silliman University proposed to the Municipal Council of Oslob, Cebu that the Sumilon Marine Park be established. The Council
rejected the proposal, believing that "the University wanted the park for selfish motives," and "if approved, would restrict the traditional rights of the townspeople to fish in the waters of Sumilon" (Gonzales 1977).

This was a misunderstanding of Silliman's goal of ultimately increasing the fishery production of Sumilon island. After discussing the benefits of a marine park and the University's objectives in fuller detail, the Oslob Council approved a second proposal. It passed Resolution No. 30 a.74 (1974) authorizing "Silliman University to establish a marine park around Sumilon Island for marine biological studies and research," and it unanimously approved Ordinance No. 6, authorizing Silliman "to regulate fishing and gathering of any marine products within Sumilon Island" (April 1974). With Mayor Jose Tumulak's cooperation, Silliman encountered few management problems until 1980.

From the outset of the park formation the University conducted an educational campaign and sponsored a study of fishermen's attitudes towards marine conservation (Cadeliña and Cadeliña 1976). Not surprisingly, fishermen resented the seemingly sudden restriction of their long-standing rights to fish the entire Sumilon reef. They perceived the seas as open to all without restriction (Cadeliña and Cadeliña 1976), and it was not clear to them how they would benefit from the marine park. The educational campaigns addressed this problem, but patience over time was being asked of the fishermen.

By 1983, ten years' management of the marine reserve according to the original plan had convinced some fishermen of the benefits of increased fish catches. Others continued "illegal" fishing in the
reserved area. The Sumilon caretaker reports that fishermen sneak inside the reserve borders and use hook and line methods when no one is watching.

These problems arise because local fishermen do not perceive large personal gains from an increased fish catch outside the reserve while the sizeable standing stock of fish in the reserve area is tempting. These problems may be alleviated with time and education. Another order of problem is that of politicians with interests contrary to marine conservation.

Local elections in 1980 brought a new mayor, Apolonio Abines, to Oslob, Cebu, and Abines's brother, Sol, to Santander, Cebu, a small town nearby. On February 11, 1980, Apolonio Abines personally led a fishing expedition into the reserved area of Sumilon using the muro-ami fishing technique (see chapter two). Again on February 14, 21, and 22, 1980 the expedition fished in the sanctuary.

These expeditions clearly violated the Oslob Municipal Resolution. According to Abines, he was trying to fulfill his campaign promise to take back Sumilon Island from Silliman and to open the restricted area to fishermen. He pointed out that Silliman acted as if it "owned" Sumilon, whereas Oslob actually owns the island and Silliman manages the marine park. Silliman filed a complaint with the head of the national police in Manila, bringing reprimands to the Mayor of Oslob. Illegal activities temporarily ceased.

Silliman's position was that Mayor Abines was motivated by personal interest since the Abines family owns the largest muro-ami fishing operation in the area. Furthermore, Abines was believed to be using his political power to influence his fishermen to fish illegally.
Silliman responded to the February fishing incidents with efforts to make Sumilon a national fish sanctuary, thus circumventing self-interested local control. In December 1980 Silliman's proposal was approved by BFAR and the national government took on a role in the management of Sumilon Marine Park. In 1981, problems of management and control persisted in a non-vocal manner.

In April 1982 Eduardo Gullas, the governor of Cebu province, gave a series of radio speeches in Cebu City claiming that the Sumilon Marine Park was dislocating marginal fishermen. Gullas asked that the BFAR Administrative Order 128 be repealed and that Sumilon Island revert to an open fishing ground. The publicity created doubts and negative attitudes towards the conservation efforts among local fishermen.

Silliman accused Gullas of trying to use his political influence to repeal the law and gain favor among local fishermen in upcoming elections. Interested government and park conservation parties in Manila supported the conservation efforts of Silliman. These exchanges mostly occurred in Cebu and in national newspapers.

Although these verbal battles abated in late 1982, several more infractions occurred in February 1983. A Philippine Constabulary patrol arrested three fishermen using nets in the reserved area, held them overnight, gave them a lecture, and released them after they signed promises not to commit the same violation again. On the following day about 30 persons, including Mayor Sol Abines of Santander, were caught fishing in the reserved area and given the same warning. This was repeated in September 1983.
Although the law is understood by local fishermen and the Mayors, the challenge of improving overall understanding and cooperation among these people remains. Interviews with Sumilon fishermen in June 1983 show that misunderstanding about the marine reserve persists.

This misunderstanding and lack of cooperation can be attributed to several factors. First, the motivation of Silliman University has been misinterpreted as antagonistic to the needs of the local residents of Cebu. The benefits of the marine reserve are not clear and research activities are often misunderstood. For example, until 1977 Silliman researchers used scuba to occasionally spearfish for food and specimens, an activity believed to be exploitative by the local fishermen. Even now (1983), residents of Cebu mistakenly believe that Silliman researchers spearfish on the Sumilon reef. These misperceptions have hindered rapport between Silliman and the southern Cebu people.

Traditional rivalry or territoriality may also be a source of conflict. It is uncommon in the Philippines for organizations to have jurisdiction over land in a neighboring province, particularly in marine areas, which are traditionally open access areas. This political problem was overlooked by the Mayor of Oslob and Silliman at the creation of the reserve in 1974. However, since 1980 Mayor Abines has tried to exercise his power over "Cebu's" territory, using irrational arguments and possibly selfish motives.

Finally, the subtleties of such arguments as improved fish catches over time are difficult to appreciate when the benefits are long-term and not easily seen. In this case, an influential community
leader, using a strong, untruthful argument, may influence attitudes more easily than subtle arguments or long-term promises.

Conservation and management of a small island fishery for the benefit of local fishermen, scientists, students and tourists may seem to be commendable from the perspective of the implementors. However, each one of these interest groups may have a different idea about what constitutes a "benefit." These different perspectives can lead to conflict. Ideally, each party should expand its perspective and interest to include those of the others; otherwise, disputes will negate the ability of anyone to implement useful measures. The presence of a selfish political leader may be more common than not, and it must be handled so as not to arouse excess bad feelings. A simple show of force, such as a reprimand from the national police, may be an effective solution in this case. On the other hand, it may arouse more local resentment. Also, the fear of losing face publicly may serve to change a politician's attitude.

Despite these problems, which serve as examples of the concrete problems encountered in marine reserve formation, the Sumilon Marine Park continues intact as the most actively managed Philippine marine reserve. Recommendations for the future management of Sumilon Marine Park rest on past lessons. They include:

1. Better communications should be initiated between the Oslob Municipality and Silliman University;
2. More complete information should be given to local fishermen concerning the purpose and benefits of the marine reserve;
3. A management board composed of representatives from local fishermen, the Oslob government, Silliman University, and Marine Laboratory, the BFAR, and an objective observer should be formed;
4. The policy of "core and buffer" areas on the west and east sides of Sunilon respectively, with the "core" being a strict reserve and the "buffer" being limited to ecologically sound fishing and collecting, should be continued;

5. Boat anchoring should be discouraged on all sides of the island and mooring buoys provided;

6. Fish catches should be monitored closely and other research activities continued; and

7. All visitors to the park, except Oslob residents, should pay a small fee to the caretaker for entrance to Sunilon and use of resthouses maintained by Silliman University. In this way field maintenance could be self-supporting.

4.4 Balicasag Island, Bohol

Overview. The vertical reef drops, clear water, and schooling fish of Balicasag Island have attracted scuba divers since the early 1970's. The island also supports a community of traditional fishermen who have recently turned to precious shell collection for cash income. Outside fishermen have exploited the reef and now scuba spearfishers frequent the area. These various interest groups make the issue of management a timely one in view of the deteriorating marine environment of Balicasag Island.

Balicasag is a low coralline island located 8 km southwest of Panglao Island, Bohol (see figure 9). Flat and oval-shaped with an area of 30 ha, Balicasag is surrounded by white sand beaches and beach rock. A fringing coral reef protrudes into the sea on all sides, varying in width from 50m to about 200m at the 10m isobath. Steep slopes descend from the reef on all sides except the southeast, where a more gradual sand slope borders the reef.

Balicasag supports a community of 600 people, or 70 households. It has a school, lighthouse, several small stores, and a basketball court. Much of the thin, rocky soil is used for simple agriculture
Figure 9. Balicasag Island, Bohol. Fringing Reef and Transects
and decorative plants. People grow corn, cassava, vegetables, and coconuts and raise a normal assortment of animals. Native beach vegetation dominates the shore and coconut palms are scattered throughout.

Most Balicasag fishing families migrated from Bohol Island during the last 50 years. People first lived permanently on the island in 1875, when a Spanish watchtower was constructed to guard against Moro invaders. In 1905 this tower was converted into a lighthouse by the Americans. It is operated today by the Philippine coast guard and a caretaker who came to Balicasag in 1936. By 1936 about 50 people, or 14 families, lived on the island (pers. comm.). The island is owned by the Philippine coast guard and all families living there are officially considered squatters.

Fishing was the chief means of livelihood on Balicasag until 1976, when people began to collect precious shells for sale to traders and tourists. Today shelling is more important economically than ordinary fishing.

In 1976 the BFAR Coral Reef Research Team (CRRT) surveyed the marine environment of Panglao and Balicasag. They suggested that the area be protected because large parts of the reef slopes were in good condition. Also, shallow reef flats bordering Panglao Island had been virtually destroyed by destructive fishing and coral extraction, making it critical to protect the remaining areas.

In 1978 Balicasag was briefly surveyed again by the Marine Parks Task Force (MPTF) of the National Environment Protection Council (NEPC) as a potential marine park site. Based on the high quality of the fringing reef at Balicasag and the immediate potential for
extensive and destructive exploitation, the area was recommended as one of three national marine park priority sites. The outer southwest fringing reef of Panglao Island was included in this recommendation. Since 1978 no management has been implemented at Balicasag and the area continues to be only recommended for protection. BFAR-CRRT has conducted several marine conservation seminars on nearby Panglao Island and has visited Balicasag only informally.

Since 1980 Balicasag has been frequented by an increasing number of scuba divers on dive tour boats from Cebu city and Manila, and in small boats locally. These visitors are attracted to the topographic relief of the reef and the very clear water. No regulations govern these visitors and spearfishing and shell collecting have become popular activities.

Balicasag was chosen as a study area because of its critical management position. Destructive fishing, spearing, and excess shelling may be inconsistent with long-term survival and sustainable use. Although the area has been recommended as a protected area, lack of implementation means that all parties — local residents (fishermen and shellers), tourists, and scientists — stand to lose.

Balicasag marine environment. Low-lying Balicasag Island is made of limestone, with coral-shell sand beaches and some beach rock bordering the shoreline (see Figure 9). Part of the classic fringing reef is distinctively narrow, with pronounced vertical drop-offs. From the northeast corner counter-clockwise around to the southern tip of the island the reef varies from 50 to 150 m wide and has steep (80-90 degree) slopes below the reef crest. The inner reef flat is
shallot on this portion and has much coralline rock and rubble and little hard coral in good condition. The reef crest forms a distinct shallow band with generally good coral cover below the shallowest parts. The fore-reef and reef slope zones are steep with a variety of encrusting and foliose corals interspersed with gorgonians and other wall-adapted invertebrates.

The reef from the southern tip back to the northeast corner is wider, more gradually sloping, and sandy. The reef crest here occurs closer to shore (50 to 100 m) and is composed of large massive, foliose, and branching coral outcrops with sand in between. The fore-reef is less diverse and more sandy. Some seagrasses occur on the eastern exposure in sandy substrate (see figure 9).

Monsoon variations do not affect Balicasag as drastically as more exposed islands. There are no spur and groove formations on the southwest side, and the sandy, wide east reef is probably associated with current flows around the island. The shallow northwest and west inner reef flats have calm waters where coralline rock has built up and branching corals live near the water surface. The northeast reef, protected by Panglao Island and Bohol, rarely has large waves except during major storms. The lighthouse caretaker reports that a typhoon in 1958 destroyed much of the shallow coral on the northeast reef. Water visibility at Balicasag approaches 50 m vertically when calm, and the temperature in September 1983 was 32 degrees C.

The four transects were placed in the southeast (1), southwest (2-3), and due south (4) sides of the island (see figure 9).

Prevailing northeast winds prevented placement of transects on the north side in September or December 1983. Table 12 shows the results
of these transects and of the systematic snorkeling surveys around the island perimeter. Figure 10 shows two transect profiles and gives a schematic picture of the reef variations. Transects 2, 3, and 4 are similar, showing a flat, shallow, low-coral-cover reef flat, as contrasted to the diverse and topographically rich reef crests and fore slopes. The generally poor coral cover throughout (21.2 percent) indicates barren or destroyed reef flats. The snorkeling surveys show a slightly higher coral cover (25 percent) because they were conducted near or on the shallow reef crests.

The high diversity of hard coral genera (44 on T-1) is due to protected reef exposures and large, steep slopes which provide habitat for genera. High chaetodontid diversity (25) is also linked to the coral diversity and to the topography of the steep slopes, both of which provide a range of habitats. The rich hard coral habitat is limited to the vertical walls and deeper reef crest zones, however.

Generally, the transect data show a shallow reef in poor condition. There is much rubble, dead standing coral, and blocks on all sides of the island except the southeast. The reef crest and fore-reef are almost always in better condition than the shallow reef (except on those fore-reef shelves where large amounts of coral rubble occur, probably from dynamite fishing). Acanthaster counts on the transects are low, but snorkeling reveals large aggregations of 20/100m² near the reef crest on the northeast corner. Much dead branching coral was also found there. Noticeable damage on the transects is also high, reflecting disturbed reef flats.

Damage at Balicasag is caused by dynamite fishing, reef walking, and boat anchors. In many areas the damage is new and appears worse
Table 12

Reef Quantitative Data,
Balicasag Island, Bohol (1983)

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* sponges and seagrasses

** Total for reef
Figure 10. Reef Profiles, Balicasag Island, Bohol
than that observed in 1978 in snorkeling surveys. Although fore-reef walls are naturally protected from these destructive forces, those shelves which protrude have also been adversely affected. In contrast, the hard coral reef base and fish diversity in deeper waters is still good, indicating a potentially healthy reef.

General fish diversity of 47 species/750m² (Russ 1984) in both the shallow and deeper reef is high, but density and biomass are low. Few large individuals are observed. Notable schooling fish, in order of frequency, are caesionids, carangids, some kyphosids, and acanthurids. Acanthurids are diverse (11 or more species) but not present in large numbers. The noticeable timidity of reef fish is probably due to heavy fishing, particularly spearfishing.

The fishery of Balicasag has not been formally assessed, although general observation of reef topography indicates a potential higher than nearby Sumilon Island. This conclusion is based on the high vertical surface area of the steep reef drop which could support a large biomass of schooling species, e.g., caesionids, carangids, and lutjanids. The shell fishery of Balicasag appears good but has not been quantified. In any case, the quantity of shells is probably not as important as the particular rare species which occur there. These are collected from the sand bottoms at 70 to 200m depth off the southeast and south sides of the island. The shallow reef in sandy areas also produces less valuable collector shells which are heavily exploited by local residents.
Balicasag reef use. The Balicasag community has grown from 14 households in 1936 to 70 today. Most of these families fish and collect shells for a living; aside from small stores and vegetable plots, no other means of livelihood are found. Food, except for fish, is scarce, and water is a problem during the months of November through May. The rich reef fishery which originally drew people to Balicasag has been replaced by the newly-discovered rare shells fishery.

Interviews were conducted with six fishermen 18-50 years old, all born on Balicasag and with an average of 5 years of education. All of these men fish and collect shells. Fish are caught primarily for consumption, constituting only 20-30 percent of their income. The respondents report that daily catches have declined since their early memories, when fish were "abundant." Today a catch of 8 kg. is described as only "sufficient" for self-consumption. Sea turtles have always been rare in the area, while sharks were once abundant but are now rare. Acanthaster have always been common, while serranids have become more scarce.

Shell collecting accounts for 70-80 percent of the fishermen's incomes. Shell nets are set at depths of 70 to 200m on sand bottoms every day about 8:00 A.M. and are retrieved and reset the following morning. One man sets and retrieves the net in a paddle bangka, using a large spindle with nylon line which is left attached to a plastic float overnight. The net is long (50-100m) and narrow (1m) and weighted on both sides so that it lies flat on the bottom. The fine mesh entangles the mollusks as they crawl along the bottom.

Valuable shells are not caught every day, but incomes average
anywhere from 500 to 3000 pesos per month (20 pesos = $1 U.S. in 1984). Two commonly known shells are Conus gloriamaris, which brings in 200 to 1000 pesos, and Cypraea gutatta, which commands more than 1000 pesos. The shells are either sold directly to buyers in Cebu City or to dealers from Cebu or Balicasag. Several island residents are middlemen and some sales are made directly to tourists.

Most local fishing using hook and line and nets is done in paddle bancas, while motorized boats are used primarily for travel to Panglao and tourist charters. According to Balicasag residents, tourists have increased significantly in the last 5 years.

The respondents characterize their own fishing methods as simple, non-destructive types, but complain that dynamite fishing is practiced by fishermen from Panglao. They believe that the only way to prevent this is through the presence of the Philippine Constabulary. Testimony as to the actual extent of dynamite fishing is contradictory.

Respondents expressed no knowledge of either modern or traditional management of marine resources on Balicasag. Several felt that destructive fishing was damaging to fish habitat. Others cited educational visits by BFAR to teach improved netting methods. The concept of a marine reserve is still foreign to local residents.

Local residents also appear to take little notice of the potential impact of tourism on the island economy. During a four-day visit in September 1983 the author observed one large scuba diving boat with 20 photographers, one banca expedition with 10 spearfishing divers, and his own group with seven marine scientists.
Balicasag management and recommendations. During the past 5 years Balicasag Island's popularity as a scuba diving destination has alerted the Marine Parks Task Force under NRMC and the BFAR-CRRT to the island's need for protection. During the same period destructive fishing has damaged the shallow reef and lowered the fish biomass. A profitable shell fishery has also evolved.

The possibility of formal management of Balicasag is not imminent nationally because the island is third on a list of other non-implemented marine parks. Nevertheless, several options exist. The BFAR and the Environmental Center of the Philippines have been conducting some conservation seminars on Panglao Island. Balicasag could be included. Also, Silliman University is interested in facilitating management at Balicasag with logistical support from the outside. Since Balicasag is not part of a local municipality and is technically controlled by the national government (specifically, the coast guard), the logical link for marine extension work is between Silliman and the Ministry of Natural Resources (MNR).

As with management on Apo Island, Negros, any solution to improved management must include the community on Balicasag. This community must be asked about its own priorities for maintenance of the reef and improvement of fish catches, and about what it is willing to forego to accomplish these goals.

The community may want to regulate or prohibit fishing on that part of the narrow north reef which is attractive to scuba divers. If it is maintained and the fish populations increase, this area could serve as a fish breeding ground and continue to attract visitors. Tourists may be the necessary incentive for local support of reef
management, for visitors could be charged a small fee to dive at Balicasag. Beach shelters could be constructed and rented to visitors. Shells contribute to this scenario also, for Balicasag residents naturally want to attract visitors who may want to buy shells. This desire to attract tourists by means of a protected area is reinforced if it brings an improved standing stock of fish for local fishermen.

As in other areas, it is important to form strong links between local residents and outside implementation of a management scheme. Although facilitation can come from outside, self-interest on the part of a community is an important motivating factor. Balicasag is a good example of how marine management may work with essentially no permanent contributions from outside agencies other than a police force to prevent illegal fishing and intrusion.

4.5 Bantayan Beach, Davao del Norte

Overview. Bantayan Beach is a control site representing a very heavily-used environment with no effective management. Because it is close to a large, densely populated town, the marine habitat is disturbed by fishing and collecting, boat anchorage, and reef walking. The beach itself is eroding.

Bantayan Beach is a barrio on the north side of Dumaguete, Negros Oriental, about one km from the city center (see figure 11). The 2 km beach front is lined from south to north with large residential dwellings, squatter houses, two beach resorts, a dense settlement of fishermen's families, the Silliman University recreation beach (800m) and the airport runway extension. Although population density along the beach has remained relatively stable over the past
20 years, the level of beach-related activities has increased significantly (pers. comm.).

The narrow beach running the length of the Bantayan barrio is sandy and fine-grained, partially of terrigenous origin. Its width depends on the distance between structures and the water at high tide. At mean tide the width of sand averages 30m. Some shoreline erosion, reported by local residents in recent years, has made the entire beach narrower, at some points eroding the foundations of bamboo structures. It is not known if this is a natural progression or if it is related to human beach-reef uses.

Nearshore marine habitat is dominated by seagrasses and some hard and soft coral communities of low density. Terrestrial beach vegetation is totally controlled by local residents and consists of a few coconut palms, decorative plants, and talisay (Terminalia sp.) trees planted to prevent further beach erosion.

The beach at Bantayan is used by fishermen to store their outrigger canoes and motorized boats. There is daily sea traffic as these small boats come and go, in addition to beach traffic of cars, motorcycles and bicycles at low tide. Inshore waters are intensively used for boating, fishing, reef gleaning, boat anchoring, swimming, and snorkeling, and occasionally for scuba diving, wind-surfing and water skiing. The beach serves as a dumping ground for garbage and other local wastes and is generally washed clean by the high tides.

At its recreation beach (Silliman Beach) Silliman University attempts to preserve a portion of Bantayan Beach for swimming, picnicking and other water-related activities. Silliman Beach is popular with local residents and outside visitors and is used as a
Figure 11. Bantayan Beach, Dauaguet, Fringing and Patch Reefs, and Transects
boat landing area by Silliman and other boat owners. General maintenance of the beach and rest houses is provided by the Silliman University Marine Laboratory (SUML). This portion of Bantayan Beach has become narrower due to erosion.

Since Bantayan Beach encompasses Silliman Beach, the entire area has been affected by the conservation ethic emanating from the SUML during the last five years. SUML has put up signs informing people not to break corals and to discourage littering. Also, illegal fishing activities are discouraged in the area and recreation is encouraged. Despite these influences, the intensity of use overrides attempts to conserve the beach and marine habitat. The heavily exploited area shows many signs of destruction.

**Bantayan marine environment.** Bantayan Beach is a gradually sloping, narrow, sandy beach descending to approximately low tide level where a seagrass community begins. Parts of the marine environment are totally dominated by seagrasses and sand. This gradually slopes to only sand at about 20m depth and 300m from shore (see figure 11). Other portions have a narrow band of seagrasses followed by a shallow, gradually sloping reef crest formation about 50-70m wide (see figure 11). Beyond the reef crest the fore reef returns to seagrass, sand, coral rubble and a few scattered coral heads and descends to sand at 20m.

Bantayan Beach faces northeast and is thus exposed to monsoon winds from November through April. It is protected from the southwest monsoon and is generally calm during the rest of the year. Currents move both north and south, parallel to shore, depending upon tidal
changes. Currents from the north often carry plankton and suspended particles from fresh water runoff. On a high or decreasing tide the water may be covered with floating seagrasses, mangrove, or other debris washed from the shore. A current from the south often brings floating plastics and other garbage from the city. Visibility is rarely more than 18m and normally somewhat less.

Three transects were placed perpendicular to the beach at places where some coral cover occurs. Areas where only seagrass grows were avoided. The three transects have been monitored for three consecutive years, 1981, 1982, and 1983. Because of the relative consistency of the transect placement and the gross changes on the reef over that time, all three transects show changes from year to year. The mean increase in sediment per year is 7.7 percent while the mean decrease in hard coral cover is 6.7 percent per year.

Table 13 shows a mean low hard coral cover of 17.6 percent. The mean rubble cover is 36.7 percent, about 20 percent higher than most other reefs in this study. Most of this rubble is recently created. The mean noticeable damage index of 5.6 indicates that more than 50 percent of the reef shows obvious signs of disturbance. The topographic index is low, reflecting a naturally flat reef with few large coral heads or outcrops (see figure 12).

Hard coral genera have probably remained more or less stable over the three-year period, but improved identification by the author shows an increase in genera. This increase could also be explained by the destruction of dominant coral species by reef disturbances which allow less competitive species to colonize the reef. However, this succession would probably show an increase of only
### Table 13
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Bantayan Beach, Dumaguete, Negros (1981-1983)

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#### ABUNDANCES

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<td>-</td>
<td>-</td>
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| Depth Range (m)            | 2/4.5 | 2/4.5 | 2/4.5 | 2/4.5 | 2/4.5 | 2/4.5 | 2/4.5 |
| Noticeable Damage (1-10)   | 6.0   | 5.0   | 7.0   | 8.0   | 5.0   | 4.0   | 4.0   |
| Topography (m)             | 0.6   | 1.1   | 1.2   | 0.4   | 0.4   | 0.8   | 0.8   |

* mostly seagrasses
Total for reef
Figure 12. Reef Profiles, Bantayan Beach, Dumaguete
several genera over the three-year period. Thus, most, if not all, of the increase can be attributed to observer changes.

**Acanthaster** density has fluctuated over the study period. Although only small numbers appear on the transects, general reef surveys show moderate numbers at certain times of the year. This phenomenon is not very important when compared to man-induced changes.

Chaetodontid species diversity is very low (10). This number includes all species seen for the entire 2 km length of beach. The limited coral habitat apparently cannot support the large diversity found on most other study sites.

The overall condition of the Bantayan reef community is poor. Large areas of the reef which had live coral cover (mostly staghorn and foliose *Montipora*) about ten years ago are now broken, crumbled, covered with encrusting algae and filled with the echinoderms *Echinoeometra* sp. (pers. comm.). The extent of coral rubble and sediment shows damage due to human causes. Aesthetically, the reef is unattractive because of the poor condition of the coral, the relative lack of fish, poor water visibility, and uncleanliness.

No assessment of the fishery of Bantayan has been made. Fishermen in the local community fish it heavily, using a variety of methods. Most report meager catches and they travel to nearby reefs to avoid the fishing pressure. Casual observation by snorkel surveys shows a lower standing stock of fish than on any other reef in this study.
Bantayan reef use. Bantayan shoreline residents range from wealthy homeowners to illegally squatting fishing families. Two hotels regularly bring in tourists who support local people in shell trading, small boat hire, and related hotel jobs. Silliman Beach attracts local visitors for swimming and picnicking. But most of the beach users are fishing families who depend on the sea for subsistence.

Since the author has lived in the community at various times since 1978, he has relied upon participant observation and informal conversations with local people to obtain an understanding of the relationship between these people and their marine environment.

Fishermen tend to be older because few young people now fish full-time. All Bantayan fishermen report a drastic reduction in fish abundance over the past twenty years, a perception which inhibits the entry of new or young fishermen into the field. Full-time fishermen fish 4-6 times a week during the southwest monsoon months when the sea is calm and less often during the northeast monsoon. The most common fishing methods are hook and line, small gill nets, bottom traps, reef gleaning and spearing. Kayaks, or drive-in, methods and beach seines are occasionally used.

A few fishermen attribute declining fish catches to the general reef degradation, but most see the decline as the result of more fishermen. Fishermen report a scarcity of sea turtles, Tridacna clams, and sharks in recent years and some say that Acanthaster was more abundant ten years ago than today. Serranids are said to be non-existent in the Bantayan reef.
Bantayan management and recommendations. This site provides a direct comparison to reef areas which are in better condition and where some management protection exists.

Interviews with resident fishermen indicate that the concept of reef management is unknown to them despite signs put up by resorts and Silliman University prohibiting coral extraction. Although fishermen do not normally use highly destructive, illegal methods, large numbers of reef gleaners systematically trample the coral at low tides and fish traps are often camouflaged with small pieces of living coral. Also, boat owners regularly drop anchors wherever it is convenient, thereby destroying coral at the heavy anchor sites. No ideas for better local management were offered by fishermen.

Despite use levels higher than any other site in this study, Bantayan Beach has received no effective management and has no prospects of being protected in the future. Its reef shows a significant decline in live coral cover from 1981-1983, at a rate which would indicate almost total disappearance of the live coral within ten years. Coral rubble, sediment, and noticeable damage (5.6) are very high while the chaetodontid diversity is low (10). All point to a coral reef with serious problems.

The potential for effective management is small because of population pressure and general lack of interest. Nevertheless, the SUMMARY continues to try to educate the local populace about reef destruction. Some success is indicated by the fact that most people will not remove corals from the reef and in conversation they speak of "the importance of corals to fish." Some people respond to garbage pollution by burning their trash, although they do not feel at ease
telling their neighbors to do the same. Some recognize the
destructive effects of dynamite fishing in the past.

Practically, Bantayan Beach is too heavily used to be managed
for reef survival. Even the simple act of dropping anchors is
difficult to alter. What needs to be considered is water quality, a
manageable problem which will have longterm effects on use patterns if
not addressed. Both fishing and recreational activities are affected
by water pollution.

The dumping of refuse and discharge of city sewage into the
ocean will increase as the population grows. Unless alternatives are
found for these disposal measures, the sea fronting Bantayan and most
of Dumaguete will be too polluted for safe bathing and swimming.

A plan for garbage pick-up points along the beach front and on
the south side of Dumaguete City could remedy much of the garbage
problem. Some provision for local sewage disposal should also be
considered.

Maintenance of a limited reef habitat would also enhance the
general appeal of the reef to tourists and fishermen alike. This
could be accomplished by selecting two relatively good reef areas,
perhaps 200-300m long, marking them well, and preventing any
destructive uses or boat anchoring within the preserves. Areas near
the resorts are most feasible, for resort owners have a vested
interest in maintaining some reef for their visitors to see.
4.6 Moalboal, Cebu

Overview. Paragsama Beach, the study site, is a barrio of Moalboal on the west central coast of Cebu. Paragsama Beach lies on a peninsula four km northeast of Moalboal town and has a population of less than 1000. Some are fishermen, but most are supported by beach resort tourism (see figure 13).

The beach front is a flat limestone formation with small rocky outcrops behind the beach and a narrow strip of white sand running its length. The narrow fringing coral reef is distinguished by an abrupt drop-off less than 100m from shore.

Small nipa houses and beach resorts line the beach front. Native beach vegetation grows north and south of the central area and there is agricultural land behind it. Cassava and corn are grown on the poor soil.

Until 1975 Paragsama Beach had few people. About that time several small resorts were built and now there are eight resorts with a combined capacity of 300-400 guests. The beach and accessible coral reef are the prime tourist attraction, and three resorts have facilities for scuba diving. The accommodations are also inexpensive, drawing low budget travelers to Paragsama. Philippine divers coming for photography and spearfishing from Cebu City are the most common diving visitors.

Traditional fishing is also done along this coast because the fishery resources are rich. This is due to the fringing reefs and the estuarine nutrient sources both south and north of Paragsama. Most fishermen use hook and line, although gill nets and fish traps are also found. Fish traps have been recently discouraged by resort
Figure 13. Moalboal (Panagsama Beach and Pescador Island), Cebu and Fringing Reefs
owners because they damage the corals. Shells are collected for sale to tourists, and fishermen often charter their boats for day trips.

The beach community, under the jurisdiction of Moalboal, has a barangay captain chosen by local residents. Local affairs seem to be dominated by the resort owners, however, who say that the barangay captain doesn't represent their needs. The mayor of Moalboal takes interest in Paragsama because of the tourist benefits accruing to the area.

Concern for management of the beach and reef area began in 1978 when the national Marine Parks Task Force visited Paragsama to survey it as a potential marine park. In response to complaints from several resort owners in 1980, the Mayor of Moalboal called a meeting to draft an ordinance banning destructive fishing methods from the beach front and from the nearby Pescador Island reef. The main targets of this document are dynamite fishing (already illegal) and fish traps lowered over the reef drop-off. This ordinance has been sporadically enforced by local resort owners. As no national plans have been carried out, all implementation thus far depends on the beach front property owners.

Although Paragsama Beach is neither a managed nor a highly exploited area, it receives much attention from tourists. It is vulnerable to the threats of careless tourism, i.e. collecting, spearfishing, boat anchors, etc., and to poor fishing practices. It has been chosen as a study site because of the motivation of local residents, in this case property owners, to effectively manage the area for their own long-term benefits.
Moalboal marine environment. The fringing reef extending north and south along Paragsama Beach has a high diversity of hard coral on the shallow, inner reef flat, fore reef, and reef crest. There is a steep 70-90° drop at the reef crest on the reef's outer edge. The highest coral cover generally occurs on the reef crest and fore reef while the inner flat is partially sand. Sand dominates nearshore. The reef slope shows a decreasing coral cover and diversity, with gorgonians predominating at lower depths. Reef width increases up to 150m south of the village (see figure 13). Paragsama's western exposure is sheltered from the southwest monsoon by Negros Island, and northeast winds and eastern storms do not normally affect the Moalboal coast. Waves are generally small. The channel is known for strong currents which flow both north and south, depending on the tidal changes. Visibility is good since no streams enter near Paragsama Beach and the peninsular location protects the local reef from siltation from Cebu rivers. Dense plankton concentrations sometimes reduce visibility.

The other site surveyed in this area was Pescador Island reef, about 4 km southeast of Paragsama Beach (see figure 13). Pescador has essentially the same exposure as Paragsama Beach with somewhat stronger currents. The small limestone island has rock and cliff beaches and is surrounded by a fringing reef with a shallow, narrow reef flat, a rich reef crest, and a fore reef drop-off. Schooling fish are found on the fore reef drops in high diversity. Encrusting corals, foliose corals, and gorgonians are common on the slopes.

Both Paragsama Beach and Pescador Island were surveyed by general snorkeling observations and systematic snorkeling (SS) to
determine bottom substrate composition, chaetodontid diversity, and the topographic index (see table 14). Although line transects were not completed at these study sites, they are included because the SS technique is sufficiently refined and consistent to give an accurate representation of the reef within confidence limits of 5 percent of transect data. At Panagsama, SS was conducted along a 1600m stretch of reef and at Pescador it was done completely around the island on the shallow reef.

The Panagsama reef survey (see table 14) shows a reef with good hard coral cover (32.5 percent) and high soft coral cover (23.4 percent). Protected from wind and waves, the reef crest grows near the water surface and the shallow reef has a flat topography. Branching and foliose corals dominate and the hard coral diversity (50 genera) is high. Chaetodontid diversity (21 species) also indicates a healthy and diverse hard coral habitat. While natural damage from storms or Acanthaster predation is low, human related damage is evident (2.1). The abrupt drop-off on the fore reef and reef slope below the shallow reef crest distinguishes the entire reef.

Overall reef condition is good. Human damage is concentrated in shallow nearshore areas where boats drop anchor and people walk on corals at low tide and on the reef drop where large fish traps have broken off branching and foliose corals. Other destructive fishing practices apparently do not occur in the immediate vicinity of Panagsama Beach. Water quality varies with the tidal currents and tide level; high tide brings in beach debris and detracts from clarity and cleanliness.

While the fishery of the total coast reef is good, there is
Table 14

Reef Quantitative Data,
Moalboal (Panagsama Beach
and Pescador Island) Cebu (1983)

<table>
<thead>
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<th>PARAMETERS</th>
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little fishing near Paragsama because of the tourism. There appears to be a sufficient density and diversity of reef-associated schooling fish to support a sizeable fishery. In contrast, the local reef is subjected to collection for minor food products and shells for sale to tourists. Carried to the extreme, both activities may detract from the aesthetic appeal of the reef.

The survey of Pescador Island reef (see table 14) shows a reef with good hard coral cover (39.3 percent) dominated by branching forms. Rubble cover (25 percent) is higher than that of Paragsama reef and probably reflects some dynamite or other destructive fishing. Chaetodontid diversity is low (11 species) and possibly reflects the small size of the reef and its greater exposure. The flat topography (1.2 m/sq/10m) also may explain the low species count, and the lack of a scuba survey here lowers the number of species seen.

Viewed overall, Pescador's reef is impressive because of the steep fore reef drop-off below the reef crest. Many schooling fish are seen over the deeper reef flat (6m) and off the reef edges. Water visibility is high and the contrast of reef to the nearby drop is aesthetically appealing. Yet the shallow reef has a noticeable damage index of 3.5 reflecting rubble from dynamite fishing and anchor damage from tourist and fishing boats.

The fishery potential in relation to the small size of the island and reef appears high. Located in deep water, the island is known by local fishermen for its schools of pelagic fish. Scuba spearfishermen are also attracted by these schooling fish. Neither the fishery of Paragsama nor Pescador Island has been quantified to date.
Moalboal reef use. Paragsama Beach and Pescador Island are affected by the growth in tourism, with its negative environmental impacts and its positive protective measures. Interviews were conducted with several resort owners. One in particular, Oscar Regner, is outspoken about the need to coordinate management for the area.

Resort owners perceive the needs of Paragsama Beach to be: (1) preventing destructive fishing, including large fish traps, dynamiting and heavy collecting; (2) controlling tourist collecting and spearfishing; (3) coordinating management and regulation with the town of Moalboal; and (4) coordinating local management among themselves.

As some owners are more concerned than others with conservation, differences of opinion exist about priorities. Most do not allow spearfishing except in designated areas away from Paragsama Beach and Pescador Island. Several think the town of Moalboal should take the initiative in management, while others believe the resorts are more effective in managing their own reef areas. Interviews indicate some awareness of deteriorating environmental quality, although fish abundance may be increasing. Lack of motivation or knowledge about how to begin discussing the above problems prevailed in all but one respondent.

Oscar Regner, a resort owner of six years, believes that progress is being made in local conservation due to persistent monitoring of the area and informing fishermen of what is damaging to the reef. He allows only hook and line fishing in front of his resort and personally prohibits all spearfishing by apprehending illegal offenders and threatening to report them to the PC or to make personal retribution. He believes that national enforcement agencies (except
the PC) are useless for surveillance and that local people must participate. Even though he takes a hard-line attitude about illegal fishing, he is on friendly terms with most fishermen in his attempts to promote a conservation ethic. Regner, considered independent by other resort owners, does not promote his ideas among the resort community.

Moalboal management and recommendations. Five hundred or more tourists per month currently visit Paragama Beach Pescador Island (pers. comm.). This heavy use affects the beach and reef, as does traditional fishing in the area. Although these problems have come to the notice of residents, local government, national government and concerned visitors, few actions have been initiated to prevent environmental degradation. Individuals can articulate the problem, but collective measures are lacking.

The rich marine environment warrants management. The coral reefs at Paragama and Pescador Island are accessible and spectacular compared to many Philippine reef areas. While degradation is not yet severe, signs of deterioration since 1978 are evident (pers. obs.). Dynamite fishing may still occur at Pescador Island and small tourist boat anchors crush coral daily. Paragama Beach debris is heavy and pollutes the calm, nearshore water. If these impacts change the attractiveness of the local environment during the next five years, tourism could decline.

The example of Moalboal illustrates the need for local coordination backed by some financial and legal assistance from national agencies. The concept of "municipal marine park" fits well.
The town of Moalboal can give legal support for local regulation, as it has done to regulate fish traps at Panagsama or Pescador Island. It could also zone the area for different tourist and fishing uses so that some areas remain pristine. Pescador Island and the immediate beach front at Panagsama are logical choices for reserves from fishing and collecting. Other zones could include ecologically sound fishing and some spearfishing. Active participation of all resort owners in a beach front association could effectively protect the immediate reef. Also, since access to Pescador is via the resorts, effective surveillance of the island would be a simple extension for the beach front association.

An association could assist in educating local fishermen in conservation ideals and use of non-destructive methods. Difficult enforcement problems could be referred to the local PC detachment. Financial assistance might come from a small tourist tax collected and administered locally and/or from yearly grants by the national marine parks task force.

One key to progress in management is coordination between local parties. Resort owners need to decide how they can mutually benefit and then make concerted demands on local and national governments.

4.7 Sombrero Island, Batangas

Overview. Sombrero Island lies south of Manila in the center of a popular scuba diving and recreation area which has attracted tourists since the mid-seventies. The area is also heavily fished by local fishermen using handlines, gill nets, and some small-scale
Most fishermen come from villages on Maricaban Island and the nearby coast of Batangas.

Sombrero is a small, hat-shaped, high island of 1.3 ha at the northwest tip of Maricaban Island, southwest of Calumpan Peninsula, Batangas (see figure 14). The island is composed of sedimentary layers of Pleistocene reef and is of terrigenous origins (McManus et al. 1981). It is sparsely covered with grasses and clumps of stunted beach trees, shrubs and herbs. The only sand beach, about 100m long, lies on the east side. The island is surrounded by a shallow-water platform, as distinguished from the fringing reefs of other study sites (McManus et al. 1981).¹

Sombrero Island and its environs was the first site in the Philippines to receive management attention by the Marine Parks/Reserve Development Inter-Agency Task Force, created by the Ministry of Natural Resources Special Order No. 61, 1977 (NRMC 1982).² The Task Force produced in-depth studies of the Sombrero area and completed management plans. Despite this interest, no legislation has converted Sombrero Island and the surrounding sites into a marine park/reserve. In 1978 Proclamation No. 1801 included Sombrero Island within its designation of "tourist zones" under PTA control, but this law could not be used to legally implement the management plans proposed by the Task Force. Thus, the area is currently in limbo with respect to government agency jurisdiction. This is a problem inasmuch as Sombrero Island's accessibility has exposed the area to more Philippine residents and foreign tourists in the past decade than any other marine site in the country.
Figure 14. Sombrero Island, Batangas, Fringing Reef and Transects
Sombrero Island marine environment. The shallow-water platform surrounding Sombrero Island supports a variety of coral habitats for an abundant fish fauna (168 species) (McManus et al. 1981) (see figure 14). On the north and south portions, the platform rounds downward into a gradual slope. On the west side, a platform approximately 200m wide drops off sharply into a steep wall from approximately 12m to 30m. Much of the east side consists of a steep sand slope reaching from the shore to over 30m depth. The southwestern portion, however, supports a coral-covered platform 100-200m wide before dropping off steeply. Here a diminishing coral cover extends to over 30m depth (McManus et al. 1981).

Winds come mainly from the southeast or southwest, but occasionally from the north or northeast. The south slope is protected from direct southerly winds by Mariaban Island, less than 1 km south. Nevertheless, wave action is most intense at this south end due to winds from the southeast or southwest. Tidal currents are strongest on the north and south sides. Although visibility has been reported at 50m, it is normally less due to zooplankton and occasional sedimentary materials (McManus et al. 1981).

Two transects were placed on the southwest corner of the reef. The wide area appeared representative of the overall reef and was chosen because environmental conditions were favorable during visits in January 1983. Table 15 summarizes the results of these two transects and the four transects conducted by McManus et al. (1981).

McManus et al. put down four directional lines radiating from the island center (see figure 14). These consisted of parallel lines 2m apart and extending from 1m to 30m depth at low tide. Two-by-two
Table 15
Reef Quantitative Data, Sombrero Island, Batangas (1983)

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* McManus et al. 1981. Four transects laid in 1980 from 1m to 30m depth show hard coral cover and diversity. Transect information is given for both the 1m to 30m range (D) and for the 1m to 5m range (S) so that comparison can be made with Transects 1 and 2 (1983).
meter quadrats divided into 400 squares were laid along the transects at approximately 2m depth intervals. Coral genera were recorded and percent coral cover was recorded as the percent of squares with coral present. The coral cover is given both for the entire transect and only the shallow (1-5m) portion so as to be comparable with the two shallower transects of this study.

The results of the two studies are quite similar, with shallow averages being 45.9 for this study and 40.7 for that of McManus et al. (1981). Total coral genera are 31 and 45, respectively; the difference is reasonable given the much deeper sampling of the 1981 study. Genera noted by McManus et al. (see table 15) in shallow water are fewer than in this study because of their few shallow stations. The relatively large marine platform of Sombrero Island is dominated by hard coral of good percent cover (see table 15). The shallow reef has a high percent cover of 45.9, as compared to 24.4 for the 1-30m deep average of the transects done by McManus et al. Relatively little soft coral is found.

One finding is of particular significance in the transect data. The high percent (21.9) of coral rubble and dead standing coral on a reef of low wave energy indicates human-caused disturbances. The low topographic index (0.9) may also reflect disturbances in the shallow areas as well as a naturally flat underlying substrate. The moderate coral genera diversity (31) on the shallow reef is normal, and the overall genera diversity (45) shows a hard coral dominant reef. The noticeable damage ranking of 4 shows a reef of moderate to heavy disturbances caused by small events. There are no signs of serious natural disturbances since no major storms have affected the reef in
recent years and few *Acanthaster* are seen.

Coral rubble seems to be unevenly distributed, primarily occurring in a band on the west side between 3 and 10m deep. The transects (figure 15) and general survey show anchor damage, as seen by broken corals, present on up to 30 percent of the reef. Transects 1 and 2 show high coral cover and low rubble cover in very shallow areas with rubble increasing at the deeper end. This is contrary to natural expectations.

On a visit to the island on a Sunday in January 1983, the author witnessed 5 anchors dropped on corals on the west side, several on *Acropora* in perfect condition. In areas less than 3m deep, where boats normally don't anchor, this type of damage is not noticeable.

In addition to boat anchors, large numbers of divers may break coral by finning and grabbing it. This has been observed on the deeper reef (5-20m) at Sombrero by Virgilio Palagañas (pers. comm.). Artisanal fishermen damage coral with anchors, by grabbing corals when diving, or by spearfishing (pers. obs.). *Muro-ami* is occasionally done on the Sombrero reef and blasting was reported by one resort owner in early 1983 (pers. comm.).

Qualitative impressions based on several visits between April 1979 and January 1983 are that more people are coming to Sombrero Island; there is more sport spearfishing using scuba; there is more garbage (cans, tinfoil, plastics, paper) on the reef and beach; and the aesthetic appearance is declining. The fish fauna also seemed more timid in January 1983 than four years before.

Sombrero Island's fishery has not been formally assessed. The relatively high diversity of fish and their visible abundance indicate
Figure 15. Reef Profiles, Sombrero Island, Batangas
an above average potential for the area. Sombrero Island is ranked number one among 21 fishing grounds by Tingloy fishermen (Maricaban Island) and third among 13 fishing grounds by Mabini (Batangas) fishermen (NRMC 1982a).

Historically, the Sombrero reef appears to have been a diverse, rich, hard coral habitat with numerous fish and invertebrates. Indications are that many small disturbances are damaging the coral habitat and beginning to affect the density and diversity of some fish.

Sombrero Island reef use. The "Sombrero Island Marine Park Complex," compiled by the Marine Parks/Reserve technical staff of NRMC in 1982, gives complete socio-economic information for the area. Some of this is presented below. In addition, interviews were conducted with staff members of NRMC and resort owners near Sombrero Island, and the author made observations during several trips to the site.

The small size of Sombrero Island and reef has not discouraged its use by fishermen from Mabini (Batangas) and Tingloy (Maricaban Island). The buffer zone of the proposed marine park, including Caban Cove, Devil's Point, Layag-layag shoal, Layag-layag Point, Sepoc Point, Shark's Reef, and Batalan Rock, (see figure 14) contains the ten priority fishing grounds of both Tingloy and Mabini. These same sites are prime recreation destinations for scuba diving, snorkeling, underwater photography, etc. Research and educational activities are also common at Sombrero Island.

If Sombrero Island and its buffer zones become a marine park, there will be an impact on nearby fishermen. Some areas will be
closed to fishing and all areas will be regulated, both with regard to fishing and recreation activities. Socio-economic surveys have shown that Tingloy and Mabini, among others, are dependent on the area for fish (NRMC 1982).

Subsistence fishermen perceive their two major problems to be dynamite fishing and commercial fishing by outsiders. The small fishermen complain of declining catches and suggest that setting up fishing boundaries would help control outside commercial exploitation. They suggest drawing a line to delineate their fishing areas and to control dynamite fishing by force.3

Some fishermen in both communities are catering to tourists by renting boats and services. For those who work full-time, "tourist" income is comparable to or better than "fishing" income. The growth in tourism at several resorts (up 50 percent/year since 1976) has brought employment to local boatmen and created general employment in the area. The number of boatmen partially supported by scuba-diving tourists in 1982 was equal to or greater than the number of fishermen dependent on Sombrero Island for its fishery (NRMC 1982).

Local fishermen use hook and line, impounding and entangling nets (including seine nets and muro-ami type fishing), and free diving with spearguns. The only frequently used destructive methods are muro-ami and kayaks, which drive fish into nets by pounding with sticks or weighted chains on the corals. Few fishermen realize the damage done to the corals by these methods.

Aquarium fish collecting is done in the area, although few respondents admit to it. Techniques include the use of cyanide and sodium. Some respondents free dive or use scuba with nets to collect aquarium fish.
Dr. Tim Sevilla of the Dive 7000 resort believes that the essential management problems of Sombrero Island are the prevention of destructive fishing (e.g., dynamite, muro-ami, and spearfishing with scuba), the regulation of the quantity of fish caught, and the frequency of tourist visits to the island. He emphasizes the toll taken by tourists in the past three years in the form of collecting, spearing, anchoring, littering, and breaking corals unconsciously with fins.

**Sombrero Island management and recommendations.** While Sombrero Island has traditionally been an important fishing ground for nearby communities, tourism and commercial fishing have increased in recent years. The management problem of the area is one of balance: how can use of the marine environment by tourists and fishermen be balanced in an equitable manner? How can the numerous destructive activities caused by these groups be regulated?

Subsistence fishermen are currently benefiting from the influx of tourists and have little to lose from better management. Short-term commercial fishing interests are more at odds with a long-term plan for maintaining a sustainable resource in the area. They may potentially cause more damage than either the local subsistence fishermen or the tourists.

The management objectives outlined by the Marine Parks Task Force of NRMC in 1982 include the following:

1. develop policy legislation for the establishment and conservation of the marine park/reserve;

2. work out a memorandum of agreement between the MP/RTF and the Municipalities of Mabini and Tingloy for the management of
Sombrero Island Complex. The agreement will focus on the role of the MP/RTF as technical advisor in the management of the area and the role of the Municipalities of the area in the direct administration and supervision of the area;

3. develop guidelines for the sustainable use of the marine resources of the Sombrero Island Complex;

4. develop survey and research methods useful for management purposes;

5. develop a feasible zoning plan for Sombrero Island Complex to control specific activities at each site;

6. develop an environmental education program to increase public awareness of the importance of conservation; and

7. develop an effective community-based organization for the management of Sombrero Island Complex.

These seven points express what is needed for an effective management program. An additional point is the active involvement of resort owners in the management scheme. Dr. Tim Sevilla suggests delegating authority to resort owners and employees to enforce the rules governing the marine reserve. He says that if destructive fishing is not discontinued soon, the immediate reef areas will be obliterated. Current scientific information is adequate and there is an immediate need for actual management at the appropriate levels. Because the strongest interest in protecting the marine environment lies with the resort owners and tourists in this heavily used area, it may be most practical to vest management authority in them.

The NRMC management plan provides for legislation, agreements, sustainable resource use, survey and research methods, zoning, public education, and community participation in great detail. Yet a field trip to the sites will show that these plans are only words. They have received no actual support from the Ministry of Natural Resources and are probably too expensive to implement even if the legal sanction existed.
Although a law is the necessary first step, in its absence certain concerned people could be employed to encourage better management of the Sombrero Island area. Resort owners could be enlisted to help NRMC staff with their field surveillance and public awareness campaigns. The mayors of Tingloy, Mabini, and other communities could be enlisted to further the marine park scheme among their communities. Cooperation among interested parties is needed to create the support base necessary for proper management. The incentive for management comes from returns to these interested parties, and these returns are ultimately dependent on a healthy marine environment. If the potential returns decline, so will the incentive for good management.

Sombrero Island is the best Philippine example of the need for timely management. It is also a very difficult case because of the many different parties involved. Methods of problem-solving in this case can provide a useful model for other similar areas in the Philippines.

4.8 Apo Reef Island, Mindoro

Overview. The extensive and mostly submerged Apo Reef has traditionally attracted fishermen from afar to its abundant marine life. Since 1975 it has become equally well known among underwater enthusiasts as a desirable diving destination. The Apo Reef complex, the largest atoll-formed reef in the Philippines, covers about 35 km². It is located 32 km west of Mindoro Island, along the central west coast of the Philippine Archipelago. Apo Reef Island, the site for the surveys of this study, is separated from the much larger atoll
reef by a 600m deep channel.

Apo Reef Island is a small, flat, coralline island about 800m long from its north to south ends. A 10 ha mangrove lagoon at the center extends out to the west side. The remainder of the island is covered with mangrove, dry scrub beach vegetation, and a few non-native species. A long white sand beach borders the southeast side and south tip, and a small beach lines the north end (see figure 16). The terrestrial habitat of Apo Reef Island is legally protected for several bird species. There are no permanent residents on the island, although the Philippine Constabulary and Coastguard are sometimes present to man the lighthouse and maintain surveillance over use of the fringing reef.

The Apo Reef Marine Park, designed in 1980 by the BFAR Coral Reef Research Project, includes the bird-populated islands of Cayos del Bajo and Apo Reef Island. Although no national legislation specifically designates these marine areas as protected, they were chosen as management sites under the above project and its leader, Porfirio Castañeda, as a result of increased tourism.

In mid-1977 the Philippine Tourism Authority (PTA) obtained jurisdiction over Apo Reef as a tourist zone (PD 1801). In late 1979 a memorandum of agreement between the PTA-Philippine Commission on Sports Scuba Diving (PCSSD), the PN, the PC-INP and BFAR gave the Coral Reef Research Project of BFAR power to implement management schemes. In 1980 the Project conducted a synoptic biological survey of Apo Reef to gather baseline data on which management guidelines could be based (BFAR 1981).
Figure 16. Apo Reef Island, Mindoro, Fringing Reef, Core and Transects
Scuba diving tourism began in the early seventies in the Philippines and in 1975 at Apo Reef. Despite the remote location, there are regular tours to Apo Reef during the calm season from December to May. The reef has an international reputation as one of the better coral reef diving areas in the world (pers. comm.).

Historically, Apo Reef had been visited by Chinese traders in the 14th century, the Spanish navy from 1600-1800, and Americans who constructed a lighthouse in 1911 (BFAR 1981). But it has been too remote for most fishermen before the era of motorized boats, and only in this century has the area come to be known as a rich fishing ground. Small-scale fishermen from west Mindoro, north Palawan, and islands as far away as Bohol in the Visayas fish on the reef. Since 1960 commercial fishing operations including muro-ami, purse seiners, trawlers and others have come to the Apo Reef area (BFAR 1981).

Apo Reef Island marine environment. Apo Reef Island is a limestone island with coral-shell beaches and jagged cliffs, 1-5m high. Surrounding the island is a 100-300m wide fringing reef of classic morphology. It consists of an inner reef flat extending from the beach, an outer reef flat, reef crest, fore reef and reef slope zones (see figure 16). The steeply sloping fore reef and reef slope zones form almost 90 degree drop-offs on the north, northeast and east sides. Slopes on the south and west side range from 45 degrees to approximately 75 degrees. The best coral cover occurs in the reef crest and fore reef zones, typical of most Philippine fringing reefs.

The southwest side of Apo Reef Island is exposed to rough conditions generated by the southwest monsoon between May and October.
The northeast side of the island is protected by a 12 km long atoll reef from rough conditions created by the northeast monsoon (November to April). Thus the northeast side is the leeward side of the island, with a diverse shallow reef flat and reef crest and a pronounced drop-off. The southwest, or windward, side has a deeper reef flat with large wave cut channels. The reef crest is deeper and less diverse on this side. Most studies have been conducted on the northeast and east sides of the island, the area most protected from exploitation since 1978 (referred to as the core area). Ross and Hodgson (1981) report water visibility of 25-30m and water temperature of 28-32 degrees C in this area.

Five study transects were placed at Apo Reef Island on the north, northeast, south and southeast sides of the reef (see figure 16). Systematic snorkeling surveys around the island offer a comparison to the transected areas (see table 16). As expected, the percent hard coral cover shown in table 16 varies between transects because of the variations in reef zones. The mean hard coral cover, 33.4 percent, is consistent with the snorkeling survey of 28.5 percent for the whole reef at a depth range of 1-4m. Since the transects descend 4-10m, the coral cover is somewhat higher.

A summary of data collected for the reef is given in table 16. Both qualitative observation and quantitative data indicate a reef of high hard coral cover and high diversity. The reef is in good physical condition. Physical disturbances are evident only on the north and south ends, where visiting dive tour boats anchor. For example, on transect 3 the percent of coral rubble is high and the noticeable damage is rated 4 (see figure 17). This transect crossed a
Reef Quantitative Data,
Apo Reef Island, Mindoro (1983)

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* mostly sponges and algae
** Ross and Hodgson (1981) report genera for this area in a detailed sampling, 1-30m deep.
Figure 17. Reef Profiles, Apo Reef Island, Mindoro
common anchorage site on the southern end. High percentages of sediment on transects 1, 3, 4 and 5 are due to the large number of blocks, or coralline rock, found on the wide shallow reef flat on both the north and south ends. This shows the bias of placing the transects in shallow areas. A low topographic index on transects 1 and 4 shows the relative flatness of the shallow reef (see figure 17).

The reef appears to have been spared both human and natural degradation, for noticeable damage is localized and rated low. No Acanthaster were seen on any transect and the author saw only a few while snorkeling. No other natural forces seem to be affecting the reef other than the dead standing coral on the shallow southern inner reef flat which is exposed at extreme low tides.

Diversity of coral genera noted in snorkeling surveys is high (43) given the relatively small reef. The general appearance of corals is healthy, and near the reef crest the coral cover approaches 50 percent or more on the entire reef.

SS for 10 stations on the east side represents the core area facing the lighthouse (see table 16). This area has been protected since 1978 from fishing and destructive activities and it shows a high hard and soft coral cover, high topographic relief, and a low percent sediment cover on the reef flat. The reef drop-off extending north attracts large schools of caesionids, acanthurids, carangids and some scarids, chaenids, lutjanids, scombrids and sphyraenids. White and Black-tipped sharks, Hammerhead sharks, manta and eagle rays, and occasionally Green sea turtles are also seen.

The fishery of Apo Reef Island has not been assessed. Casual observations comparing it to known reef standing stock and
productivity figures would place it higher than those of Sumilon Island, Cebu, or Apo Island, Negros, by a range of 10 to 30 percent.

**Apo Reef Island reef use.** The size and remoteness of Apo Reef makes it impossible to interview local fishermen in the area. Instead, an indepth interview with Porfirio Castañeda, the head of the BFAR Coral Reef Research Project and a 25-year observer of the Apo Reef area, is the source of data on reef use. Mr. Castañeda was dive master on the boat *Lady of the Sea* during the time the author conducted research off the boat at Apo Reef.

Castañeda indicates that before 1960 fishing at Apo Reef was artisanal (subsistence fishing boats of less than 3 tons) only. Although the present (1983) number of artisanal fishermen hasn't changed, commercial fishing (boats of more than 3 tons) has increased significantly. Most artisanal fishermen come in 10m boats from west Mindoro and north Palawan. Commercial fishing includes *muro-ami* boats with more than 200 fishermen on board, trawling, tuna long line, aquarium fish collectors, and some blast fishing. Commercial fishing on the large reef or in deeper water surrounding the reef damages the larger reef complex. Apo Reef Island is mostly exempt from commercial fishing although artisanal reef cleaners and spearfishers sometimes visit the island when it is not guarded.

Castañeda reports a noticeable decline in schooling fish at Apo Reef Island between 1957, his first visit, and the present. He says that sea turtles have almost disappeared, but that reef fish (i.e. serranids) and invertebrate abundance has remained largely unchanged. An important change since 1975 has been the influx of diving tourists
who cause anchor damage, deposit litter near anchor sites, break some coral, and collect shells. Except for anchor damage, these impacts are relatively minor.

Casteñada notes that the most important environmental factors affecting management and use of the area are monsoon winds, as described above, and the relative remoteness of the area. Until the advent of larger commercial vessels these factors effectively controlled exploitation in the area.

Recent management efforts have included placing PC guards on Apo Reef Island to prevent illegal fishing in the immediate area. The larger reef has not been protected in this way. Coastguard patrol has also been used sporadically, although it is too expensive to maintain permanently. The Coral Reef Research Project is currently conducting a community education campaign among the artisanal fishermen in west Mindoro to increase their awareness of reef management. In addition, informal contacts are made with the larger commercial fishing companies to dissuade them from destructive fishing practices. The effect of these activities has not yet been evaluated.

Apo Reef Island management and recommendations. The remoteness and logistical difficulty of managing Apo Reef, the largest single reef complex in the Philippines, is compounded by a lack of traditional use and concern. No local governments or communities take responsibility for the area. As a result, the BFAR Coral Reef Research Project has taken on Apo Reef as a special project and has recommended it as a marine park. Even though no legislation designates the area as a park, BFAR management schemes and influence
have been able to discourage destructive activities around Apo Reef Island since 1978.

The entire Apo Reef complex offers a variety of coral reef morphology, habitats, and diversity of species, but Apo Reef Island itself has the richest concentration of marine organisms and is in the best physical condition. Thus, because of biological criteria, practicality, and accessibility, the island was chosen as a management area and has been the site most frequented by visitors.

National management plans, as formulated by BPAR appear adequate and logical. They include the following:

1. designating Apo Reef Island as a core zone where fishing, collecting, and other exploitative activities are prohibited;

2. providing mooring buoys at appropriate locations for boats visiting Apo Reef Island;

3. prohibiting human landings in bird sanctuary areas during the nesting season of June to August;

4. prohibiting human movement on sand beaches during the sea turtle breeding season of October to January;

5. enforcing all Philippine laws protecting marine life and habitats and preventing destructive fishing in the Apo Reef complex;

6. designating several protected zones on the greater reef where unusual habitats or marine species occur;

7. prohibiting dumping of garbage on any island or shallow reef area;

8. designating shipping lanes adjacent to Apo Reef which will ensure adequate protection from oil spills or other dumping;

9. communicating with commercial fishing companies, tour companies, and visitor groups to ensure compliance with rules and conservation support;

10. communicating with all artisanal fishermen who frequent the area; and
11. Communicating with supporting government agencies to ensure that mutual goals are coordinated.

Implementation and enforcement of the above guidelines are difficult at best. Coordination with the national ministries of Tourism and Natural Resources and the Philippine Navy and Coastguard will be essential. Financial support for the coordinating agency or agencies will be needed, as well as leaders who are dedicated to conservation.

Apo Reef could potentially meet the criteria for an International or Southeast Asian Marine Heritage site. If selected, the area could be managed, with financial support and expertise from the UN or ASEAN agency responsible. In such a case, however, some control should remain with the agency which knows the area best, the Coral Reef Research Project of BFAR. These management ties could be said to be "traditional" in a modern sense and should not be severed lightly.

4.9 Tubbataha Reefs, Sulu Sea

Overview. Since 1980 Tubbataha Reefs has been the most desirable scuba diving destination in the Philippines. Despite its reputation as a pristine area, limited transportation to its remote location makes it accessible to only a few. Some fishermen have traditionally exploited the reef, but monsoon winds inhibit fishing nine months of the year. Tubbataha was chosen as a comparative control for this study because of its unspoiled condition and its potential as a large Philippine marine park and scientific reserve.

The Tubbataha Reef complex consists of two atolls located in the middle of the Sulu Sea, approximately 150 kms southeast of Puerto
Princesa, Palawan. The atolls, separated by a channel eight km wide, are oriented southwest to northeast (see figure 18). The larger north reef is approximately 16 kms long and 4.5 kms wide. The reef systems of both atolls are composed of continuous reef platforms 200-500m wide completely enclosing sandy substrate lagoons, 1-24 m deep (NRMC 1982c). A coral islet (Bird Islet) of about 3 hectares is located in the northeast end of the north reef. A smaller coral islet located on the southeast end of the south reef supports a lighthouse constructed in 1980. Jessie Beazley Reef on the northwest side of the two atolls has a small 100m wide sand cay and a 1 km diameter shallow reef flat and fringing reef.

Tubbataha is fully exposed to both monsoons. The unpredictable southwest monsoon creates rough seas from July through October. The more regular northeast winds from November through March also create moderate waves. Thus, most tourist and fishing vessels visit Tubbataha only from March or April through June.

The Tubbataha Reef complex was surveyed in April and May 1982 by the Marine Parks/Reserve Development Program of NRMC and the Coral Reef Research Team of BFAR. That survey led to a proposal to make Tubbataha Reefs a protected area for tourism and scientific research. Although interest in this proposal still exists in the above agencies, no action has been taken because of other management priorities and the remoteness of the site.

Scuba diving tours to Tubbataha from Puerto Princesa began in 1980. The short calm season from April through June limits the number of tours per year, and the distance makes the trip expensive. In 1984 only two boats, carrying up to 25 divers each, served the area.
Figure 18. Tubbataha Reefs, Sulu Sea, Fringing and Atoll Reefs, Sites and Transects
Traditional fishing in small boats is limited because of the distance and rough seas. Commercial-sized vessels frequent the area during calm weather and exploit the reef's fish. *Tridacna*, lobster, and precious and edible shells. They also harvest sea turtle eggs, sea turtles and some seabirds nesting on the coral islets. Pelagic fishing also occurs in the vicinity but is poorly documented.

**Tubbataha marine environment** The two coral atolls comprising the Tubbataha complex are of classic morphology. The reef platform, of coralline origin, is shallow and at some points exposed at extreme low water. The shallow platform becomes deeper at the outer reef flat (100-300m wide) and crest, and it terminates in steep, often perpendicular walls on the seaward side. The inner sides are composed of shallow reef flats, seagrass beds and a deeper sandy lagoon in the center.

The northeast islet (Bird Islet) rises 2 meters at mean low water. Except for a matting of grasses, it has no vegetation. It is a rookery for the Brown booby (*Sula leucogaster*) and a few Red-footed boobies (*Sula sula*). Dead sea turtle shells are scattered about and presumably nesting occurs on the sandy southern end. The whole islet is surrounded by a seagrass bed 300-500m wide.

The southeast sand cay on the north atoll (see figure 18) is a resting ground for the Green sea turtle, *Chelonia mydas* (NRMC 1982c). South Rock (see figure 18) is used by terns (*Sterna* spp.) as a rookery (NRMC 1982c).

The lighthouse islet on the south atoll has several *Euphorbia* spp. trees and is covered with grass and nesting seabirds. These include
the Red-footed booby, the Brown booby, the Common noddy (*Anous stolidus*), the Sooty tern (*Sterna fuscata*) and the Crested tern (*Sterna bergii*). Sea turtles also nest on the islet (NRMC 1982c).

The remoteness of Tubbataha Reefs protects them from pollution and unnatural water turbidity. In April 1984 the general water visibility at all sites on the outer reefs was greater than 30 m, and water temperature was approximately 30–32 degrees C. Currents around the reef are strong and unpredictable in direction. Currents have not been well documented and thus hydrographic charts do not include this information. Because of the Sulu Sea exposure, the reef shape, and the current regimes, many areas are unsafe for anchoring. During rough seas even fewer sites are safe.

Five sites on the outer fringing reef of the north and south atoll and Jessie Beazley Reef (see figure 18) have been observed for this study. Data were collected on a nine day trip in April 1984 aboard the *Lady of the Sea*, a Philippine scuba dive vessel. These data are summarized in table 17 and figure 19.

At site one large surge channels are present on the southwest side and stands of *Acropora* cover more than 75 percent of the 6m deep reef crest. T-1 records 53.8 percent hard coral cover and SS 46.3 percent, contrasted to a low percentage of rubble. T-1 shows a high density of *Tridacna* (27/100m2) and 27 chaetodontids, higher than any other site in the study. Conspicuous fauna include manta rays, White-tip sharks, schools of barracuda, tuna and carangids and diverse acanthurid and balistid families. Topography measures 2.1 maa/10m, high by study standards. Some substrate damage from boat anchors and blasting was noted near the reef crest.
### Table 17

Reef Quantitative Data,
Tubbataha Reefs, Sulu Sea (1984)

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* t total for all sites
Figure 19. Reef Profiles, Tubbataha Reefs, Sulu Sea
Site two on the northeast corner of the south atoll has no surge channels and a more diverse coral community on the reef crest than site one. SS records 49 percent hard coral and 16 percent soft coral, with Acropora tables dominant. Several large areas located between healthy coral cover appeared blasted, giving a slightly higher noticeable damage rating of 2.4 (see table 17). Fish diversity appears high, and serranids are particularly plentiful and tame.

Site 3 on the southwest corner of the north atoll has well-developed surge channels and a reef crest 10-15m deep on the western side. High coral cover contrasts with low rubble substrate except on the shallow reef flat where wave action naturally creates coral rubble. Topographic relief is particularly high on parts of the reef crest and fore reef. Thirty-seven coral genera and 26 chaetodontids, both indicators of a diverse reef, are recorded. Large fauna include sea turtles, small sharks, manta rays and schools of barracuda.

Site 4, the northeast corner of the north atoll, is a reef of high quality by all measures. There are no apparent damaged areas, the SS shows 66 percent hard coral cover, and the reef crest is more than 80 percent hard coral (see figure 19, T-3). The reef crest (3-6m deep) is aesthetically pleasing with 31 genera of hard coral occurring in 10 m². Abundant schools of tame acanthurids, carangids and caesionids add to the richness of this reef.

Site 5, Jessie Beazley Reef, has a shallow (2-3m) reef crest on the south side with a vertical fore reef drop-off. The deeper (5-10m) west reef shows much damage (30 percent rubble) from boat anchors and blast fishing. SS shows 36.3 percent coral cover on the south side
and high (35.8) block cover, with little damage in this area. Although the steep fore reef could not be measured, general observation shows good (>50 percent) coral cover and dense, tame, schools of large acanthurids, carangids, lutjanids, serranids, and caesionids. Lobsters can be seen in shallow areas (5m), and 25 chaetodontids are noted.

All five sites at Tubbataha have consistently high coral cover and diversity and low measures of disturbance. Coral rubble is low except where blast fishing occurs, most notably at site 5. No Acanthaster are observed. Minor anchor damage is noted at those sites frequented by tour boats and fishermen. The total coral genera (44) recorded at Tubbataha may be low by at least 25 percent due to the short exposure of this survey, and the 27 chaetodontids observed may be low by ten percent (NRMC 1982c).

The fishery of Tubbataha Reefs has not been assessed. Casual observations comparing it to known reef standing stock and productivity figures would place it higher than that of Sumilon Island, Cebu, by 30 to 40 percent.

Tubbataha reef use. The inaccessibility of Tubbataha reefs makes it difficult to interview fishermen in the area. Conversations with NRMC and BFAR employees and the dive boat manager, in conjunction with general observations, have served as the sources of information on exploitation and management of the area.

According to dive boat manager Teresa Hizon, Lady of the Sea personnel have witnessed blast fishing, large-scale collecting of sea turtle eggs, killing of sea turtles, collecting of seabird eggs,
molesting of seabirds, Tridacna collection by Philippine and Taiwanese boats, commercial trolling for tuna, spearfishing by other tour operators, some aquarium fish collection, and general reef gleaning. These reports have been confirmed by BFAR personnel. Since 1980 more blasted reef areas have been reported, and dive boat anchorage sites show minor degradation of coral. The Lady of the Sea management is aware of these problems and prohibits littering in shallow areas, spearfishing, and collecting by tourists or crew.

Collectors of precious shells were observed on the inner shallow reef flat for two days during the author's nine-day visit. No other fishing or tour boats were seen at this time. Collectors of sea turtle eggs reportedly come from the Sulu Archipelago and/or Sabah because the eggs are valuable in Malaysia. They are not commonly sold in the Philippines. Most fishing is done by reef gleaning while the relatively small (10-20m) boats remain anchored at protected sites on the shallow reef.

A decline in seabirds has been reported by BFAR and dive boats during the past few years. Ground nesting birds are extremely vulnerable to intruders. The boat crew and tourists accompanying the author's research visit were observed disturbing the birds and playing with them. It may be assumed that fishermen do the same.

The lighthouse constructed in 1980 was manned by one caretaker until he was killed two years later by unknown persons. It is rumored that pirates from the south visit the area, possibly to gather food.
Tubbataha management and recommendations. Tubbataha Reefs, like Apo Reef, Mindoro, have recently attracted attention from commercial fishermen and diving tour companies. Until now remoteness and unpredictable weather have protected it. Traditional use and concern for the area are lacking, and no local governments have taken responsibility for the area.

This vacuum is being filled by the national government. In 1982 a joint NRMC-BFAR survey trip evaluated the resources and management problems of Tubbataha Reefs. Even though no formal management plans or legislation emerged from this survey, the NRMC-BFAR group continues to stay abreast of management problems and illegal events. They talk periodically with dive tour companies and the PN in order to learn about illegal sea turtle and egg collecting, blast fishing and Taiwanese Tridacna extraction. Other than this informal information exchange, no real management exists in the area.

Tubbataha Reefs, as seen in the reef data summary, is a rich and diverse coral reef ecosystem. In all categories of evaluation Tubbataha has a higher rating than other study areas (see chapter 5). Although it will eventually require management attention if it is to be maintained, it is protected by isolation and its destruction is not imminent.

The highest value of the pristine reef may be to marine science and to conservation as a genetic reserve. The Reefs can also serve as a limited fishing and tourist area. Because dive tourist visits appear to cause little disturbance and provide virtually all existing monitoring information, controlled tourism should be encouraged. BFAR and NRMC should work closely with all tour boats.
With regard to fishing, the area is remote, difficult to patrol, and lacking in local governmental interest. For these reasons the entire area should be closed to exploitive activities. This approach is not wise where local people depend on marine resources. But in this case, most exploitation is destructive, already illegal, and often done by the fringes of Philippine society (pirates) or foreigners (Taiwanese and Malaysians). Even though zonation and more exacting management may be appropriate in the future, the only currently feasible plan is to close the area and make all fishing illegal. Recommendations are similar to BFAR management plans for Apo Reef, Mindoro. They include:

1. completion of the resource survey report and management plan based on 1982 NRM-C-BFAR field trip;

2. general closure of two main atolls to all exploitive activities by National Decree;

3. designation of prime tourist locations and scientific research areas;

4. enforcement of all current laws regulating destructive activities;

5. placing mooring buoys at appropriate locations for tour and research boats;

6. prohibiting human landings in the dense bird and sea turtle nesting areas;

7. prohibition of the dumping of garbage on any island or shallow reef area;

8. designation of shipping lanes adjacent to Tubbataha Reefs;

9. communication with commercial fishing companies and tour companies to ensure compliance with management guidelines and to continue monitoring information;

10. communication with government agencies in Palawan and the national government to ensure coordination of management; and
11. recommendation of Tubbataha Reefs as an ASEAN Heritage site for international protection and management support (see Apo Reef, Mindoro).

4.10 Calauit Island, Palawan

Overview. Calauit Island has been chosen as a study site because of its unusual status as a large, protected area with active management. It includes an 18 km coastline of marine habitat and two small islands visited by few, if any, tourists. Marine resources are only lightly exploited and sea turtles are actively protected. The area is thus useful as a comparison to other sites which are heavily used and little managed. Maltanubong Island, north of Calauit (see figure 20), is also discussed because it has a protected sea turtle nesting beach, a good quality fringing reef, and abundant marine vertebrate life.

Calauit Island covers about 4000 ha and is located on the northernmost point of Palawan Province (see figure 20). It is separated from nearby Busuanga Island by a narrow mangrove channel. This technically makes Calauit an island, although it is sometimes referred to as a peninsula. The island has small hills, thin rocky soil, dry scrub forest, and open grass fields. It has fringing coral reefs on the west, north and east sides and a mangrove lagoon on the south. On the west and east sides several long, shell-coral sand beaches line coves which are used by sea turtles for nesting.

In 1976 Presidential Proclamation 1578 declared Calauit Island a Game Preserve and Wildlife Sanctuary for endemic and exotic animals. The latter consisted of a total of 104 giraffes, zebras, impalas, waterbucks, Grant's gazelles, elands, topis and bushbucks imported
Figure 20. Calautit Island, Palawan. Fringing Reef and Transects.
from Kenya. These animals now number more than 200 and graze the valley grasslands and trees. All residents other than park employees were removed from Calaut when it was declared a park. The employees number 100 families and live in a village in the south end (park manager, pers. comm.).

It appears that the game preserve was intended as a large area "zoo" where people could observe African game animals. Whether it was also intended as a hunting area is not known, although wild boar are now hunted there (pers. obs. 1983). Sea turtle nesting is protected on Calaut beaches and several nearby islands, and destructive fishing is discouraged in the area. The Game Preserve is presently managed by the Presidential Committee for the Conservation of the Tamaraw (POCT) through the Presidential Assistant on National Minorities (PANAMIN).

The terrestrial environment of Calaut was surveyed in 1976 (Agaloos and Nepomuceno 1977), but the marine environment was not documented until May 1983. At that time POCT contracted the Silliman University Marine Laboratory to conduct a survey of the island's indigenous marine and terrestrial resources. The author was part of a 15-member team headed by Dr. A.C. Alcala. Their six-day survey of the island is the source of the data for this summary (SUML 1983).

****Calaut Island marine environment**. Calaut Island is bordered by open seas on the west, north and east sides where fringing coral and rocky reefs extend out from the shore (see figure 20). A protected bay borders the south side, providing good anchorage all year. This bay is lined with mangrove forest. The northeast monsoon between November and April causes choppy, rough waters on the
northeast side of the island, while the southwest and west sides are
buffeted by the southwest monsoon and south China Sea storms from May
through October. These create a high wave-energy environment.

The effects of these two seasonal weather patterns are evident
in the shore and reef morphology of Calauti. Southwest and west
shores have well developed white sand beaches and a wide reef flat
with spurs and grooves. The more protected environment of the
northeast exposures is reflected in coral communities of higher relief
and greater diversity.

Nearshore sandy substrates support seagrass and algal
communities which cover most of the shallow inner reef flat. Coral
communities of varying quality fringe the reef on its outer edges and
drop-offs. Generally, below the shallow reef crest are a gradual fore
reef and steeper reef slope, followed by coral rubble and sand at
10-20 m.

The fringing reef bordering the three exposed shores of Calauti
extends from 300-900 m from the shore and descends to approximately
20 m. Thus, along the entire 18 km coastline there is about 9 km² of
reef, although much of it consists of limestone rock, sand, rubble,
and biotic communities other than living corals. A living coral
community 50-100 m wide fringes the reef, with an estimated 1.8 km² of
living coral cover. This must be qualified by the survey results
showing actual living coral within this coral community.

Transects were placed on the east and west sides of Calauti,
showing a contrast between the two exposures (see figure 21). Both
transects include more seagrass and sand than others in this study,
and substrate percentages are affected accordingly. A systematic
Figure 21. Reef Profiles, Calauit Island, Palawan
snorkeling (SS) survey was made on an eastern cove and an outer reef area and on Maltanubong Island. Table 18 summarizes the results of the transects and SS in these areas.

The SS survey and T-1 on the east side show a hard coral cover of 33.4 and 20.5 percent respectively. The discrepancy between the SS and transect data reflects the greater representation of the reef crest zone in the SS. A high sediment cover is primarily attributed to sand and blocks, both of which seem to result from naturally caused reef substrate characteristics. The rubble cover of 8.8 and 17.5 percent results from a high wave environment on a shallow reef and appears not to be use-related. The noticeable damage index is low (1 and 2). The coral diversity (40 genera) is high and distinguishes the east side from the west side, which has only 25 genera. Topographically the east reef is much richer than the west side and it has numerous massive Porites and other corals.

The low topographic relief (0.5m) and coral cover (7.0 percent) on the west transect seems to reflect the southwest or South China Sea exposure. Similar conditions were observed on other reefs in the area. Otherwise the reef did not appear to be disturbed. The high sand cover (51.1) reflects the large seagrass community occurring within the transect (see figure 21), and the large number of Tridacna crocea in the reef rock indicates little exploitation by fishermen. As with coral diversity, fish fauna is more diverse and plentiful on the northeast and east reefs.

There is little evidence for human-caused disturbance on the reef as a whole. Generally, coral rubble constitutes a low percentage of the substrate and broken coral heads were not often seen. It appears
Table 18
Reef Quantitative Data, Calauit Island, Palawan (1983)

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* mostly seagrasses
t total for reef
that the west reef, although not rich, is in a natural state. Factors such as wave energy, water movements, and transport of sediments have created an environment with a relatively simple coral community. A different combination of factors has created more relief and diversity on the eastern side. In a few areas excess coral rubble is present, indicating possible past disturbance such as dynamite fishing. Broken and overturned coral heads may be attributed to either boat anchors or large waves.

Collecting pressure appears light as fish are often larger than those seen on Visayan reefs. *Tridacna* are plentiful and empty *Tridacna* shells suggest that some fishing does occur. On the other hand, lobsters seen in shallow depths (less than 10m) indicate that it is not heavy. Whether the lack of fishing is due to the protection of the Calauit Reserve or because the reefs do not attract fishermen is not known. It also appears that the reef is not used for tourism or scuba diving.

Although not aesthetically beautiful, the Calauit reef is rich in marine organisms and is in good physical condition. Scarids, acanthurids, serranids, Hawksbill and Green sea turtles, and sharks are among the more conspicuous marine fauna. *Tridacna* and lobsters are still common and of good size, while a variety of bivalves and gastropods inhabit the reef. Although the fish fauna is not very dense, it is diverse and some large individuals exist.

The small (800m long), steep Maltanubong Island has a carbonate sand beach on the south and southeast sides which serves as a sea turtle nesting ground. A fringing reef with 35 percent hard coral cover, 9 percent soft coral and only 3 percent rubble surrounds the
island (see table 18). There are spurs and grooves on the southwest and west sides and large high relief coral heads on the northeast and east sides. Sand substrate lies between. Fish life is highlighted by schools of carangids and bumphead wrasses (scarids), Black and White-tipped sharks, and schools of acanthurids and scarids. The water visibility of 30m is noticeably better than at Calauit since current flow is strong around the exposed small island. The general aesthetic appeal is high and there appears to be little human disturbance.

Calauit reef use. Due to the nature of the survey trip and the rules governing activities on Calauit Island, only several formal interviews were made. Most information was obtained from general observations as to reef use during the author's six-day survey of Calauit Island.

When the Calauit Island and adjacent island Game Preserve and Wildlife Sanctuary was declared in 1976, eight species of herbivorous range animals were imported from Kenya. All have successfully propagated with intensive management. Except for about eight managers, biologists and consultants from Manila, park employees (100 plus) were hired from local residents. These people now manage the park on a budget in excess of one million pesos per year.

Casual conversations with a few park employees indicate that most food, including fish, is imported; only a little is grown in home gardens. According to respondents, fish are not caught in Calauit. Since rules prohibit these activities, the reports are to be expected. Whether some fishing actually occurs is not known, but it is probable.
Nobody had opinions on the rationale for or benefits from the Game Preserve.

A recent (1982) addition to the Game Preserve is a sea turtle hatchery and rearing project for mostly Hawksbill and a few Green sea turtles. In 1983 several hundred Hawksbill hatchlings were reared on Calauit (see figure 20) for release to the open sea. Prompted by extensive Hawksbill egg laying on Maltanubong Island, Calauit Island, and several other islands, the project appears to be well managed and feasible. The small island beaches are surveyed by the Task Force Pawikan (TFP) of the Philippine Ministry of Natural Resources and are now maintained by the Calauit Project in coordination with TFP.

The park manager indicated that fishing per se is not prohibited along the shores of Calauit but that all destructive fishing is prohibited and the shores are patrolled. Maltanubong has a caretaker stationed on the island and has signs posted stating that landing is illegal. This may seriously discourage fishing along these shores. During the six-day survey the author saw no fishermen on the coast of Calauit or the small adjacent islands except for several small paddle canoes moving through the area. These observations indicate that fishing is currently not intense.

Calauit Island management and recommendations. Calauit Island, the largest actively protected land reserve in the Philippines, is an anomaly among Philippine protected areas, having been set up as an exotic game preserve. Two by-products of the game preserve are the 18 km of coral reef partially protected from destructive exploitation and the beach habitat for nesting sea turtles. The normal incentives for
reserve areas, that is, tourism and benefits for local municipalities or fishermen, are absent in the Calautit area. Instead, a "large area zoo" for animal observation, hunting, and private interests probably precipitated preserve formation. Marine conservation has more recently entered as a reason for continuing the project.

Since the marine survey shows an environment in good condition, it deserves further management attention. It may be possible to piggyback marine management onto the protection already given to the terrestrial area.

Several management options exist for potential uses of this marine area. As a strict reserve prohibiting collecting, the reef would serve as: a) a breeding ground; b) a protected area for certain rare and/or endangered species such as Triton, Tridacna, sea turtles, and Dugong (reported in the area); and certain ecologically important but vulnerable fish, such as scarids, some serranids, sharks and mantas (all common in the area); c) a genetic reserve; d) a research area; and e) a pristine reef for tourism.

As a multiple-use reserve where only a portion or portions of the reef are strictly protected, the reef would serve as: a) all of the above; b) a fishery reserve for local fishermen using ecologically sound fishing techniques; c) an experiment comparing two adjacent areas, fishing and non-fishing, in terms of fish standing stock; and d) an opportunity to strictly ban all destructive fishing practices in a controlled area.

Further observations are needed before exact boundaries or reserve design are implemented, for many human and environmental variables must be considered. Also, Maltanubong Island, described
above, is an opportune site for a small island marine reserve requiring little additional management beyond that which already exists. Its rich coral community makes it a good example of a small, healthy reef which could serve as a breeding area for fish and some invertebrates, as mentioned above. It would also interest scuba divers and underwater photographers because of its aesthetic beauty. Its apparent lack of fishing pressure and its small size would make implementation of regulations for a protected area relatively easy to accomplish.

4.11 Introduction—Indonesia

Two Indonesian study sites are included in this thesis to add perspective to the problem of marine reserve management in Southeast Asia. Marine waters constitute about 62 percent of Indonesia's territory. Because this marine environment is a center of economic activities, damage to reefs from coral mining, limestone removal, blast fishing, other destructive fishing methods, and overfishing are increasing near most population centers and many rural coasts (Soegiarto 1983).

The concept of reserve is well established in Indonesia. However, out of the 79 marine reserves of varying legal status, very few are being managed (Soegiarto 1983). The present government has inherited many legally protected areas from past regimes and has designated more reserves in the name of conservation. Nevertheless, governmental policies have inhibited effective management and only recently has Indonesia begun to implement field management. These management problems make the country a relevant case study of marine management.
Bali Barat National Park and the Pulau Seribu Marine National Park have been chosen as study areas. Bali Barat, on northwest Bali Island, is the only marine area in Indonesia which is effectively protected. Polunin et al. (1983) note that conditions at Bali Barat are optimal for a successful reserve because the area is conducive to local and international tourism and the local government infrastructure is good. Pulau Seribu is now being recommended as a marine national park because of its proximity to Jakarta. The reef resources are diverse and in some areas still pristine, although exploitation is increasing. The site was chosen for this study because management potential is good and the large area, if protected, would be a significant contribution to Indonesian marine conservation.

4.12 Bali Barat, Bali

Overview. Bali Barat coast and Menjangan Island are the only effectively protected marine areas in Indonesia (pers. comm. Salm). Menjangan Island reefs attract scuba divers from southern Bali and elsewhere whose use of the reef sometimes conflicts with traditional Javanese fishermen and residents of the Bali Barat area.

Bali Barat and Menjangan Island, located on the northwest corner of Bali Island, comprise a wildlife reserve and marine reserve which are jointly proposed as a national park (see figure 22). The coastal area around Bali Barat contains an array of ecosystems. About 6220 ha of the coastal sea is included within proposed marine boundaries. This includes approximately 310 ha of mangroves, 40 ha of seagrass beds, 430 ha of reef-flat, and 380 ha of reef-slope. Beyond these shallow-water areas are 2200 ha of shallow (<50m) shelf, 2660 ha of
Figure 22. Bali Barat, Bali, Coastline, Park Boundaries and Zones
deep (50–200m) continental shelf, and 200 ha of continental slope 
 (>200m deep) (Polunin et al. 1983). Bali Barat shore is approximately 
 60 km in length. Half of it is sandy beaches and the remainder is 
 mangroves and raised limestone rock.

Rainfall is low in the area and there are no major rivers in the 
 reserve. Although southeast and northwest monsoons affect the area. 
 the conditions are generally calm because the landmasses of Java and 
 Bali afford protection from monsoonal winds (Polunin et al. 1983).

Bali Barat Wildlife Reserve (see figure 22) was created in 1947. 
 In 1978 one island, Pulau Menjangan (175 ha), and three islets, Pulau 
 Kajong, P. Burung and P. Gadung (total area 18 ha), in Teluk Lumpur 
 were added (see figure 22). This existing legal reserve amounts to 
 19,600 ha of land, but does not currently include the surrounding sea. 
 Since 1981 the resident manager has attempted to prevent 
 mangrove-cutting, reef mining, and illegal fishing. Thus the proposed 
 marine reserve extending approximately one km offshore is already 
 being partially enforced (Robinson et al. 1981).

The island of Bali has a dense population, a distinctive human 
 culture, and rich natural resources. An exception to this is the Bali 
 Barat region, which is dry and traditionally underpopulated. Although 
 coastal gatherers and fishermen have inhabited the area for over 2000 
 years (Polunin et al. 1983), population density has remained low. The 
 Balinese prefer agriculture and are fearful of the sea. Even today, 
 they do not use marine resources extensively. The Bali Barat area has 
 thus been exempted from heavy marine resource exploitation and those 
 disturbances common in other parts of Bali and most of Java.

Recent interest in Bali Barat has been displayed by the PPA
(Directorate of Nature Conservation), Bali Provincial government, WWF and FMO for several reasons. First the relatively pristine condition of Bali Barat in relation to impending population pressure and exploitation makes it a critical area. Second, Indonesian efforts in nature conservation are focusing on areas which are feasible to manage. And finally, tourists on Bali are looking for better marine areas to visit. Because of this mix of factors, Bali Barat has been selected as the main Indonesian study site in this thesis.

**Bali Barat marine environment.** A narrow, steep-sided fringing reef borders much of the Bali Barat National Park and Pulau Menjangan shores. Shallow bays (Teluk Terima and Teluk Lumpur) and sheltered areas have more discontinuous and gradually sloping reefs, and there are no reefs on the southwest coast in Bali Strait below Gilimanuk (Polunin et al. 1983).

Menjangan reefs are the richest in species of fish and corals and the most productive in the Bali Barat Reserve (Polunin et al. 1983). All data for this study were collected there (see figure 23). As it was not possible to place underwater transects at Menjangan, the reef was documented by SS and data from previous reef surveys (T-1).

The physical profile of the fringing reef varies around Menjangan Island. On the southeast side the reef is particularly steep and regular with a shallow reef flat and crest and steep fore reef and slope. On the north coast the upper reef is more rounded and there are shallow surge channels on the outer reef flat (see figure 24).

Coral cover on the north coast is generally high as evidenced by SS-1 and T-1 (Polunin et al. 1983) in table 19 and figure 24. In
Figure 23. Menjangan Island, Bali, Fringing Reef, Park Zones and Transects
Figure 24. Reef Profile, Menjangan Island
Source: (Polunin et al. 1983)
### Table 19

**Reef Quantitative Data, Pulau Menjangan, Bali Barat (1984)**

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SS-1</th>
<th>SS-2</th>
<th>SS-1–2 mean</th>
<th>T-1*</th>
<th>Reef Total</th>
</tr>
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<tr>
<td><strong>PERCENT SUBSTRATE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>sand</td>
<td>8.2</td>
<td>4.8</td>
<td>6.5</td>
<td>12.8</td>
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</tr>
<tr>
<td>rubble</td>
<td>9.8</td>
<td>20.9</td>
<td>15.4</td>
<td>26.0</td>
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<tr>
<td>blocks</td>
<td>15.0</td>
<td>32.2</td>
<td>23.6</td>
<td>-</td>
<td></td>
</tr>
<tr>
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<td>17.1</td>
<td>10.9</td>
<td>-</td>
<td></td>
</tr>
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<td>75.0</td>
<td>56.4</td>
<td>38.8</td>
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<td>Hard Coral</td>
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<td>21.5</td>
<td>34.1</td>
<td>61.2</td>
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<td>Soft Coral</td>
<td>15.4</td>
<td>3.5</td>
<td>9.5</td>
<td>-</td>
<td></td>
</tr>
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<td>other</td>
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<td>0</td>
<td>0.1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>ABUNDANCES</strong></td>
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<td></td>
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<td></td>
</tr>
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<td>Hard Coral Genera/100m²</td>
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<td>-</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
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<td>0.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acanthaster/100m²</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Chaetodontid Species</td>
<td>19</td>
<td>20</td>
<td>-</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Fish Species</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>137</td>
<td>137</td>
</tr>
<tr>
<td>Depth Range (m)</td>
<td>2/6</td>
<td>1/5</td>
<td>-</td>
<td>0/40</td>
<td></td>
</tr>
<tr>
<td>Noticeable Damage (1-10)</td>
<td>2.5</td>
<td>5.6</td>
<td>4.1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Topography (m)</td>
<td>2.4</td>
<td>1.5</td>
<td>2.0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* Polunin et al. 1983. Rubble on T-1 includes blocks and dead standing coral.
contrast, the south reef has a low coral cover (21.5 percent) and much natural shallow rubble and blocks. The south fore reef and slope, however, have high fish density and good coral cover.

Other indicators point to a reef in good condition. Acanthaster is almost absent and Tridacna are abundant, although this is not reflected in the SS-1 because of sampling variation. Chaetodontid diversity is moderate at 22, but may be underestimated because of the short (3-day) survey time. Serranids are common and tame on the shallow reef crest and drop-off, in contrast to more exploited reefs.

Conspicuous fauna include small White and Black-tip sharks, dense schools of acanthurids, carangids, caesionids, one school of Bumpheaded wrasses and Chanos chanos (milkfish), and one sea turtle.

Human impacts appear minor but include nine small blast sites and four anchor-damaged areas around the the northeast reef. Anchor sites near the beach shelters also have broken corals. Most human-caused damage appears to have occurred before 1980, and human impacts are currently minor. Damage to the reef is mostly due to its environmental and geographical setting. Water clarity (15-20m), for example, is lower than many Philippine reefs and this naturally limits coral growth. The very shallow south reef flat appears in poor condition because of periodic exposure at low tides, wave action, and perhaps some historical reef walking and fishing.

Bali Barat reef use. The number of fishermen actually living within the reserve is small, but the area is accessible to surrounding settlements on Bali and East Java. There, fishermen typically use a range of simple methods, including beach-seine, gill-net, cast-net,
scoop-net, hand-line, trap, spears, poison and explosives (Polunin et al. 1983). *Trochus* shell has long been collected in the area and milkfish fry (*Chanos chanos*) are seasonally important. Most marine life is consumed locally, an exception being the ornamental fish taken by Javanese fishermen for export. They use hand-nets and cyanide poison to catch over 70 species (Polunin et al. 1983).

Fishing occurs mostly along the northwest periphery of the reserve and not near P. Menjangan. The park manager maintains that fishermen don't frequent Menjangan; but three fishing boats were seen during the survey trip and the national PPA office reports some fishing at Menjangan (pers. comm. Salm). Nevertheless, fishing is not intense and destructive methods are strongly discouraged.

On the west side of the reserve, 4-5 km from Menjangan Island, blast fishing is common, ornamental fish collecting prospers, limestone is mined and reef gleaning is common. Mining has been significantly slowed since 1978, but local and Javanese businesses continue to export limestone to East Java.

Local and foreign scuba divers are beginning to visit Menjangan Island. During the author's three-day island survey he witnessed two dive groups of ten divers each from Denpasar. The tour leaders indicated that the island offers the best Bali diving and that groups come almost daily. These visitors pay an entrance fee to the park and hire park-owned boats to ride to the island. The guides seem to enforce the no spearfishing or collecting rules.

Two park employees stay on the island to watch visitors, prevent illegal fishing, and maintain the shelter area for visitors. They have no means to effectively patrol the island for fishing.
**Bali Barat management and recommendations.** Bali Barat Reserve, now proposed as a land and marine national park, is one of Indonesia's first accessible and effective marine protected areas. It is beginning to provide public education in marine ecology and to offer an example of rational conservation. Its field policies may help to answer questions about the type of management which is practically possible in such an area. It is used by some local traditional fishermen and by more and more tourists. To what extent Bali Barat can continue to grow depends on how it is managed.

Bali Barat is now under the authority of the national PPA office in Bogor, Java, but is practically managed by the PPA office in Denpasar and the Bali Barat field manager. The Denpasar PPA office issues permits for visitors and guides policy development for management of the park. Because rational funding is small, most revenue is raised locally from the provincial government, permits, and equipment rental to visitors. Out of the 24 wardens stationed at the reserve, only two patrol the marine area. Yet most tourist use of the reserve is marine-oriented, and marine facilities are being improved in an attempt to increase park revenue.

Although the marine areas are not legally protected by Indonesian law, national regulations prohibit destructive activities, including coral mining and blast fishing. These are being successfully enforced by a dedicated field manager at Bali Barat.

Polunin et al. (1983) point out that more careful planning is required to conserve the marine resources of the area as a whole. The needs of tourists and local subsistence fishermen must be reconciled. Many management issues are being addressed by proposed implementation
of three major zones in the reserve (see figures 22 and 23). The 'traditional use' zone allows traditional, non-destructive fishing. Fishing will be prohibited in sanctuary and wilderness zones, which are protected exclusively for management and research (sanctuary) and for tourist and educational activities (wilderness). It is proposed that these zones be enforced by means of visitor and fishermen permits, constant surveillance, intensive use landing beaches and mooring buoys, and proper education through signs and brochures.

Despite lack of supporting legislation, enforcement of the marine reserve area near Menjangan Island is being accomplished due to constant surveillance. It is also evident that the more exacting management schemes of zonation, education, patrolling, and permits are still only in the planning stages. Since Bali Barat reserve is accessible, environmentally sound, and has initiated management, it can be a good example of marine reserve management in Indonesia. The recommendations below are intended to improve current field management at Bali Barat as observed by this author. It is suggested that:

1. the legalization of the national park and marine areas be finalized;
2. all currently illegal fishing practices be stopped by means of more patrols;
3. the zonation scheme be simplified to two zones (traditional use or buffer and sanctuary or core) with small intensive visitor areas inside the sanctuary. These would be enforced by means of marker buoys, brochures, education and patrols;
4. tourist facilities continue to be improved and revenue generated from these facilities be used for field operation of the park;
5. the Denpasar PPA office and the field manager be the effective decision-making body for park policies, with advice from PPA Bogor and selected observers;
6. the park wardens be given training in conservation, marine ecology, tourist guiding, and scuba diving, and the services of park employees be used in conjunction with tourist company personnel;

7. the island facilities include mooring buoys, adequate shelter, toilets, and refuse containers for visitors; and

8. intensive use areas be monitored for human impact so that wardens and park managers stay aware of visitor impact on the reef environment.

4.13 Kepulauan Seribu, Java Sea

Overview. The Seribu ("thousand islands") Archipelago is the best developed patch reef system in Indonesia. The many undamaged reefs have high coral and fish diversity and a variety of unusual communities. The endangered Hawksbill turtle (Eretmochelys imbricata), for example, regularly nests on several islands. Located near Jakarta, the archipelago is a potential site for large-scale tourism and is currently threatened with habitat destruction, construction, overfishing, shell collecting, and tourist damage. This site is a good example of the tensions between development, traditional uses, and environmental preservation in Indonesia.

Because the author did not visit the site, the Kepulauan Seribu section is written from secondary information based on field work done by Kvalvaagååes and Halim (1979), Robinson (1981), and reports by Salm (1982a and 1982b).

The islands and reefs of the Seribu Archipelago (see figure 25) rest on a substrate of mud and sand typical of the Java Sea's Sunda shelf. There are 108 coral cays in the archipelago in addition to many submerged and sea level reefs. These extend north for 80 km from Jakarta. The cays are typically small (< 10 ha average) and no more
Figure 25. Kepulauan Seribu, Java Sea, Patch Reefs, Sand Cays, and Park Boundaries and Zones
than 3m above sea level. Most are surrounded by a narrow white sand beach.

On all but the smallest cays the original vegetation has been stripped away and replaced by coconut plantations and/or by tourist and private bungalows. An airstrip has been built on one island and a golf course is proposed on another.

Attention was drawn to the conservation value of K. Seribu in 1979 by Kvalvaagmæs and Halim; in 1981 Robinson et al. outlined plans for a national park. The PPA currently plans to establish a Marine National park at K. Seribu and implement the management plan prepared by PPA and WWF (Salm et al. 1982b). On July 21, 1982 the entire proposed park and buffer zone area (108,000 ha) was declared a reserve by ministerial decree. This was an interim measure pending legislation to reclassify the area as a marine national park. Little field management has begun under this reserve status.

Jurisdiction of the islands in the proposed park and its buffer zone (see figure 25) is shared by two village heads. Most of the islands are either uninhabited, seasonally inhabited by fishermen, leased or owned as private islands (23), or developed for tourism. Coconuts, fisheries (including aquarium trade), and mining of coral and Tridacna clams are the principal industries of islanders. Tourism which involves local residents is rapidly developing.

Kepulauan Seribu marine environment. The reefs of K. Seribu are "patch" reefs with a maximum depth of 15-20m. There are two types of patch reefs, permanently submerged and sea level reefs. They afford
habitats for both characteristic coral morphologies and specific biotic assemblages. Probably all shallow water species of western Indonesia occur on these reefs. A total of 61 coral genera comprising 132 species of hard corals have been identified in the park area (Salm et al. 1982b).

Two weather patterns affect the islands. The northwest monsoon from November to March brings strong winds, waves, and heavy rain and is considered the rough season. The southeast monsoon from April to October brings calm weather and an increase in water clarity.

Reef fishes are plentiful in some areas and depleted in others because of variations in fishing intensity. Valuable commercial fish species (notably serranids and lutjanids) are uncommon, found in small sizes, or entirely absent on heavily fished reefs. *Tridacna gigas* is apparently extinct throughout the islands, and people now dig up the reef-flats to find the buried shells of dead *Tridacna*. Other mollusks (such as pearl oysters, *Trochus*, cowries and turbans) are heavily harvested by free divers.

Hawksbill turtles feed, sleep, and breed on the reefs and nest on beaches of the northern islands. A few Green turtles nest there also. Ninety-five nests were counted during a three-week period in May 1981, 71 of them on two small cays.

Although large sections of reef habitat in K. Seribu are degraded, much of the area is still intact. Only a few reefs, however, support relatively pristine fish populations. As tourist attractions, the patch reefs are limited by poor water visibility during certain months due to monsoon-created waves.

In summary, the overall quality of K. Seribu reefs is only
moderate, but because the area is large and diverse a few reefs remain pristine. Compared to the other reef areas easily accessible to Jakarta, those of K. Seribu can be rated good.

**Republauan Seribu reef use.** K. Seribu reefs support a fishery of 279 small and 85 medium sized fishing boats based in the buffer zone south of the park boundary (Kvalvaagnaes and Halim 1979). These boats exploit reef species for food and the aquarium trade. They also mine coral and clam shells for export to Jakarta and for local construction. Outside commercial operators collect mother-of-pearl shells and other mollusks. As these shells become rarer, techniques for locating them become more damaging. Coral colonies are frequently smashed to obtain hidden mollusks (pers. comm. Salm).

Coral reefs attract scuba divers and snorkelers to the islands, and the extensive beaches are desirable for small resorts, beach combing, sailing and camping. One tour company owns or leases 12 islands and is negotiating for more. Sea turtles, sea turtle eggs, and some mollusks are collected by local people and commonly sold to tourist resorts.

Since K. Seribu is close to Jakarta, the surrounding sea serves as a shipping lane. Threats to the reefs and beaches include discharges of oil and trash from ships, northward expansion of pollution from Jakarta Bay, increased inland erosion and sediment run-off, and oil well blow-outs from drilling sites west of the proposed park.
Kepulauan Seribu management and recommendations. Except for some remote sites, the reef resources in the Seribu Archipelago are heavily exploited. No field management has yet been implemented, but as of May 1984 K. Seribu appeared to be a priority PPA site for field implementation.

The proposed PPA management plan for the area attempts to integrate conservation and visitor use in the same protected area without creating an overly complicated system of zones and regulations. At the heart of the management plan is a zonation scheme which designates the areas of highest conservation interest as sanctuaries (see figure 25). These include beaches with dense Hawksbill turtle nesting and undamaged reefs of high coral diversity. The two proposed turtle sanctuaries include 75 percent of all nests found in the islands. The coral sanctuary includes a cluster of small reefs which contain 96 percent of all coral genera recorded in the park and buffer zone.

The reefs and islands surrounding privately controlled islands, including those planned for tourism, are zoned for recreational activities or intensive use. Recreational fishing is allowed in marginal areas of this zone.

A wilderness zone connecting the two turtle sanctuaries, the coral sanctuary, and the intensive use zone accommodates those visitors who wish to camp, hike, dive and snorkel but require no facilities. No collecting or fishing is allowed in this zone.

The marine national park boundary encompasses the sanctuaries, the intensive use zone, and the wilderness zone. The entire park boundary is enveloped by a buffer zone (see figure 25) which is open
to commercial, non-destructive fishing, thus compensating fishermen for the loss of fishing grounds within the marine park. Only licensed island residents will be permitted to fish there.

The marine park management plan designates 46 staff, one headquarters office, and two guard posts in the park. Permits will be required for park entry.

Ministerial disputes have prevented actual funding and implementation of the park plan. Lack of trained personnel is also a factor slowing progress. In the face of these problems, the author suggests that certain critical issues be addressed prior to large-scale implementation of the marine park. A simple preliminary field plan, including the following considerations, may be more feasible during the initial stages of park management. It is suggested that:

1. the area of the proposed Marine National Park be put under PPA jurisdiction;
2. some small-scale implementation be initiated with a few trained staff;
3. sea turtle sanctuaries be protected and egg and turtle collection be prohibited;
4. prohibitions on fishing and coral mining be enforced;
5. the use of coral for any type of construction be prohibited;
6. development construction which negatively affects beaches and/or reefs be stopped;
7. legal fishing or collecting using damaging techniques be stopped; and
8. tourism be promoted in a controlled manner allowing for both the benefits of recreation, education, and environmental contact for tourists and the benefits of revenue, public support, use and conservation for the park.
As in other protected areas, the marine park may serve as a core area to replenish the surrounding reef fisheries in the buffer zone. Monitoring of this replenishment would be helpful. Salm (pers. comm.) recommends that a sanctuary also be designated for *Tridacna*, which has almost totally disappeared from the archipelago. Salm believes that by re-introducing *Tridacna* and allowing them to prosper, fishermen will be diverted from fishing over the whole area. Mariculture sites set up in the buffer zone would provide alternative income.

4.14 Introduction—Malaysia

Two Malaysian study sites are included in this thesis to give a perspective on reef management in a country with problems different from those found in the Philippines and Indonesia. Reefs constitute a smaller proportion of the marine environment in Malaysia. The 1600 km long Peninsular coastline of Malaysia, for example, supports very little coral growth. Most reefs occur around the offshore islands of the east and west coasts, and the richest reef ecosystems are found along the Sabah shore and offshore islands.

Some threats to Malaysian reefs are natural. *Acanthaster* infestation is responsible for partial denudation of shallow corals on fringing reefs around islands off east coast Peninsular Malaysia (De Silva 1982; Warner 1978). Human damage includes blast fishing, sedimentation from fresh water run-off, and commercial fishing, and to a lesser degree coral mining, aquarium trade collection, spearfishing, use of fish nets, and some types of pollution (De Silva 1982). Generally, population density and its associated pressure is not as critical a problem in Malaysia as in other Southeast Asian countries.
Concern for conservation in Malaysia has been evident since 1961, when Sharma (1961) discussed the importance of coral reefs to tourism. In 1967 the Malayan Sub-Aqua Club adopted a resolution recognizing two west coast areas and two east coast areas where diving members would conserve all reef fauna, but by 1972 two of the areas chosen were no longer suitable for conservation (Lulofs 1979). In 1976 the Malayan Nature Society Symposium urged the creation of four marine national parks, e.g. Pulau Perak, west coast; Pulau Paya/Segantan group of islands, west coast; the south coast of Pulau Redang, east coast; and Pulau Lang Tengah, east coast (see figure 26).

Detailed surveys have been made of these areas as well as Pulau Perhentian, Pulau Kapas and Pulau Tioman (see figure 26). Legal protection as a marine national park has recently (1983) been given Pulau Redang, but management plans are incomplete. WWF Malaysia has completed (1984) management plans for Pulau Paya/Segantan and is strongly recommending legal protection (WWF 1983). Nevertheless, despite the two decades of interest and activity in marine conservation, actual field management of Peninsular Malaysian marine environment has not yet been implemented.

Protection of marine areas in Sabah is more advanced than Peninsular Malaysia, although actual management there is limited also. The first marine park, Tunku Abdul Rahman National Park (3377 ha marine) was declared and gazetted as a park in 1974. Turtle Islands National Park (1722 ha marine) was declared in 1977 and Pulau Tiga's National Park (15,257 ha marine) in 1978 (Davidson 1982). The proposed Semporna Marine Park and Sipadan Marine Reserve (figure 27) were surveyed in 1980 by WWF and a detailed management plan was
Figure 26. Peninsular Malaysia and Offshore Islands
Figure 27. Marine Protected Areas, Sabah
completed. Although some limited field management has begun, these areas are not legally protected.

The limited reef resources of Malaysia are well documented and threats to them are described. While several management programs have begun in Sabah, no effective protection exists along Peninsular Malaysian coasts. The two study sites, Pulau Perhentian and Pulau Redang, were thus chosen to illustrate the condition of coral reefs on east coast islands and the type of management problems which exist there. Pulau Perhentian is documented through field data while Pulau Redang was not visited by the author. It is a Malaysian example of a legally protected area.

4.15 Pulau Perhentian Besar and Kechil

Overview. Pulau Perhentian Islands are proposed as land and marine reserves by the Malaysian Departments of Wildlife and Fisheries. Malay tourists consider them to be a desirable destination for camping and water recreation, and privately owned resthouses are available on the uninhabited island of P. Perhentian Besar. A traditional village of about 700 persons on P. Perhentian Kechil is a base for both subsistence and commercial fishing. Although residents farm fruits, vegetables and animals, they are dependent on the reef and offshore areas for much of their protein needs and income. These two islands were chosen for research because they represent a relatively remote Peninsular Malaysian reef habitat with pending management decisions.

These two high, continental islands are steeply sloping and forested. They are located 25 km off the northeastern coast of
Peninsular Malaysia (see figure 26). The dense tropical growth on the larger island, P.P. Besar, is mostly intact and provides habitat for numerous bird species and several mammals, including monkeys. P.P. Kechil has been partially deforested for agriculture but retains much (75 percent) forest cover. Both islands have plentiful fresh water from good watersheds and frequent rains.

The islands are surrounded by shallow fringing reefs of gradually sloping morphology. These reefs rarely extend more than 100m from shore, and they range down 15-20m, with coral growth ceasing at 10m in many areas. Many small bays with white sand beaches and well-formed shallow reefs indent the coasts. Protruding headlands descend quickly into deep water and support encrusting coral growth on the rock substrate.

The marine environment of Perhentian Islands was first surveyed in May 1984 by a team from the Faculty of Fisheries and Marine Sciences of Universiti Pertanian Malaysia (UPM). Requested by the Malaysian government and funded by UNEP (Coral Reef Monitoring Project), the survey team headed by R.N. De Silva collected detailed data on coral diversity, coral abundance, reef conditions, reef use, and potential management schemes. It will be the basis of a future study of general management plans. This preliminary survey also serves to draw the attention of the national Department of Fisheries to the protection of marine areas of Perhentian.

Tourism is limited in Perhentian and scuba diving is available only by a chartered boat from the mainland. Nevertheless, the relatively pleasing aesthetics of the forested islands, white beaches, and coral reefs have prompted interest in island and marine
management. Also, expansion of the traditional and commercial fisheries threatens to cause overfishing of both inshore and offshore fisheries.

**Pulau Perhentian marine environment.** The shores of Perhentian Besar and Kechil are lined with white sand beaches interspersed with rocky headlands. Several of these beaches are nesting grounds of Hawksbill and Green sea turtles (see figure 28). Shorebirds light on many of the beaches and sand-oriented crustaceans and mollusks are common.

Similar to most of the Southeast Asian region, two monsoon seasons prevail off east coast Malaysia. Strong northeast weather affects the islands from November through March or April, limiting small scale fishing. The calmer southeast monsoon during remaining months brings rain squalls and mostly calm seas.

Data for this study were collected during the ten-day survey trip conducted by UPM. Scuba transects and/or SS were made in ten bays in the two islands. These data are presented by sequential description of Bay 1 through 10. Table 20 summarizes the substrate compositions and abundances and figure 29 shows two representative reef profiles.

The gradually-sloping, shallow fringing reefs around the islands are similar in topography and coral composition. Protected from strong currents and weather, the bay reefs are often dominated by stands of shallow staghorn (*Acropora formosa*), other *Acropora* species, and foliose and branching *Montipora*. Water visibility is often less than 10m and fine sandy bottom sediment is common. In contrast, the rocky headland reefs with boulder substrate have more encrusting coral
Figure 28. Pulau Perhentian Besar and Kechil, Trengganu, Fringing Reefs, Bays and Transects
Figure 29. Reef Profiles, Pulau Perhentian Besar and Kechil, Trengganu
Table 20

Reef Quantitative Data,


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B Bay
T total for area
growth and massive forms in clearer water. Fishes are more abundant and diverse in these headland areas.

Bay 1 and 2 on southern P. Besar are both disturbed areas with much dead standing Acropora caused by an Acanthaster outbreak in 1977 and 1978 (De Silva pers. comm.) (see figure 29). Live coral cover and topography are low (see table 20) and noticeable damage is high in each bay. Fish diversity is low and the general aesthetics are poor.

On the west shore of P. Besar, bays 3 and 4 have higher live coral cover (see table 20) in a rocky, exposed environment. Each bay has a high diversity of coral genera (encrusting, massive and branching forms) and more encrusting soft coral than other areas. Topographic relief combined with schooling Bumphead wrasses, scarids, caesionids, and carangids indicate a rich habitat as compared to other Perhentian reefs.

Bay 5, surveyed by SS, has a shallow reef crest close to the beach with gradual sloping sand and rubble substrate. Massive and branching corals show weather and possibly Acanthaster-related damage.

Live coral cover in bays 6 and 7 (P. Kechil) are 34 and 43.1 percent respectively (see table 20). Both reefs are narrow and shallow and coral cover ceases at a depth of 8m. Acanthaster damage on the dominant Acropora appears minor, but plankton and suspended sediments make the water cloudy and unpleasing. Bay 8 is similar in general appearance and recorded parameters (see table 20).

Bays 9 (T-4) and 10 (SS) are notable for high densities of Tridacna clams, with 20 and 14.7 individuals per 100m² respectively. This is higher than any other site in the study. Bay 10 has a shallow reef with high coral cover and diversity. Most coral below 4m
has been broken, shattered or inverted, presumably from blast fishing and anchors (De Silva pers. comm.).

Pulau Susu Dara, an islet west of P. Kechil (not shown on figure 28), was also surveyed because of its drastic condition. The once Acropora-covered reef flat now has 2 percent live cover. The damage is caused mostly by Acanthaster and also by blast fishing.

All sites surveyed at Perhentian have high percentages of rubble and dead standing coral, indicating both natural (Acanthaster) and human caused damage. The protected shallow climax coral communities, dominated by Acropora formosa, may have been vulnerable to large-scale Acanthaster infestation in the late 1970's. Now almost no Acanthaster are seen (recorded only at Bay 6). Blast fishing may be a problem, although it was not observed directly, and small-scale fishing boats may cause the apparent anchor damage.

Biogeographically, the islands off the east coast of Peninsular Malaysia are distinct from those east across the South China Sea. This, and the poor habitat may explain the low diversity of fish. Nine species of chaetodontids is lower than any other study site. In contrast, coral genera density is moderate and the total genera (39) is comparable to many study areas.5

It is notable that Tridacna density is high, indicating a low exploitation rate and possibly little reef gleaning by local fishermen. This favorable exception aside, the Perhentian reefs in general are not rich fishery resources.

There is also little potential for tourists, as the generally low visibility, moderate coral condition, and low fish diversity give a poor aesthetic impression.
Pulau Perhentian reef use. Several visits to a fishing village on P. Rechil provided observational and interview data about how local residents depend on marine resources. Almost all of the 150 families living on P. Rechil make more than 50 percent of their income from fishing. Several families own small stores, some have small farms, and some are beginning to grow cloves as a cash crop. Although most have home gardens and raise fowl, all receive about 75 percent of their protein needs from seafoods. Half of the fishermen do not own their own boats, but work for others on small to medium-sized diesel fishing trawlers. Several families are middlemen for fish export. An additional source of income for about 12 families is the collection and export of sea turtle eggs, as discussed below.

Hook and line in deep water is the most common fishing method, except during the monsoon months of November through February. Then reef fishing in protected areas is common. Local reefs are an important breeding ground for cuttlefish and possibly squid, which are caught by jigging in March and April (De Silva pers. comm.). They are dried and exported as an important cash source. Nets are seldom used and 3 to 4 offshore trawlers are based in the island. These hire local fishermen. Large fish traps made from chicken wire are used by about 10 percent of the fishermen, but very few report reef gleaning for subsistence food or shells. This contention is supported by the plentiful and large Tridacna which are unexploited on the reefs. Blast fishing on north P. Rechil was attributed to outsiders.

Environmental surveys suggest that the fishing ground should be large enough to support the village of 700 people, yet the reef fishery appeared depleted and fishermen reported decreasing catches.
They attribute this decline to outside trawlers which catch pelagic fish and squid. The outsiders include Thai fishermen seen during the author's survey. Habitat disturbance was not suggested by fishermen as a reason for declining catches although most of them were aware of the *Acanthaster* invasion of the late 1970's. Sea turtle and egg abundance was also reported to be declining.

Tourists are a recent phenomenon in the area. Local residents make small incomes by selling food to tourists and renting out beach shelters on P. Besar. The village headman owns two such rental houses. Tourists are attracted by the white sand beaches, the lush tropical vegetation, and the swimming rather than the underwater scenery.

Collection of sea turtle eggs is licensed in Malaysia, and in Perhentian the license is owned by one man and shared with ten others. It was valued at $17,700M (8000US) in 1983. Hawksbill (*Penyu sisak*) and Green (*Ibu agar*) sea turtle eggs are collected at Perhentian and sold in Kuala Besut for $.35M and $.67M respectively. The annual income averages $5000M/11 people. Average clutches of 70 eggs (Green) are collected from April through October with a peak of 120 nests in July. A total of 530 (Green) nests were reported in 1983. Collectors frequent eleven beaches on the two islands and rarely miss a nest. About 10 percent of the eggs are purchased by the National Fisheries organization for hatching. With a hatching rate less than 40 percent and the subsequent death of hatchlings in purse seine nets, the prospects for long term survival of the turtle populations are dim.
Pulau Perhentian management and recommendations. Like most islands on east coast Peninsular Malaysia, Pulau Perhentian are continental high islands, with forests and aesthetically pleasing coasts, but lacking attractive fringing reefs. They draw some tourists but are of most value as fisheries for local residents. The initial survey of May 1984 is the first step toward formulating management plans under the auspices of national and state agencies and UPM.

The community on P. Kechil appears generally prosperous. A variety of occupations are available although most residents are fishermen. People have noted a decline in squid, some fish, and sea turtle abundance, but serious depletion problems are not evident. Locals feel that outsiders are causing fishery depletion and they would support protection of the islands from non-local fishermen.

Management problems center on destructive and excessive use of the island fisheries. Local people damage the environment by some blast fishing and dropping anchors, but they are probably not responsible for overfishing. Large trawlers from Peninsular Malaysia and Thailand probably help deplete benthic and pelagic fish, but not reef fish. To the extent that local fishermen depend on reef fisheries which are in bad condition and on pelagic fisheries which are overexploited, there is a conflict of interest. A solution may lie in a combined zonation and reef revival scheme.

Natural improvement of reef quality will take time and must be combined with education of local people to prevent further destruction. Legal support prohibiting fishing by outsiders may also be needed. Zonation of Perhentian reefs might include:
1) permanently protected areas which can serve as breeding grounds for fish and squid and can attract diving tourists (i.e. east coast P. Besar); 2) areas for ecologically sound fishing; and 3) temporarily protected areas where improvement in reef quality is monitored by fishermen and fishing is resumed when appropriate. A plan which gives reef and shore (in the case of sea turtles) rights to local people will involve them in conservation efforts and nondestructive use of resources. Tourism encouraged by better quality reefs is a by-product of such a scheme.

Effective zonation of the waters surrounding Perhentian is difficult because of the problems of enforcement. The national Department of Fisheries, for example, has a very limited patrol capacity for east coast Malaysia. A zonation plan would include areas where outsiders and locals could fish and areas where only locals could fish. A boundary surrounding the island shores should be set at about 500m where outside boats could not enter. Detailed surveys are needed to determine actual disturbance in fisheries and seasonal patterns before zonation is attempted.

Several specific recommendations for progress toward comprehensive management of Perhentian are to:

1. formulate legal agreements between managing agencies;
2. collect remaining baseline data necessary for planning and zonation;
3. begin education programs in the island community;
4. coordinate tourist interests between outside parties and local people;
5. formulate sanctuary areas (which don't conflict with local fishing patterns) with the local community;
6. designate sea turtle sanctuaries;
7. enforce current laws on illegal fishing (destructive types) by nationals and illegal entry by Thai fishermen;
8. encourage monitoring of reef condition by local people in relation to natural and human caused damage; and
9. communicate with commercial fishermen about potential conflicts of interest and overfishing.

4.16 Pulau Redang

Although Pulau Redang was not visited by the author, it is included as a site because it is the first legally protected area off Peninsular Malaysia. Marine environment and reef use patterns resemble those of P. Perhentian (De Silva pers. comm.), as do management problems. The national perspective discussed here may thus indicate what problems and issues may be faced by P. Perhentian and other offshore islands in the future.

Pulau Redang lies 22 km north of the Trengganu coast in east Malaysia (see figure 26). The high forested island is 6 km wide and 7.5 km long and has several small fishing villages (Green et al. 1979). Shallow coral outcrops flourish in areas sheltered from direct storm and monsoonal influences. The southeast coast of Pulau Redang has extensive white sand beaches, and off it lie seven islets, one large shoal, and four or more submarine outcrops. Each islet has more or less extensive coral areas, depending on exposure and reef shape (Green et al. 1979). It is this coast and islets which are included in the national park area.

First surveyed in 1977, the coral reefs of Pulau Redang were reported to be in excellent condition. Lulofs (1979) writes: "The
south coast of Redang contains the most extensive and viable coral reefs still existing in Malayan waters. Assuming this to be correct, the same reefs are much changed today (1984). De Silva (pers. comm.) reports significant damage, presumably by Acanthaster and destructive fishing.

After completion of WWF Malaysia's 1977 field survey and management plan for P. Redang, recommendations were made to the Trengganu State government and national Department of Wildlife and Fisheries for protection and management of the area. No legal agreement was reached until May 1983, when the area was gazetted as a national marine park (New Straits Times 1983). Because 35 percent of the fish caught on east coast Malaysia are "reef-associated," a protected area was seen as a necessary breeding ground and controlled zone for reef species important to inshore and offshore fisheries. Tourism was also cited as a reason for protection.

Field management is supposed to begin in 1984, but WWF Malaysia reports this may be optimistic (Chan pers. comm.) due to complex jurisdictional issues. The park will be managed by the Trengganu State government in agreement with the national Departments of Fisheries (for marine areas) and Wildlife (for terrestrial areas). As no actual management has begun (1994), a continuing problem may be determining which government agency has the jurisdiction and capacity for management over the marine area. It is not clear that the state can manage the area as a national marine park in a neutral manner.

For example, the state could decide to promote large-scale tourism, thus eroding local Redang support and undermining other conservation or fishery-related goals.
Universiti Sains Malaysia plans to formulate a more complete and current management plan for Redang. It will focus on achieving a sustainable use of fishery resources and documenting local use patterns and needs. Presumably, it will put the perspectives of Redang residents in the forefront.

The overall theme emerging from these observations concerns the various levels of jurisdiction and interests. At the national level there is a conflict of interest between the Departments of Fisheries and Wildlife over management goals. While Fisheries can declare protected waters for fishing, it has little interest in preservation or tourism. Wildlife has an interest in parks and reserves but has no jurisdiction over marine areas. The state government has jurisdiction over the land but the national government controls the water. In addition, the local villages which use the marine resources have no rights over water areas. They are thus not encouraged to engage in sustainable use because their fishing grounds are fished by outsiders.

The jurisdictional tensions which emerge in the consideration of P. Redang will also arise at P. Perhentian as management is planned. It is thus suggested that local, state and national agencies be considered in the management plan and that the communication channels proposed be opened.
Notes

1. McManus et al. (1981) refer to the shallow-water platform which supports coral communities rather than fringing reefs. This is done because it is believed that the underlying geological formations are more important to the reef morphology and distribution than the actual growth of coral to form a "fringing reef". This distinction may be more valid for high islands as contrasted to low coralline islands. All other study sites in this study are described as fringing reefs even though they all may not technically be fringing. The distinction is difficult to make without adequate geological data.

2. The task force is composed of consultants from MNR and representatives from BFAR, University of the Philippines Marine Science Center (UP-MSC), Bureau of Forest Development (BFD), Philippine Tourism Authority (PTA), Natural Resources Management Center (NRMC), National Environmental Protection Council (NEPC), and the Armed Forces of the Philippines-Philippine Navy (AFP-PN). The technical support group and field team, headed by Virgilio Palaganas of NRMC, is composed of NRMC, BFAR Coral Reef Research and UP-MSC personnel.

3. Dynamite fishing, although banned by the government, has been continuously done in the area by unscrupulous fishermen, most of whom are from other parts of Batangas or Mindoro. The onset of commercial fishing, or large "bascigan" boats, with up to 18 electric lights for night trawling, has dwarfed the single man and lamp boats.

4. Patch reefs are found in areas of generally shallow substrate (i.e. the Sunda Shelf) and grow sporadically to form submerged and sea level reefs in association with sand cays.

5. The UP&M survey team found 51 genera with intensive search methods during the ten-day trip. Thus, the 39 genera sighted on four transects or within 400 m² represents approximately 75 percent of the genera in the vicinity.
CHAPTER FIVE
COMPARISON OF SITES AND PROGRAMS

5.1 Introduction

Documentation of the qualitative condition of coral reef areas is a principal purpose of this thesis. This has been presented site by site in chapter 4. In chapter 5 between-site comparisons of reef parameter data, human influences, and environmental setting are made. Section 5.2 compares environmental parameters among study sites. The effects of management, exploitation levels and environmental settings on reef quality are explored in section 5.3. This section also summarizes the importance of negative human and environmental influences on reefs. Section 5.4 takes a detailed look at how different management approaches affect the environment, and section 5.5 presents specific evidence for coral reef sustainability. Since the data are not repetitive and since each site is unique in many ways, quantitative statistical analysis is not used. Conclusions are derived from qualitative comparisons between sites, allowing for a holistic consideration of the various factors affecting coral reef habitats.

5.2 Environmental comparisons among study sites

Table 21 summarizes the quantitative data for each study site. The parameters selected for this table are indicators of the relative richness of habitat and the relative impact of environment, human use,
Table 21

Summary of Reef Quantitative Data (Percent Substrate Cover, Abundances, Noticeable Damage, Topography, and Indicators of Management, Exploitation and Remoteness) for All Study Sites*

| STUDY SITES** | ARL | ANR | SRL | SNR | BAL | BAN | MAO | SOM | ARR | ARI | TUB | CAL | BB | BHK |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|
| **PARAMETERS** |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |
| **PERCENT SUBSTRATE** |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |
| rubble & dead standing coral | 18  | 10  | 12  | 26  | 34  | 42  | 19  | 30  | 21  | 22  | 14  | 19  | 26  | 32 |
| Total Sediment | 38  | 57  | 39  | 71  | 68  | 81  | 44  | 42  | 30  | 61  | 41  | 72  | 56  | 67 |
| Hard Coral | 44  | 28  | 46  | 16  | 21  | 18  | 33  | 46  | 47  | 29  | 50  | 20  | 34  | 29 |
| Total Coral (soft and hard) | 62  | 43  | 61  | 29  | 33  | 19  | 56  | 58  | 70  | 39  | 58  | 29  | 44  | 32 |
| **ABUNDANCES** |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |
| Hard Coral Genera/100m² | 28  | 25  | 32  | 28  | 38  | 22  | -   | 26  | -   | 33  | 35  | 33  | 37  | 26 |
| Total Hard Coral Genera | 48t | 48t | 55t | 55t | 52  | 37  | 50  | 45  | 41  | 49  | 44  | 42  | 42  | 39 |
| Tridacna/100m² | 0.5 | 2.0 | 1.7 | 2.0 | 0   | 0.7 | -   | 0   | -   | 1.5 | 19  | 7.5 | 0.8 | 6.9 |
| Chaetodontid Species | 21  | 25t | 22  | 14  | 26  | 10  | 21  | 23  | -   | 27  | 27  | -   | 22  | 9  |
| Noticeable Damage (1-10) | 2.8 | 5.7 | 1.8 | 3.3 | 3.4 | 5.6 | 2.1 | 4.0 | 1.0 | 2.0 | 2.2 | 1.7 | 4.1 | 5.2 |
| Topography (m) | 2.5 | 2.0 | 2.3 | 1.4 | 1.4 | 0.7 | 1.3 | 0.9 | 2.5 | 1.6 | 1.9 | 1.2 | 2.0 | 2.0 |
| Management Status (0,1,2) | LF  | 0   | LF  | LF  | 0   | 0   | L   | L   | LF  | 0   | LF  | LF  | 0   |    |
| Exploitation Level (0,1,2) | 1   | 2   | 0   | 2   | 2   | 2   | 1   | 1   | 0   | 1   | 1   | 0   | 0   | 1  |
| Remoteness (0,1,2) | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 2   | 2   | 2   | 1   | 1   | 1   |    |

* Data from Tables 9-20 and site descriptions in Chapter 4
** Codes for sites are given in Table 8
† total for reef
L Legal protection or management
F Field management existing
0 No management, not exploited and/or not remote
1 Lightly exploited and/or remote but still accessible to fishermen
2 Heavily exploited and/or remote, not easily accessible
and management. Study sites here and on following tables include only those areas where primary data were collected. Those sites where reserves exist (e.g. Sumilon Island, Apo Island, and Apo Reef Island) have each been considered as two separate sites, reserve and nonreserve.

Those parameters which indicate disturbance include percentage of rubble, percentage of dead standing coral, percentage of total sediment, and noticeable damage rating. Higher than normal percent rubble and noticeable damage is caused by physical damage to corals from various reef uses. Dead standing coral tends to indicate Acanthaster or other predator infestation and/or encrusting organisms. The level of exploitation may be discerned from Tridacna density, and in some cases a low chaetodontid diversity may indicate intense fishing.

Chaetodontid diversity, topographic relief, and total sediment cover are all indicators of habitat richness. Total coral cover (including soft coral) indicates general habitat richness. While hard coral cover normally indicates the same, it also carries information concerning physical reef disturbances because of its fragile structure. General biologic richness can be read from hard coral genera density and diversity, both of which are little affected by most disturbances.

Management status, exploitation level and the remoteness of each site are also presented in table 21. This information has been extracted from chapter 4 site descriptions and roughly quantified. Management status is expressed as non-existing (0), legal (L) and/or field (F). Exploitation level is rated as absent (0), light (1) or
heavy (2), as defined by these study sites. Remoteness is rated as not remote (0), moderately remote but accessible to fishermen (1), and remote, not easily accessible to humans (2). These provide a simple indicator of site accessibility to exploitation, use and management.

In general, two contrasting site environments emerge from table 21. Apo Reef Island reserve (ARR) shows the highest mean total coral cover (70) while Bantayan (BAN) reef shows the lowest (19). Consistent with the high coral cover, Apo Reef Island reserve has low (1) noticeable damage and high (2.5) topographic relief. A rich habitat in excellent condition by study standards, ARR is also remote (2), not exploited (0), and has some legal protection and field management (IF). It may be assumed that the remoteness, lack of exploitation, and/or management have contributed to the well preserved reef.

In contrast, Bantayan reef (BAN) is not remote (0), is near a city and highly exploited (2), and is not managed (0). It also shows the highest rubble and dead standing coral cover (42) and a high noticeable damage (5.6), both of which are indicators of disturbance. In addition, the habitat is poor by measures of hard coral genera density (22) and chaetodontid species (10). This site has obviously suffered from its location, associated use, and lack of protection.

Similar comparisons can be made for each study site from table 21.

5.3 Effect of management, exploitation and setting on reef quality

Reef quality variations. Ranking each study site by coral cover provides a gradation from high to low reef habitat richness (see
figure 30). Complementing this ranking are trends for topographic relief and chaetodontid species diversity. Both trends show a similar progression from high to low with several individual variations explained in chapter 4. Hard coral genera density is shown and management status, exploitation level and remoteness as described above are included.

The first four sites of figure 30 (Apo Reef reserve (ARR), Apo Island reserve (AR), Sumilon reserve (SR), and Tubbataha (TUB)) have very high habitat richness by all indicators and show a comparison between remote and not remote areas. ARR and TUB are both remote, TUB has no management and ARR has low level management, and exploitation is zero at ARR and low at TUB. Remoteness thus seems important in habitat condition, given naturally rich habitat areas.

Apo Island reserve (AR) and Sumilon reserve (SR), in contrast, are not remote, but both have legal and field protection. Management here is the important factor, especially when considering the heavily exploited surrounding reefs of both AR and SR.

Sombrero Island (SDM), Moalboal (MDA), and Bali Barat (BB), not considered remote, also have relatively rich reef habitats. All are legally protected and BB has field management. SDM and MDA are both lightly fished and frequented by tourists while BB has no fishing and increasing tourism. Considering site uses and the relatively good reef quality, these areas may also be examples of the generally favorable impact of management in maintaining reef quality.

Sumilon nonreserve (SNR), Calauit (CAL), and Bantayan (BAN) show the lowest coral cover of all sites and together with Perhentian (PBK), these sites have the lowest chaetodontid diversity. They all
Figure 30. Site Reef Habitat Richness Ranked by Coral Cover as Compared with Hard Coral Genera Density, Chaetodontid Species Diversity and Topographic Relief, Management, Exploitation and Remoteness
appear to have inherently poor habitats. HBK and CAL are less affected by human use, since exploitation levels are low (1 and 0 respectively) and the sites are moderately remote (1). In contrast, SNR and BAN, when compared to nearby sites such as SR and AR, have potentially richer habitats than HBK and CAL. However, because of high levels of exploitation (2) and accessibility at SNR and BAN, these habitats are in poor condition.

In contrast to the scheme of relative habitat richness shown in figure 30, each site may be viewed from a perspective of relative habitat limitation and disturbance. Figure 31 ranks sites by total sediment cover and compares them as to rubble cover, noticeable damage, *Tridacna* density, remoteness, level of exploitation and management.

Bantayan Beach (BAN), Balicasag Island (BAL) and Apo Island nonreserve (ANR) are not remote and show high levels of exploitation. All have no management. Although specific influences vary, the general reef condition and use situation is similar for each. Here uncontrolled human use and easy accessibility without management guidance appear to contribute to reef degradation. The indicators of disturbance correlate well here with stressed reefs.

Caluit Island (CAL) and Sumilon Island nonreserve (SNR) are not inherently rich habitat areas. CAL shows low indicators of disturbance which implies that the management, relative remoteness and low exploitation may have a maintenance effect. At CAL fishing would probably be heavier if not for protection. SNR, in contrast, is heavily fished and used for recreation, and it shows signs of disturbance. Nevertheless, some maintenance effect is indicated by a
Figure 31. Site Reef Habitats Ranked by Total Sediment Cover and Coral Rubble as Compared with Noticeable Damage, Exploitation, Tridacna Density and Remoteness
reef flat which has substantial new coral growth of *Acropora* and *Seriatopora* (see chapter 4).

*Tridacna* density is shown on figure 31. Density is universally low where exploitation is heavy and the site is not remote. In contrast, several sites (Caluit (CAL), Perhentian (PBK) and Tubbataha (TUB)) have higher densities. Moderately remote and unexploited CAL shows high numbers of small clams and remote TUB has higher numbers of medium-sized *Tridacna*. PBK is the only accessible and exploited site where there is a high density of *Tridacna* because the local people do not collect them for food.

**Factors affecting reef quality.** Human and natural influences on reefs at all study sites are summarized in table 22. The most common fishing methods are shown, and their frequency and degree of impact are indicated. Reef influences occurring frequently (F) or occasionally (O) are qualified by significant negative impact (+). Negative impact is determined by general observation of reef condition in terms of coral rubble, dead standing coral, and obvious physical disturbance to coral as quantified by the index of noticeable damage. Recreational uses, three common types of pollution, and scientific uses are also included as reef influences. Natural environmental influences are limited to the obvious and most significant (i.e. storms, *Acanthaster*, and 'other predators').

Hook and line fishing, reef gleaning and spearing are the most common fishing methods at all sites (see table 23). Hook and line is harmless to the physical environment, but reef gleaning is damaging because of reef walking techniques. Blasting and *muro-ami*, although
Table 22

Impact and Frequency of Human and Natural Influences on Reefs at All Study Sites

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<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
</tr>
<tr>
<td>other predators</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
<td>O+</td>
</tr>
</tbody>
</table>

* Codes for sites are given in Table 8
F Frequent
O Occasional
+ Significant impact as determined by cover of coral rubble and dead standing coral and level of noticeable damage
Table 23

Composite Frequency and Negative Impact of Reef Uses and Natural Events at All Study Sites

<table>
<thead>
<tr>
<th>REEF INFLUENCES</th>
<th>NUMBER OF SITES</th>
<th>FREQUENCY* (Percent)</th>
<th>NEGATIVE IMPACT** (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Uses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing</td>
<td>11</td>
<td>79</td>
<td>-</td>
</tr>
<tr>
<td>Hook and Line</td>
<td>11</td>
<td>79</td>
<td>11</td>
</tr>
<tr>
<td>Anchors</td>
<td>10</td>
<td>71</td>
<td>80 ***</td>
</tr>
<tr>
<td>Gleaning</td>
<td>10</td>
<td>71</td>
<td>60 ***</td>
</tr>
<tr>
<td>Spearing (traditional)</td>
<td>9</td>
<td>64</td>
<td>33</td>
</tr>
<tr>
<td>Bottom Nets</td>
<td>8</td>
<td>57</td>
<td>50</td>
</tr>
<tr>
<td>Traps</td>
<td>6</td>
<td>43</td>
<td>50</td>
</tr>
<tr>
<td>Blasting</td>
<td>4</td>
<td>29</td>
<td>100 ***</td>
</tr>
<tr>
<td>Muro-uni</td>
<td>3</td>
<td>21</td>
<td>100 ***</td>
</tr>
<tr>
<td>Poison</td>
<td>1</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Recreation</td>
<td>13</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>Snorkeling</td>
<td>13</td>
<td>93</td>
<td>8</td>
</tr>
<tr>
<td>Scuba Diving</td>
<td>12</td>
<td>86</td>
<td>8</td>
</tr>
<tr>
<td>Anchors</td>
<td>10</td>
<td>71</td>
<td>90 ***</td>
</tr>
<tr>
<td>Spearing (Scuba)</td>
<td>6</td>
<td>43</td>
<td>100 ***</td>
</tr>
<tr>
<td>Collecting</td>
<td>6</td>
<td>43</td>
<td>83 ***</td>
</tr>
<tr>
<td>Scientific</td>
<td>14</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Research or Monitoring</td>
<td>14</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Collecting</td>
<td>9</td>
<td>64</td>
<td>22</td>
</tr>
<tr>
<td>Education</td>
<td>8</td>
<td>57</td>
<td>0</td>
</tr>
<tr>
<td>Pollution</td>
<td>14</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Garbage</td>
<td>14</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>5</td>
<td>36</td>
<td>40</td>
</tr>
<tr>
<td>Chemical</td>
<td>2</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>Natural Events</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Storms</td>
<td>10</td>
<td>71</td>
<td>10</td>
</tr>
<tr>
<td>Acanthaster</td>
<td>7</td>
<td>50</td>
<td>71 ***</td>
</tr>
<tr>
<td>other predators</td>
<td>3</td>
<td>21</td>
<td>0</td>
</tr>
</tbody>
</table>

* Percent of all sites where influence occurs
** Percent of sites showing negative impact where influence occurs
*** Incidence of negative impact more than 60 percent
not common, are destructive when used. Anchors related to fishing have a negative impact at 80 percent of the sites where anchoring occurs (see table 23).

Snorkeling and scuba diving have little effect on the reef. In contrast, spearing on scuba has a negative impact at 100 percent of the sites where spearing occurs because of the scare and selection effects on fishes in snorkeling and diving areas. Collecting, although not common, is damaging when done intensively. Recreation boat anchors are another negative force in many reef areas.

Some type of research and monitoring is performed at every study site. The only negative aspect of scientific reef work is overzealous collecting.

Small amounts of garbage pollution occur at every site, and plastics and bottles mar beaches in remote areas. Sedimentation is found in small quantities at five sites (see table 23). Chemical pollution, which occurs at only two sites, is considered to have a more negative impact because relatively low concentrations can adversely affect large reef areas (e.g. Bantayan Beach).

The most destructive natural reef factor is *Acanthaster*, seen at seven sites. None of these had numbers large enough to cause significant damage at the time of observation.

5.4 Effect of different management approaches on the environment

The term 'management' has been used to cover many types of protection and regulation, including legal regulation, field management, national strategies, and locally administered schemes.
Differences in types of management have been discussed in the site descriptions and are again referred to here. An attempt is now made to isolate more and less effective types and levels of management.

Types of management are characterized by approaches used by management agencies. These approaches may include strong legal enforcement and interpretation of laws, participatory decision-making, education, presence of tourism, exacting field research, and active or passive field personnel. Levels of management refers to the governmental body from which management originates. Typically, local community, municipal, provincial and national are levels of managements.

The composite apparent impact of management inputs in relation to reef location and exploitation is shown in table 24. The relative strength or presence of each factor is quantified by assigning three levels (0,1,2) based on site analysis and general observations (see chapter 4). The relative importance of each factor in causing the apparent impact cannot be determined. Thus, the "composite apparent impact" is arrived at by combining the factors shown in table 24 with field impressions comparing all sites. As shown in chapter 5, strong management with two or more inputs correlates with low exploitation levels and incidence of destructive uses. Nevertheless, an exact cause-effect relationship is uncertain.

Municipal level control affects only those sites close to or adjacent to municipal governments. No remote sites fall under municipal jurisdiction. Five study sites fall within municipal jurisdiction (see table 24). Apo Island reserve (AR), for example, has been made legal by the town of Dauin, Negros, and it has been
Table 24

Management Types and Their Relative Effectiveness at All Study Sites

<table>
<thead>
<tr>
<th>STUDY SITES*</th>
<th>AR</th>
<th>ANR</th>
<th>SR</th>
<th>SNR</th>
<th>BAL</th>
<th>BAN</th>
<th>MOA</th>
<th>SOM</th>
<th>ARR</th>
<th>ARI</th>
<th>TAD</th>
<th>CAL</th>
<th>BB</th>
<th>RBK</th>
</tr>
</thead>
</table>

**LOCATION—USE—CONDITION**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Code 0</th>
<th>Code 1</th>
<th>Code 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remoteness (0, 1, 2)**</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exploitation Level (0, 1, 2)</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Destructive Use (0, 1, 2)</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Relative Coral Cover (a, b, c)</td>
<td>a</td>
<td>b</td>
<td>a</td>
</tr>
</tbody>
</table>

**MANAGEMENT INPUTS**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Municipal LF</th>
<th>LF</th>
<th>LF</th>
<th>National LF</th>
<th>LF</th>
<th>LF</th>
<th>LF</th>
<th>LF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Education (0, 1, 2)***</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Scientific Interest (0, 1, 2)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Tourist Interest (0, 1, 2)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Composite Apparent Impact****</td>
<td>+</td>
<td>N</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>N</td>
<td>-</td>
</tr>
</tbody>
</table>

* Codes for sites are given in Table 8.

** Codes of evaluation given in Table 21 and text:

- a > 45 percent
- b > 32 percent < 45
- c < 32 percent

*** Codes for education, scientific and tourist interest; not present (0), moderate (1), strong (2)

+ positive

N neutral

- negative

**** As noted in Table influences and explained in site descriptions (see chapter 4) by general area observation and comparison to other study sites.
given some field support by the Apo barrio village and Silliman University. The Apo Island nonreserve, on the other hand, has no legal protection. In contrast, the Sumilon nonreserve is considered a buffer zone and is municipally protected from destructive activities. Sumilon reserve (SR) had full protection municipally until political changes affected the reserve (see chapter 4). Moalboal beach area and Pescador Island (MDA) are legally protected from destructive activities and Bali Barat (BB) has received legal support from the local Balinese government. Four of these five municipal sites show an apparent positive effect as evidenced by high coral cover and/or other reef maintenance effects due to management inputs (see table 24).

National legal support exists at seven sites and four of these have some form of field management (see table 24). At Sombrero Island (SDM) this consists simply of frequent visits by ministry employees, while Apo Reef reserve (ARR) has two coast guards and two PC personnel stationed on the island. Both Cabilao (CAL) and Bali Barat (BB) have full, rationally supported park staff present. Six of these seven rationally protected sites show an apparent positive effect from management inputs (see table 24). The only site with some legal-field management and showing a negative impact is Sombrero because of poor tourist control.

Education of local people is a factor at eight non-remote sites (see table 24). Apo Island, Negros has had educational inputs since 1978 and the communities of fishermen which frequent Sumilon Island since 1974. Balicasag (BAL), Bantayan (BAN), Moalboal (MDA) and Sombrero (SDM) have been exposed to formal and/or non-formal educational programs since 1977 or 1978. In all cases, educational
efforts serve to increase the awareness of local people about the value of the reef habitat to the fishery (see chapter 4). Also, these people are more aware of the impact of destructive fishing methods and intensive reef use. In general, educational inputs correlate with municipal level management of sites: the four sites with the most educational activity (Apo reserve [AR], Apo nonreserve [ANR], Sumilon reserve [SR], and Sumilon nonreserve [SNR]) are all managed locally. This correlation exists because local management (e.g., Apo Island) has been predicated on participation and knowledge of community members.

Scientific interest and tourism may exert a protective or management effect on a coral reef area. The presence of research may educate local people and increase environmental awareness. If a scientific institution is present, blatantly illegal activities tend to be minimized. This is true at Sumilon Island, where Silliman University researchers are often present. Although tourism may cause minor damage, most tourists and tour companies are foresighted enough to realize that an intact reef habitat will attract more tourists and that a destroyed area will not. This argument is also convincing to local residents who depend on tourism. At Balicasag, where divers are attracted by the aesthetic habitat, islanders benefit from the sale of precious shells. Table 24 shows a correlation between richness of habitat and incidence of tourism, and the usually positive (or neutral effect of management.

Municipal and/or national legal and field management is present at all sites showing some form of reef maintenance. At each readily
accessible site, education is a strong factor. At remote sites, distant communities make education impractical. Tourism is associated with the better quality sites and in combination with management can have a positive impact. Tourism is equally associated with a negative impact when uncontrolled, as at Sombrero Island. National management in remote sites appears effective at Apo Reef, Galaut and Bali Barat. At these sites law enforcement is critical and is made possible by the presence of several armed personnel.

The effectiveness of any one management type is linked to the presence of other factors, as shown above. Sites showing the most positive effects also have good education programs for local people and legal support from national and local officials. Scientific and tourist interests are often present and may contribute to effective municipal management (e.g., SR and BB). Effective national management depends on some consistent field support. National enforcement and the presence of concerned tour operators are factors at most remote sites. For example, the only monitoring of Tubbataha Reefs is by tourist scuba diving boats whose operators are concerned with conservation.

5.5 Evidence for environmental sustainability

Positive and negative impacts on reefs must be seen in terms of long-term maintenance of reef environments. A negative impact implies degradation or erosion of quality, indicated in this thesis as a predominance of poor substrate cover. A positive impact does not imply only improved quality, but also reef maintenance, which could
allow improvement over time. No longitudinal improvement in reef quality has been measured during this study; rather, the potential for improvement has been documented.

Reef sustainability can best be documented over several years of observation of key reef parameters. This study has documented some reef substrate cover parameters over a three-year period. As explained above, gross negative changes have been noted at one site (Bantayan) but more subtle changes have not been documented. Nevertheless, a few sites where good management is present show some indications of stability over time. The other sites appear from the composite analysis to be declining.

Several reef parameters are useful as indicators of reef stability and ecosystem sustainability. Substrate changes over time (longitudinal) or differences between similar habitat areas (cross-sectional) are used in this study. Fish density can equally be monitored over time or compared cross-sectionally between comparable areas with implications for levels of exploitation. Fish yield change has implications for level of exploitation and quality of habitat. Also, exploitation pressure or fishing effort observed cross-sectionally indicates potential fish density and yields between sites. Although difficult to obtain, good evidence for sustainability should include a combination of indicators with at least one longitudinal perspective.

Sumilon Island reserve has good evidence for sustainability. Fish yields from Sumilon during 1977-1980 ranged from 14 to 24 tons/km² for 'reef' fish. Between 1976 and 1979, the catch more than
doubled (Alcala 1981). In a comparative study between Sumilon, Apo Island, Balicasag and Bantayan Beach, Russ (1984) found Sumilon reserve had a significantly higher abundance of fishes, the highest overall species richness, a significantly higher species richness of chaetodontids, the highest abundance of most species considered as favorable 'targets' for fishermen, and a significantly higher standing crop of serranids than the other study sites. These comparisons do not show change over time per se, but when contrasted with Sumilon nonreserve they show that at least a maintenance effect has occurred in the Sumilon reserve since management began in 1974.

Apo Island reserve displays a rich reef habitat but has a substantially lower abundance and overall species richness of fishes and a much lower abundance of 'target' species than Sumilon reserve (Russ 1984). Even though evidence exists for habitat stability, it appears that fishing pressure is high and the reef fishery may not be sustainable. This has implications for improved management which could capitalize on the rich habitat by controlling fishing. The reserve is a first management attempt and is not totally honored by local fishermen.

The apparent strength of management at Bali Barat and Calauit Island is evidence for sustainability. Regardless of reef quality and assuming no serious historical destruction, strong management can insure the opportunity for reef maintenance. In both cases, the size of the areas and continued management should at least maintain the natural reef integrity.

Although remote, the Tubbataha and Apo Reef sites do not have guaranteed maintenance. They have so far benefited from being remote
and unexposed to over-exploitation. Heavier use and disturbances will come as accessibility increases. Some management at Apo Reef has fended off these dangers, but this protection is by no means certain or enduring. Tubbataha is guarded by weather and distance but is still vulnerable.
CHAPTER SIX

RELEVANCE FOR REGIONAL MARINE CONSERVATION

6.1 Introduction

As established previously (see chapter 2), marine reserves are considered a viable means of ocean resource management. Nevertheless, the Philippines, Malaysia and Indonesia are now only beginning to use reserves for coastal management, and they lack alternative approaches to management. One purpose of this study, therefore, is to identify ways in which knowledge about appropriate management schemes can be shared among countries. The study also proposes to enhance national management capability in relation to national needs and to identify common problems of reserve planning and implementation among these countries.

Chapters 6 and 7 take a regional perspective and discuss problems common to each country and solutions potentially useful for Southeast Asia. Section 6.2 discusses the usefulness of standardized data collection within countries and the region. Criteria for selecting management areas are discussed in section 6.3 with regard to both national and regional application. Several important regional sites for management are suggested in section 6.4, and various common national management problems are elaborated in section 6.5.

6.2 Standardized data collection

The practical implementation of marine reserves starts with complete field surveys, not unlike those undertaken in the field work
for this dissertation. A survey within one country should collect comparable data at all sites in order to make the exchange of information useful. In addition, exchange of data between countries, is facilitated by collection of comparable data in each place. It is thus recommended that standardized methods be established for general coral reef surveys conducted for management purposes.

In this study, data gathering methods were chosen for their simplicity, completeness in overall perspective, replicability, and relevance for management application (Dahl 1977). Also, the methods have been adapted for use by persons relatively new to the coral reef environment. This is important when inexperienced field workers are involved.

The data generated by the survey methods used in this study present an overall view of coral reef condition and provide enough specific information to allow monitoring over extended time periods. These factors are prerequisites for formulating good marine reserve management plans.

The author's field experience indicates that the three countries studied employ a variety of field methods to document their reefs. Either detailed data, relevant for in-depth research on one biotic community or organism, are being collected from small areas, or general, casual surveys with little long-term information value are being made. Consequently, the data provided to the author by other workers were usually not comparable to data collected at other sites. It would be more practical for survey groups to standardize their methods and resultant data.
The methodologies used in this study can be used as a beginning reference point. Systematic snorkel surveys by a practiced observer should note bottom substrate, indicators such as Acanthaster and Tridacna, visibility, and general reef morphology. Maps of land and marine areas should be made and some photographs taken. Longitudinal monitoring requires transects that can be repeated at similar locations on similar reef zones using replicable methods. Comparison between sites must take note of different reef zones (Russ pers. comm.) Monitoring of fish abundance, diversity and density has not been attempted for this thesis but is a useful and necessary complement to bottom substrate data. Methods using snorkeling and/or scuba for general or exact fish observation are recommended as described by Russ (1984).

Reef transects used to measure bottom substrate in this study (see chapter 3) were simple (see figure 4), as contrasted with those tested in Thailand in 1982 (UNESCO 1983). There, point quarter sampling was recommended for regional use. Experience with point quarter at four sites in this study suggests that it is unnecessarily time-consuming to gather and organize the data, particularly if bottom cover is the prime objective. It is thus suggested that line transect measurements be standardized as a common method.

Data collected by comparable methods are useful in several ways. They can be readily shared within and among survey groups. Workers become more practiced if similar methods are repeated, and efficiency of survey teams is increased. Standardized data better serve to evaluate a range of sites within a local region, an entire country, or
in Southeast Asia. Criteria can then be formulated for selecting priority areas for management, and decisions can be based on objective information.

6.3 Criteria and methods for selecting and ranking management areas

The criteria for selection of management areas may address how well the area fits the requirements and functions of reserves, and they may also be used to prioritize sites (Ray 1976). The following broad criteria were used to evaluate study sites in this thesis after initial surveys were complete. These criteria, derived from Ray (1976) and UNESCO (1974), are:

A. Ecological Criteria (conservation values):

1. representativeness and/or uniqueness—a unique site is one that is rare and a representative site is exemplary of a general area;

2. diversity—determines how large an area is needed to include various habitat types (e.g. mangroves and reefs) and a certain proportion of organism species or genera known to exist in the general geographic vicinity;

3. naturalness—the degree to which the environment has escaped alteration by human activity; and

4. criticalness—the degree to which important ecological functions or species life histories are dependent on an area. Examples are endangered species or feeding, resting and breeding areas essential to species and/or populations.

B. Practical Criteria (economic and use values)

1. feasibility for management (accessibility and/or existing management);

2. degree of threat or fragility;

3. value for food or other fishery resources;

4. aesthetic, recreational and tourism value; and

5. value for research and education.
The above criteria may be applied to each study site in this thesis in order to determine the overall site usefulness to conservation, economic and other use values. This is accomplished by correlating general site and reef quantitative data with the criteria categories. Site quantitative data can be used to evaluate uniqueness, diversity, naturalness, criticalness, value for food or other resources, and aesthetic, recreational and tourism values. Subjective evaluation combining general site information must be used to determine representativeness, feasibility for management, degree of threat or fragility, and the value for research, monitoring and education. Table 25 quantifies the criteria for each site using site and reef quantitative data and subjective or intuitive summation of the factors affecting each area. The result is a ranking of sites by the above criteria. Management priorities can better be set when an objective view of each site in relation to others is known (Salm and Usher 1984). Below is the step by step process used to evaluate one of the sites shown in table 25.

The values shown in table 25 are based upon the quantitative reef data gathered in field surveys and upon several subjective choices based on general site surveys. Bali Barat (BB), for example, has a 71 percent conservation value and a 71 percent practical value. Representativeness (2) is high at Bali Barat because the site includes most marine ecosystems and features common to the general geographic vicinity of Bali Island. Uniqueness, based on coral cover, is rated moderate (1) because coral cover falls below 45 percent. Diversity of ecosystems is high (2) because more than three ecosystems are present
### Table 25

Valuation of Ecological and Practical Criteria for All Study Sites

<table>
<thead>
<tr>
<th>STUDY SITES*</th>
<th>AR</th>
<th>ANR</th>
<th>SR</th>
<th>SNR</th>
<th>BAL</th>
<th>BAN</th>
<th>MOA</th>
<th>SOM</th>
<th>ARR</th>
<th>NRI</th>
<th>TUB</th>
<th>CAL</th>
<th>BB</th>
<th>BKB</th>
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<tbody>
<tr>
<td>Criteria</td>
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<td>Ecological</td>
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<td>Representativeness&lt;sup&gt;a&lt;/sup&gt;</td>
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</tr>
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<td>Uniqueness&lt;sup&gt;b&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Diversity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecosystems present&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0 0 1 1 0 0 0 0 1 1 2 2 2 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total coral genera&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1 1 2 1 2 0 2 1 1 1 2 1 1 0</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1 1 2 1 2 0 1 1 2 2 2 1 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Naturalness&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1 0 2 1 1 0 1 1 2 2 2 1 2 1 0</td>
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<td>Endangered species&lt;sup&gt;g&lt;/sup&gt;</td>
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<td>Conservation value (possible 14)</td>
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<td>Percent of total</td>
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<td>Practical Value (possible 10)</td>
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<td>Percent of total</td>
<td>90 70 90 70 60 60 60 70 60 60 60 40 30 70 20</td>
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<td>Combined mean value</td>
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* Codes for sites are given in table 8

- **<sup>a</sup>** low (0), medium (1), high (2)
- **<sup>b</sup>** relative coral cover, < 32 percent (0), 32 percent and < 45 (1), > 45 percent (2)
- **<sup>c</sup>** one ecosystem (0), 2-3 ecosystems (1), 3 or more (2)
- **<sup>d</sup>** < 40 (0), > 40 and < 49 (1), > 49 (2)
- **<sup>e</sup>** low (0), moderate (1), high including large species (2)
- **<sup>f</sup>** inverse of noticeable damage, > 5 (0), < 5 and > 2 (1), < 2 (2)
- **<sup>g</sup>** zero present (0), one (1), two or more (2)
- **<sup>h</sup>** no management (0), legal (1), legal and field (2)
- **<sup>i</sup>** no danger (0), vulnerable (1), highly vulnerable (2)
- **<sup>j</sup>** no dependence of local people (0), moderate dependence (1), high dependence (2)
- **<sup>k</sup>** chondriformes < 15 (0), > 15 < 21 (1), > 21 (2)
- **<sup>l</sup>** accessibility and feasibility poor (0), acceptable (1), good (2)
(i.e. coral, seagrass, mangrove, beach and estuarine). Total coral genera (1) falls below 49 and fish diversity from general impression is moderate (1). Noticeable damage seen on the reef results in a low naturalness rating (1), and criticalness is rated (2) because some endangered species are present (i.e. two species of sea turtle and some large Tridacna). The practical values are derived in similar ways. Feasibility of management is high (2) because it exists, is functioning, and is accessible. Degree of threat and food resource values are moderate (1) since the area has not traditionally been highly exploited. The aesthetic and tourism value is high (2) since chaetodontid diversity is more than 21, and the research, monitoring and education value is considered moderate (1) because of limited access to research organizations and Balinese people.

Some arbitrary decisions have been made in determining the values of criteria in table 25. These decisions are based on the range of data represented by the different sites and the range of impressions accumulated by the researcher. More sites would necessarily broaden the range of criteria rating. It becomes evident once again that data need to be consistent among sites and that more complete data allow a more objective evaluation. Also, the criteria used here are not exhaustive and the model presented is flexible.

The conservation values of table 25 reflect the environmental integrity of each site as compared to the others. This perspective includes not only the listed criteria (see above) but those conservation values not easily quantifiable, i.e. the preservation of gene pools, ecological processes and functional units, and the intangible value to humans to know that representative, pristine
environments still exist. These intangible values are reflected in the criteria of representativeness, uniqueness, naturalness, and criticalness on table 25. The practical value is quite different in that it represents the feasibility of management of a site in relation to economic value of site resources. It might be noted here that Tubbataha (TUB), with a conservation value of 93, has a practical value of only 40 because it would be difficult to manage and has a low immediate food resource value.

6.4 Important regional sites for management

The interconnections of ecosystems through the ocean medium is an important theme of this thesis. These interconnections have implications for localized management of one coral reef ecosystem, as well as for the macro-scale of large islands, current flows or species movement between distant places. With regard to marine resources, national boundaries in Southeast Asia are indeed "fluid", as many populations such as turtles, Dugong, whales and oceanic fishes may be shared by two or more countries. One country's neglect of a critical habitat, e.g. a turtle nesting beach, may mean a species' disappearance from a neighboring nation. Similarly, productive habitats in one country may affect production off its neighbor's shores down current. Larvae of organisms breeding in local marine ecosystems may be indispensable for the replenishment of areas far removed (Salm et al. 1982) (see chapter 2).

Even though this study does not focus on ocean habitat and movements of species, larvae, and/or nutrients, several management areas with regional importance should be highlighted. Multinational
collaboration and regional strategies for management of marine resources in these instances is a prerequisite for species protection.

Some strategies and regional plans are discussed in chapter 2 and here only certain sites are reconsidered. Sea turtle habitat and range, for example, normally cross national boundaries. Turtle Islands National Park in Sabah, cannot effectively protect turtle populations in the vicinity without cooperation from the Philippines. Equally, the only Loggerhead turtles nesting in Indonesia may be those spilling over from Sarawak into northwest Kalimantan. This population requires cooperative management between Malaysia and Indonesia (Salm et al. 1982).

Many ecologically rich areas or species habitats do not require cooperative management but are valuable from a regional or international perspective. These areas, although managed nationally, could often benefit from regional support. Such support, whether financial or moral, may provide an impetus to pending national management plans. Here a strong case is made for the management of several areas which may qualify as regional heritage sites of conservation value to more than one country. The areas surveyed or researched for this study and evaluated with international criteria include:

1. Beaches on the Trengganu coast of Peninsular Malaysia and in Pulau Perhentian and Redang where Green, Hawksbill and Leatherback sea turtles continue to nest in denser aggregations than in any other single area in Southeast Asia;

2. Apo Reef and Tubbataha Reefs in the Philippines, described in chapter 4 and evaluated above as having the highest conservation rankings of any site (86 and 93 percent respectively); both areas represent extensive, mostly intact, coral atoll ecosystems unmatched in Southeast Asia; and
3. Bali Barat National Park, currently being managed but in need of additional support to ensure long-term protection for both marine and terrestrial habitats in the park and to promote the value of the area for environmental education and tourism in an increasingly populated and exploited portion of Indonesia.

6.5 **Shared national management problems**

During the course of this research, numerous national management strategies and problems have been described. Some are particular to one country, but most occur in all three countries studied and have implications for management in Southeast Asia in general. A discussion of problems faced by each country follows.

The Philippines has been troubled by the lack of clear ministerial jurisdiction in its marine management programs. The Ministry of Natural Resources has failed to designate one agency responsible for marine management, and in areas where tourism is important the Philippine Tourism Authority has wanted to be involved. Consequently, few programs are clearly under the jurisdiction of one agency. Priorities change with political changes and continuity of programs suffers. Funds have been divided among many small projects, thus preventing sufficient, coordinated funding for a few, well-managed field projects. Personnel turnover among project employees has also contributed to lack of continuity.

The Philippines illustrates the need for defining several manageable field projects at the national level. These should either be managed by ministry personnel, as in the case of remote sites like Apo Reef, or by local municipal officials in an area such as Apo Island, Negros. Philippine legal and police support benefits locally managed projects and may be the most appropriate national contribution.
Key individuals are present in every successful marine management project in the Philippines. The consistency of management which does exist at sites like Apo Reef and Sumilon Island has often been dependent on one or two dedicated individuals.

In Indonesia a great deal of legislation protecting marine areas has never been implemented. Like the Philippines, ministerial and agency jurisdiction over field projects is not well-defined, and interagency squabbles over funds and program priorities are common. This has interfered with much marine field management (Salm pers. comm.). The few successful projects have depended on foreign expertise and financial support in their initial phases. At Bali Barat, for example, a dedicated local field manager assumed control from foreign advisors but has been subsequently frustrated by lagging financial and personnel support. Current management attempts in Indonesia are also confounded by low awareness of marine conservation among local people and the rapidly mounting pressure for exploitation of existing marine resources.

The integration of traditional fishing patterns into management plans has been accomplished for Pulau Seribu and Bali Barat through zonation schemes (see figures 22 and 25). Nevertheless, the patrolling of these zones is logistically difficult and expensive. A solution may involve large scale education campaigns and meticulous licensing of all reef users in the vicinity of these managed areas.

In Malaysia, which is less dependent on its coral reef resources for food, tourism is a major factor influencing conservation efforts. But once again governmental control is divided. The state governments are more autonomous in Malaysia and have jurisdiction over land area,
while the national government retains rights over marine areas (see chapter 4). Management with a tourism emphasis is state controlled while management of fisheries is national. This lack of coordination impedes effective local field management, and local communities have not become involved.

Malaysian nature organizations and universities have been able to gain national support for marine conservation via media and good public relations. Often this support funds field surveys and scientific studies, and excellent records of coral diversity and cover have been collected from many areas. Nevertheless, the strong emphasis on field data collection has not furthered field management.

Field surveys have not adequately documented local use and perceptions of marine resources. Management plans are thus not practical or inclusive of traditional use patterns, and they are weighted with theoretical rules of management for an ideal marine park.

Since Malaysian reef resources are already well documented, the next phase of field work may involve formulating and implementing workable field management procedures. The existing plans need testing, and field personnel need to be trained both at the local and national levels. Local education is needed as in the Philippines and Indonesia, but the process may be less tedious because the pressure on marine resources is less and the level of general education higher. Also, large-scale commercial use of marine resources will have to be considered in any useable management plan.

The problems of each individual country are present in varying degrees in all three countries. These commonalities may facilitate taking steps within national ministries to find solutions. The
problems of jurisdiction involve a struggle for power, and until definite priorities of management are decided, jurisdictions will remain unclear. Starting new programs is always a temptation because, initially, more interest groups are pleased and more personnel employed. Even as funding becomes scarce, programs suffer and become ineffectual. Such difficult issues take years to solve but a necessary prerequisite is increasing awareness of their existence among national policy makers.

Notes
1 Site comparability was lessened by not integrating reef zones into the survey design of this thesis. By comparing similar habitats or reef zones, it is easier to discern and control for the more subtle impacts of outside factors.
CHAPTER SEVEN
FINAL INTERPRETATIONS AND RECOMMENDATIONS

7.1 Introduction

The marine reserve as a concept and a place has been discussed at length in this dissertation. Nevertheless, a clear definition is lacking. This chapter defines marine reserve by ecological criteria and practical reality, and the marine reserve as a functional unit is discussed. Traditional and modern management are compared to give a cultural and historical perspective. Then progressing to current management problems, two levels of management are elaborated. Site specific management is contrasted with a national planning and management strategy. These final sections are elaborated with recommendations for improving current site and national management programs.

7.2 Marine reserve/park defined

A marine reserve is a defined space with limited entry and some form of management. This broad definition encompasses the various types of marine management discussed in this thesis. The many types of reserves represent a spectrum reflecting different degrees of control with different objectives (Polunin 1981) (see table 6). For example, one type of reserve is the marine 'park,' in which recreation or public education is emphasized (Ray 1976). In the basic reserve
system presented in chapter 2 (see figure 2) the 'core' and 'buffer'
areas are included within a reserve and/or a park. The core
constitutes that portion of a reserve or park considered the "critical
marine habitat" (Ray 1976:101) and is often synonymous with the
'sanctuary zone'. The buffer area surrounds the core and serves as an
'ecological buffer' protecting the core area. The buffer area may
include traditional or visitor use zones and linked habitats important
for ecological maintenance of the core area (Ray 1976; Salm 1984).

Defining core and buffer boundaries for reserves is not simple.
Theory suggests calculated ecological limits which are often difficult
to implement. Practice normally dictates less extensive and less
ecologically sound boundaries. Ray (1976:101) emphasizes the
interdependency between terrestrial and marine environments when he
suggests that marine protected areas "should incorporate adjacent land
areas either within their boundaries or in their management plans."

He makes two general recommendations:

1. "Boundaries for core areas should encompass entire ecological
units (habitats and communities) in so far as possible, including adjacent terrestrial areas," and

2. "Buffer zones should encompass upstream effects and contiguous
ocean water." (1976:101)

Salm (1984), in support of Ray's boundary principles, attempts
to more exactly define the size necessary for "critical marine
habitats" to maintain ecological processes through time. He discusses
which habitats and how large a reef area is needed to preserve the
biotic diversity of reef communities. According to Salm (1984), the
design of a reserve requires detailed knowledge of: 1) the coral
habitat to be included in a reserve (ie., the environmental survey
data of each study site of this thesis); 2) the neighboring coastal habitats (ie., seagrass beds, mangroves, beaches, and estuaries as defined in chapter 2); and, 3) the linkages between the various habitats, since "reefs are intimately linked by dynamic processes to distant areas and may be influenced by activities there; management must extend beyond the protected-area boundaries for reefs bordering large-island or mainland coasts." (Salm 1984:10). The links between habitats may even include upland forest areas which are sources of reef sedimentation.

Maintenance of reef species diversity within a defined area depends on the size of the area. Theoretically, an equilibrium state means that the extinction rate and the immigration rate of replacement species for a given area must be equal (MacArthur and Wilson 1967). On coral reefs the extinction and immigration rates are affected by many environmental and human factors (see chapter 2). Large protected areas tend to be more effective in maintaining ecological processes and species diversity, all factors being equal. This is particularly important if the preservation of biotic or genetic diversity is the principal management objective.

Salm (1984) contends that core areas need to contain at least 300 ha for each reef type in the Chagos Archipelago. This minimum core area was determined to be the smallest reef area in which all coral genera found in the vicinity would have a 100 percent chance of being found on all reefs of the same size. Similar studies have not been done for other reef organisms so the 300 ha criterion should be used with caution.
Although theoretical principles should be applied to the design of a marine reserve/park, there is a problem in integrating these principles (i.e., core and buffer zones as determined by ecological constraints) with practical limitations. This thesis is primarily concerned with describing what constitutes a marine reserve in practice. The site examples presented in chapter 4 outline the practical reality of reserves and how they are managed. The degree to which these existing reserves conform to the ecological principles discussed above deserves consideration.

Size is one theoretical guideline which has not been adhered to in practice. No managed areas in this study include a core or sanctuary zone of 300 ha. Although three proposed areas, Apo Reef, Tubbataha Reefs and Pulau Perhentian, have reef areas large enough to meet this criterion, practical management prospects for these large areas are unlikely. At Apo Reef, for example, only Apo Reef Island has been protected and only the northeast side of the island (an area of less than 10 ha) has been actively protected. Most reef areas studied are much smaller than 300 ha and due to the general physical setting and composition, few single reefs anywhere in the Philippines, Indonesia or Malaysia are 300 ha in size.

In contrast, the three guidelines requiring information on coral habitat, adjacent ecosystems, and linkages between habitats have been partially or completely met in all the managed areas cited. Detailed field studies with good environmental data have been completed in most cases. These data have been used to design the existing reserves within the practical limits of each site. A good example is Bali
Barat National Park, where field studies directly influenced design of park use zones. At Apo Island, Negros the reserve, or 'core' area, was located on the richest reef habitat not in conflict with traditional use. This points to one practical limit present in any reserve design, i.e., accommodating traditional and modern uses by humans.

7.3 Traditional and modern management

The management practices observed in this study include both traditional and modern techniques. If "modern" is meant to imply scientifically designed and implemented reserves, none exist. If "traditional" is taken to mean protection of an area because of native territorial rights, none exist in a pure form. Rather, elements of both approaches are present in varying proportions in the managed and proposed reserves studied here.

Although traditional management as described by Johannes (1978) in Micronesia does not exist in the areas studied, there are examples of territoriality and the presence of local control over reef resources. This desire for control is evident in the municipal reserves of Apo Island, Negros, Sumilon Island, Moalboal, and Pulau Seribu and P. Perhentian. In each place local people use and depend on reef resources. These people want to use and maintain their resources and to maximize their own benefits. When these traditional management forces are promoted in the context of non-destructive and sustainable use they serve to effectively manage reef areas. But indications from this study are that local interests cannot maintain a reef area without outside support and advice. It appears that
traditional management does not, and probably cannot, stand alone.

Modern management must be incorporated into traditional settings and combined with traditional desires. Each municipality studied here became interested in protection and reef maintenance only after outside models were brought into the community. Models or ideas were brought by the national government, local and foreign advisors, research organizations, private development organizations, and tourist companies. In each case the idea of protection for use and benefit by local people stimulated traditional feelings of territoriality. These feelings were then applied to some form of management.

The balancing of ideas and governmental control from outside against local needs, uses, and perceptions is the crux of successful management in the marine areas discussed. The equilibrium point is slightly different at each site, depending on environmental setting and condition, use and interests of locals and outsiders, and the management ideals to be implemented. The complex array of environmental, sociological, political, and personal factors affecting Sumilon Island was discussed in chapter 4. Sumilon Reserve, the product of these forces, is a small protected area with an uncertain future. While benefits from this protected area accrue to all parties concerned, several strong personalities and political interests continue to destabilize the situation. Here the traditional control of a local resource by local people and their mayor has been turned against the modern management imposed by Silliman University.

The problem of balance between outside inputs and local participation points to the subtle issue of how an outsider can
suggest management guidelines without endangering their potential for success. After observing management programs at Sumilon Island and Apo Island, Negros, Russ (1984) writes:

"efforts to introduce conservation and protective management programs to ensure rational use of a resource are often viewed as measures which deny an immediate and attractive gain on the basis of a promise of long-term gain to be reaped in the future. Such views are held at levels ranging from the politician to the fishermen and, particularly at the level of the fishermen, the views are often resentful and perfectly understandable. The socioeconomic and demographic conditions of this country (Philippines) make such problems even more acute, yet at the same time make effective educational (extension) programs on resource management even more vital. I believe that for protective management programs to be successful at the 'grass-roots' level they must offer fishermen more than just a promise for the future." (Russ 1984: 46)

Russ goes on to suggest that more immediate benefits to fishermen are important incentives. A more efficient but ecologically sound fishing technique may be one incentive. Another is the alternative source of income generated from reef-based tourism. Such small-scale tourism can bring a potential market for crafts produced locally, rental income for beach shelters and boats, and fees for the right to scuba dive and snorkel in the protected reef area. These incentives are beginning to be accepted at Apo Island, Negros, and Moalboal, Cebu, as legitimate and profitable reasons for maintaining the reserve.

Many of the benefits of reef maintenance cannot be perceived by local fishermen. These include: 1) the maintenance and possible increase in species richness of fishes; 2) provision of an undisturbed breeding grounds for fishes; 3) the export of fish biomass; and 4) the increase of fish biomass over a wider general area by larval dispersal (Russ 1984). Evidence for the first three is provided in this thesis, but the fourth point as indicated by Russ (1984) is very difficult to
test and is not known to be true. Although the first three benefit local residents in a number of ways, people may not perceive these benefits because they are not immediate. The export of fish biomass from a core area may increase general fish catch after several years, as indicated at Sumilon Island. The first two points are prerequisites for export of fish biomass and tend to attract tourists who indirectly benefit local populations. The fourth reserve benefit, if true, is a boon to surrounding fishing areas and would help maintain abundance and diversity even though heavy fishing occurs.

Modern management uses ecological criteria to test results such as export of fish biomass. Traditional management relies on different criteria. It assumes that territories and abundance of fishes are dependent on the number of fishermen frequenting an area. Traditional perception may not understand ecological explanations linking protective actions and fishery maintenance. Yet the perceptions of traditional fishermen may be able to incorporate concepts about ecological links into a traditional, territorial model to the benefit of the local community and modern academic and governmental managers.

7.4 Site specific planning and management

Whether or not a marine reserve/park is effective in maintaining environmental quality and sustainability of marine resources depends on daily events at the reserve site. This dissertation has described those events that are damaging to the environment and its resources and those events (such as planning and management) which have a maintenance effect. While many site specific problems and solutions
are particular to one site, many are also common to more than one area. Here a summary is made of those planning and management practices which are useful for general application.

Effective field management planning at sites close to human habitation and exploitation should:

1. determine the perceptions and needs of local people (communities and organizations) concerning their marine environment;

2. determine local use patterns of marine resources;

3. evaluate local ideas about resource problems and solutions to these problems;

4. complete environmental surveys to determine extent and condition of coral reef and surrounding habitats and their linkages;

5. design the reserve to incorporate the perceptions, needs and solutions of local people in combination with the existing environmental parameters;

6. incorporate core and buffer areas which maximize benefits to local and outside users as determined by ecological constraints;

7. decide whether local and outside (government, institution and conservation) needs can be adequately met in relation to the ecological value of the site and cost of implementing management;

8. formulate protective legal documents and complete legislation through appropriate municipal and national channels; and

9. inform legal enforcement agencies (municipal and national), the local communities, and other interested parties (research institutions, tourist companies and educational groups) about existing plans to elicit reactions and support.

In practice, field management may not follow the planning stages chronologically. There are examples of field management preceding adequate planning and, more often, instances of planning never progressing to field management. A mixture of the two is most likely to occur as evidenced in the sites of this study. Nevertheless,
assuming some order and control over the process, guidelines for field management implementation to follow planning include:

1. disseminating management plans and schedules to all concerned parties at the local, municipal, and national levels;

2. continuing needs assessment at the local community level in coordination with already accepted management plans;

3. recruiting local individuals from community, education, and other private organizations to begin implementation of management plans;

4. conducting in-depth non-formal and formal education programs and workshops for the benefit of those people dependent on the reef resources within the management area about the rationale for and benefits derived from management implementation;

5. physically marking boundaries for the core and buffer areas using buoys, land marks, and signs;

6. placing mooring buoys at appropriate sites;

7. surveying managed areas by locally recruited individuals;

8. developing mechanisms for the local community to become involved in small scale tourism through beach access, fees for scuba diving and snorkeling, beach shelter rentals, and selling crafts; and

9. attending to small details of maintenance to ensure continuity of the reserve and aesthetically pleasing environs; examples include maintenance of buoys, signs, facilities, and garbage removal.

Planning should be integrated with management so that management decisions are current and based on needs arising from the present situation. Feedback from successes and failures of management in relation to original management goals may influence reserve uses, boundaries and function. Several ongoing activities can help provide current data for proper management and scientific interest. These include:

1. periodic environmental surveys which note changes in the reef condition resulting from management or lack of management; monitoring themes may include: a) reef substrate covers and condition; b) fish and other organism abundance and diversity;
c) obvious disturbances from humans or natural events; d) water visibility; e) pollution; and f) use by people.

2. research on coral reef ecology and biology;

3. use of the area for educational purposes; and

4. reassessment of local needs as perceived by the primary users of an area.

The above guidelines for planning, implementation and monitoring of a marine reserve are directed to those persons involved in the various levels and stages of these processes. They are relevant for municipal level managers, concerned institutions, development agencies, and national resource managers. These guidelines are not necessarily useful for national policy but are directed to site specific problems.

An emphasis is placed on planning and managing a reserve in the context of a populated area. Since most potential sites are in populated areas, these guidelines are relevant. For those sites not yet affected by population pressure and heavy exploitation, management is simplified and those guidelines pertaining to local community involvement are not as useful.

7.5 National planning and management

A national perspective on marine reserve management includes valuation of resources, selection of priority management areas, and determination of what factors influence resources in those areas. The national view should note the needs of different interest groups and weigh economic interests against conservation necessities. Policy should focus on those issues which can practically be decided at the national level, such as financial and legal support. Control of
large-scale factors such as oil pollution and illegal, destructive and commercial fishing are other useful national roles.

National governments can educate people about what activities are destructive to the marine environment by passing laws regulating these activities. Field evidence suggests that various fishing techniques and types of exploitation affecting reefs should be banned or modified. Those activities with good evidence for banning include:

1. blast fishing;
2. shallow reef or bottom trawling;
3. use of cyanide poison;
4. spearfishing on scuba (in certain areas);
5. collecting fish by coral removal;
6. reef gleaning in vulnerable areas;
7. use of large fish traps in vulnerable areas;
8. reef mining;
9. removal of corals for construction or export; and
10. collection of endangered species such as sea turtles, sea snakes, and certain mollusks, and disturbance of their habitats.

Those activities affecting reefs which should be modified or regulated include:

1. muro-ami and kayaks fishing techniques modified so that scare lines do not use weights;
2. inappropriate use of small mesh nets;
3. overintensive fishing in vulnerable areas;
4. anchoring in vulnerable areas;
5. shoreline construction affecting reefs;
6. shoreline and mid-water waste disposal and dumping;
7. oil exploration, removal and transport; and
8. movement of ships on routes near vulnerable areas.

Although not exhaustive, this list of activities indicates where rational regulations might be useful in combination with education and legal enforcement. These regulations can affect maintenance of the marine environment at large (particularly coral reef areas) as well as marine reserves. If enforced, these regulations may contribute to marine reserve survival and maintenance, but they will not guarantee proper reserve management and continuation through time. Several rational policy guidelines to enhance marine reserve planning, management and long-term success include:

1. formulating appropriate ecological criteria for selecting protected areas (see chapter 6);
2. using standardized field survey methods, data collection and analysis (see chapter 6);
3. designating clear ministerial jurisdiction over marine areas and marine areas including a terrestrial component;
4. formulating management priorities for coastal zone management including development and conservation needs;
5. maintaining continuity of marine planning and management programs through one or more agencies;
6. focusing on priority areas to ensure adequacy of at least the most essential programs;
7. giving attention to local community needs in management areas to ensure local participation and acceptance;
8. supporting local institutions and key individuals in actual management implementation;
9. providing legal, financial, and technical support when needed;
10. using national media channels for education and eliciting public support for priority programs;
11. eliciting private institutional support and channeling it directly to site specific projects;

12. not overburdening local project managers and institutions with unnecessary government bureaucracy;

13. taking into account the socio-cultural differences between national government officials and local project participants; and

14. joining and participating in international organizations with an interest in marine resource management and conservation such as IUCN, the World Heritage Convention, the Wetlands Convention, the Migratory Species Convention, the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES), the ASEAN plan for nature conservation, the UNEP Regional Seas Program, and the International Whaling Commission.

In summary, effective management of marine reserves cannot be guaranteed without cooperation among many groups at many levels. At the national level, many interests tend to dilute clear-cut priorities and management programs. Jurisdiction between governmental agencies is often not clear and management goals are not well defined. At the local level, needs of people and organizations are less complex. A useful lesson learned from many of the poorly maintained national marine reserves in this study is that objectives must be clear and that appropriate support must be given to local governments and institutions. In several cases single individuals could be much more effective at implementing simple protective programs than national agencies. If national bodies could then offer adequate legal, financial and consulting support, many more small but effective marine management programs might be successful.
### APPENDIX

### SURVEY FORMS

#### SURVEY FORM I. Site Description and Qualitative Evaluation

<table>
<thead>
<tr>
<th>Site/Location</th>
<th>Qualitative Rating (1-low to 10-high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>a b c d e f g</td>
</tr>
<tr>
<td>Observer</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td></td>
</tr>
</tbody>
</table>

#### A. Accessibility
- Distance
- Transport
- General site description
- Anchorages

#### B. Facilities

#### C. Weather patterns

#### D. Terrestrial component
- Geology
- Topography
- Flora
- Fauna
- Impact on marine area

#### E. Marine component
- Reef type, area, width
- Bottom topography, depth
- Community types
- Coral cover
- Diversity
- Currents and tides

#### F. Socio-Economic
- Community size
- Occupations
- Water systems
- Waste disposal
- Relation to marine environs
- Government jurisdiction
- Reef uses

- a uniqueness of environment
- b naturalness of environment
- c size of area and ecosystems
- d criticalness of general area
- e feasibility for management
- f recreational value
- g scientific value
<table>
<thead>
<tr>
<th>Site/Location</th>
<th>Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Tide</td>
</tr>
<tr>
<td>Observer</td>
<td>Currents</td>
</tr>
<tr>
<td>Transect</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Calibration (m)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>rubble</td>
</tr>
<tr>
<td>blocks</td>
</tr>
<tr>
<td>dead standing coral</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td>branching</td>
</tr>
<tr>
<td>massive</td>
</tr>
<tr>
<td>flat/encrusting</td>
</tr>
<tr>
<td>foliose/cup</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Hard Coral</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Soft Coral</th>
</tr>
</thead>
<tbody>
<tr>
<td>sponges</td>
</tr>
<tr>
<td>algae</td>
</tr>
<tr>
<td>seagrass</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hard coral genera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft coral genera</td>
</tr>
<tr>
<td>Acanthaster</td>
</tr>
<tr>
<td>Tridacna</td>
</tr>
<tr>
<td>Chaetodonids</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Noticeable damage (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography (m)</td>
</tr>
<tr>
<td>other</td>
</tr>
</tbody>
</table>

| Notes |
SURVEY FORM III. Socio-Economic, Reef Use and Perceptions

**Background**
- Fishing ground
- Home community
- Years in vicinity
- Birthplace
- Age
- Education
- Occupation
- Share of Income from fishing
- Sell or buy fish
- Marketplace

**Changes Between the Present and Original Site Contact**
- Number of fishermen
- Time fishing/week
- Catch/unit effort
- Meals/day with fish
- Meals/day with other seafood
- Fish abundance
- *Tridacna*
- Sea turtles
- *Acanthaster*
- Sharks
- Groupers
- Tourists
- Other

**Fishing Methods and Capacity**
- Boat size
- Number of fishermen

<table>
<thead>
<tr>
<th>Method</th>
<th>Now</th>
<th>Before</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hook and line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trawling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muro-ami</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kayakas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spearin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gleaning</td>
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<tr>
<td>Blasting</td>
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<tr>
<td>Poisoning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Perceptions**
- Seasons and weather for fishing:
- Idiosyncracies of organisms:
- Traditional management:
- Modern management:
- Why changes in resources and environment:
- Alternatives of management:
- Opinions:
BIBLIOGRAPHY


ASEAN Agreement on the Conservation of Nature and Natural Resources (draft), 1982. As revised by the Workshop of Legal and Technical Experts of the ASEAN States. Manila, Philippines, November 3-5.


Council. 1974. Excerpt from the minutes of the municipal council of Oslob, Cebu in regular session, Municipal Session Hall, August 2.


McManus, J.W. 1983. Coral patches of Southeast Asia: Lest we forget the humble. Contribution No. 000, Marine Sciences Center, University of the Philippines, Diliman, Quezon City 3004, Philippines, pp. 1-18.


Interviews

Alcalá, Angel. Professor of Biology, Silliman University, Dumaguete, Philippines, 1984.


