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DRAFT

COASTAL RESOURCES MANAGEMENT
Ulugan Bay, Palawan Island, The Philippines

Volume I

ecology, culture

and socio-economics

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PROJECT SUMMARY

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Coastal zones contain many of the Earth's most complex, diverse and productive ecological systems; productive in both a biological and an economic sense. Reefs, mangroves, wetlands and tidelands are: (i) the nursery and feeding areas for many marine species; (ii) important areas for the recycling of the nutrients, and (iii) buffer areas for storm protection and to control erosion.

Coastal ecotones are very complex systems that foster a dynamic balance between the terrestrial and marine environments. Sustainable development strategies for the management of these ecosystems should be oriented towards a strong evaluation of the functional characteristics of the system (i.e. carrying capacity) to preserve this delicate balance and to maximize the benefits to the stakeholders. Basic knowledge of the ecological characteristics of coastal ecotones should include the study of the ecological processes, the analysis of flow of resources that coastal systems generate, as well as the potential use of these resources for social and economic development purposes.

Due to the complexity of both human activities and coastal ecosystems, an integrated management scheme is needed to both allocate coastal resources effectively, and minimize environmental degradation. Choices and compromises have to be made between competing users and uses of the coastal zones if an escalation of conflicts and resource degradation are to be avoided.

The paramount objective of integrated management is to devise a framework for "sustainable utilization" of coastal resources. This exercise may be subdivided into three broad areas:

1) Policy to form the basic parameters for coastal management planning;
2) Planning for the allocation of resources;
3) Implementation of planned decisions, including restorative or remedial works (Carter, 1988)[1].

FORMULATION OF MANAGEMENT STRATEGY

Local Community involvement *- A prerequisite for integrated management is the acceptance of the management plan by the government, and its support by all the stakeholders in coastal areas. Achieving a balance between the top-down legislative authorities and the bottom-up community involvement approach requires a delicate balance of issues and a strong link to stakeholders of the area.*

Baseline Information *- Availability of baseline information is key to the planning exercise. Planning also requires an understanding of the relationship among key parameters and factors in order to properly identify and prioritize management issues. This baseline should provide information on the coastal resources system, including biophysical, ecological, socio-cultural, economic, as well as institutional, organizational and implementation data. Also included in this component is the requirement for solid sectoral indicators and models to make appropriate projections of the area's development trajectory.*

Collection of data *- Where data gaps exist, primary data must be collected, updated and verified to ensure reliability of information required for decision-making. Multi-disciplinary teams have to conduct relevant applied scientific research in the biological, ecological, physical, socio-economic aspects of the site, as well as determining the existing institutional and organizational responsibility for resources management of the area.*

Formulation of management strategies and policy opinions *- The output of the previous stages provides the basis on which management policy options are formulated, alternative strategies are developed to address specific management issues, and final management plans are defined. The process involves both top-down and bottom-up approaches for the formulation of policies, strategies and actions needed to resolve the problems.*

[1] R.W.G. Carter, 1988. *Coastal Environments*. Academic Press, London.

Implementation of approved, sustainable management plans – *After assistance in the planning exercise, the community should be assisted in the implementation phase.*

This is often not the case, and attention is required for community confidence building, technical training for drafting legislative inputs to support the management plan, as well as the training for the joint community and government implementation of the plans. Joint planning and implementation through the stakeholders and legislated agencies fosters a joint stewardship of the coastal resources within the community and government services.

THE UNESCO/UNDP PILOT PROJECT - SUMMARY

The "Coastal Resources Management and Sustainable Tourism in Ulugan Bay" is a project that is being implemented by the United Nations Education, Scientific and Cultural Organization (UNESCO). The project is supported by the United Nations Development Program (UNDP), involving the Local Government Unit of Puerto Princesa City, as an on-site executing agent.

The primary objective of this project is to generate a model for community-based coastal resource management using a multi-sectoral approach. This project is inter-disciplinary in nature, specifically comprised of:

1) Scientific collection of data on the ecology, culture and socio-economics and establishment of a fisheries database as tools for gathering information and filling data gaps.
2) Establishment of experimental fish farms and community-based sustainable tourism activities as important components for community involvement, income generation and alternative/supplemental employment opportunities[2].
3) Environmental education and training in coastal resources management for both youth and adults as tools for local community empowerment and awareness.

[2] Many resource management plans advocate restrictive measures without taking in to consideration the ability of the stakeholders to absorb these restrictions and still survive in the community. Appropriate planning balances the restrictive use of the coastal resources with suggestions for alternative income or food security to maintain the very sensitive daily balance for survival in the rural, coastal communities.

The success of the project was therefore built around the strengthening of the community's involvement in the sustainable development of Ulugan Bay.

Ulugan Bay is a shallow bay located on the central, western coast of Palawan Island Province, and the mouth of the Bay opens into the South China Sea at the northern end (Fig i.1). The Bay is situated some 47 kilometers from the provincial capital city of Puerto Princesa. The Bay, covering 7,200 ha, is noted for its distinct coastal mangrove forest that is in turn associated with tidal flats, seaweed beds, small islands, and smaller bays. In Ulugan Bay there are about 790 ha of mangrove, 1,200 ha of coral reefs and approximately 500 ha of seagrass beds thus making it a very sensitive and vitally important resource for the province.

In general, the Bay is very deep. It has no less than 14 fathoms in the fairway. Oyster Bay affords anchorage in 10 to 14 fathoms of mud bottom. The other inlets are apparently all shallow. Dotting Ulugan Bay are two islands and three islets. The 140 ft high Camungyan Island, also called as the Three-Peaked Island, or popularly known as Tres Marias, lies northward of Northwest Head, or what is also called Nagkikiyang Point. Rita Island, an elongated island about 25 hectares, is one-and-a-half miles in length north to south, by about 200 yards in breadth. It has a detached rock at its northern extremity, 45 feet in height, named Observatory Rock, from which rocky bottom, with 5 and 7 fathoms, extends in northerly direction. Tarakawayan Islet is a tiny islet lying nearly half a mile offshore between Kayulo and Bahile Rivers at the head of the Bay. Reef Islet, locally named as Manyokos, lies on the eastern portion of the Bay near Marabay Point. South of Tarakawayan Island is White Rock Islet or Puting Bato.

The peninsula forming the western side of Ulugan Bay comprises an undulating highland reaching to the Kasoglan Range, south of Oyster Bay. The east coast of Ulugan Bay, on the other hand, is a low undulating terrain that extends from the head of the Bay to Tapul Bay. Conical Hill, 1,190 feet high, lies on the eastern side of the low saddle, and a range extends northward from it along the eastern shore of Ulugan Bay to Piedras Point (also locally called Punta Diablo). The highest point on the Bay end, Bintuan Peak at 1,730 feet, lies near the shore of Dalrymple Point and is separated from the northern peak Sangbauen, 1,816 feet high, by a wooded valley that lies at the back of Watering Bay. The mountains are heavily forested. Over ten rivers empty into the Bay. Although these coastal ecosystems are presently threatened with degradation due to a number of factors, the Bay is still one of the main sources of livelihood for most of the residents of communities surrounding the Bay. Ulugan Bay is considered one of the most significant coastal and marine

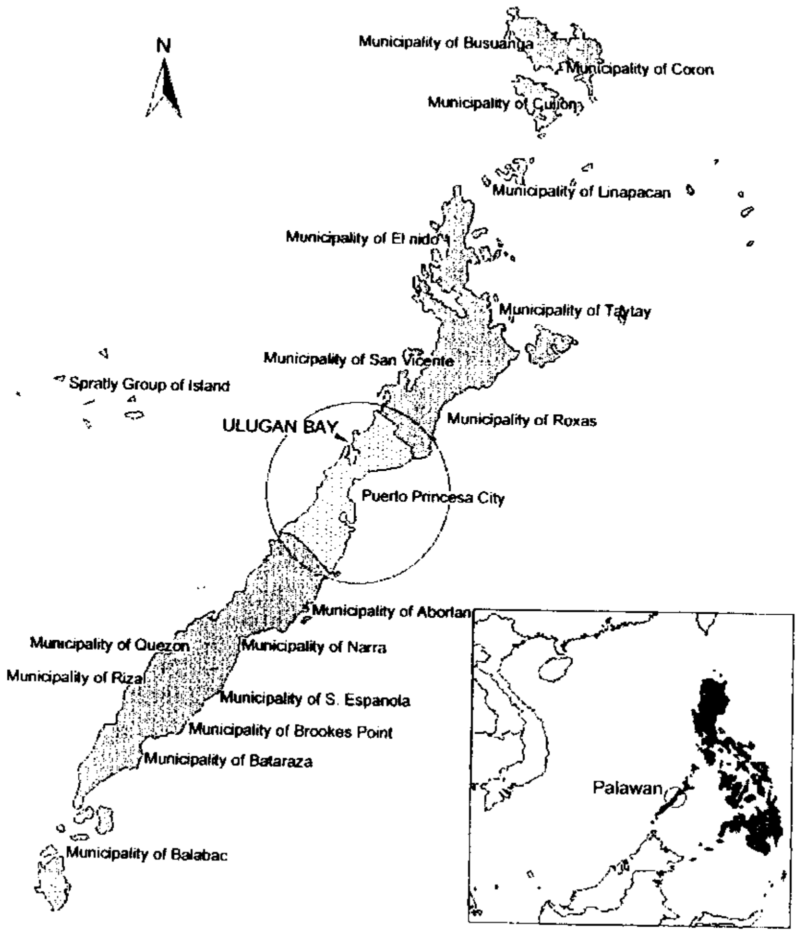

Figure i.1 Ulugan Bay and the Palawan Province
Geographic Information System
City Government of Puerto Princesa
Office of the City Planning and Development Coordinator

ecosystems of Palawan Province. Its unique natural environment and its productivity have resulted in Ulugan Bay becoming the most significant source of fish for the markets in Puerto Princesa City. Unsustainable fishing practices and increased siltation of the Bay however, threatens the livelihood and survivability of the local fisherfolk as fish stocks have declined.

There are five barangays (villages) in Ulugan Bay: Bahile, Macarascas, Buenavista, Tagabinet and Cabayugan. They cover approximately 42,124 ha. The topography of the land surrounding the Bay outside of the river mouths is hilly and mountainous, with several crests higher than 300 m within 3 km of the shore. Forest cover is still extensive in the upland areas of the watersheds around the Bay, but extensive clearing for agriculture and human settlement has occurred in most lowland areas. As of 1998, Ulugan Bay was home to 5.999 people. A majority of them are farmers and fishers. Rice, corn and root crops are the major farm products. In fishing, about 35 out of the 63 species of fish are known to be of commercial value, including the high-priced *lapu-lapu* and *suno* (groupers). The area is also of significant importance for national security, due to its strategic location on the South China Sea. Its cultural importance is due to the presence of indigenous populations in the coastal and upland areas. In addition, the northern part of Ulugan Bay is included in the *Puerto Princesa Subterranean River and National Park*, which is one of the two Natural World Heritage Sites in the Philippines.

LEGAL FRAMEWORK

Palawan was declared as a Biosphere Reserve by UNESCO's Man and Biosphere Program (MAB) in 1991, one of only two in the country. In 1992, the Philippine Legislature passed, and President Corazon Aquino signed into law the Republic Act (RA) 7611 adopting the Strategic Environmental Plan (SEP) for Palawan. This created the Palawan Council for Sustainable Development (PCSD) which oversees SEP implementation directly under the Office of the Philippine President. Recognizing its biological and cultural richness and diversity, several areas in Palawan were already declared, prior to the adoption of the SEP, as reservations or sanctuaries.

The year 1992 also saw the enactment of the National Integrated Protected Areas System (NIPAS) Act (RA 7586), an Act that integrated all protected areas in the country into one system under the Department of Environment and National Resources (DENR). The challenge to this system however, is the Local Government Code that devolves coastal area management to the municipalities, hence close partnerships and liaison is required between DENR and the Local Government Units to effectively manage these areas.

The above reasons were significant factors in the choice of Ulugan Bay as a study site for UNESCO to implement inter-sectoral activities for sustainable coastal zone management and development, under the UNESCO Unit for Environment and Development in Coastal Regions and in Small Islands (CSI).

In 1996, in line with efforts to develop an integrated planning approach, UNESCO organized a *Strategic Planning Workshop for the Stakeholders of Ulugan Bay*. This workshop served as the forum for discussing problems and issues affecting Ulugan Bay management, identifying areas of concern, and harmonizing Stakeholders' efforts towards a common vision. The workshop also identified goals, objectives and strategies for effective and sustainable resource management in this area. As a significant outcome of the workshop, an Interim Ulugan Bay Multi-Sectoral Management Committee was established as a working group to coordinate and integrate all activities and actions. This workshop was followed by a series of consultations with National, Provincial and Local Authorities, Institutions, and dialogues with the local communities and indigenous groups living around the Bay. A specific survey was carried out to identify needs and potential alternative income generating activities that would be appropriate for both for local and indigenous communities.

In 1997 the Project commenced activities in two main directions (Fig i.2). On one hand, UNESCO-CSI started a process that resulted in the development of a project document for planning inter-sectoral activities to be implemented in the Bay. On the other, UNESCO also concentrated on capacity building for local institutions. A series of training sessions on ecological coastal zone assessment (UNESCO-CSI) and on participatory rural appraisal method (UNESCO-SHS) were organized. The main aim of these training sessions was to upgrade the capability of local institutions and organizations in data collection by direct involvement of local communities. The field activities carried out during the training, plus the multi-disciplinary campaigns for data collection provided the basis on which management options were formulated and activities were identified for the Project.

In 1998, with the support of UNDP, in conjunction with The Government of the Philippines (NEDA), and in close collaboration with the Government of Puerto Princesa City, UNESCO started the implementation of the two-year project *"Coastal Resources Management and Sustainable Tourism in Ulugan Bay"* (UNDP-PHI/98/007). The main objective of this project was to develop a model for coastal resource management for Ulugan Bay using a community-based, multi-sectoral approach; said model to serve as a possible reference for other initiatives.

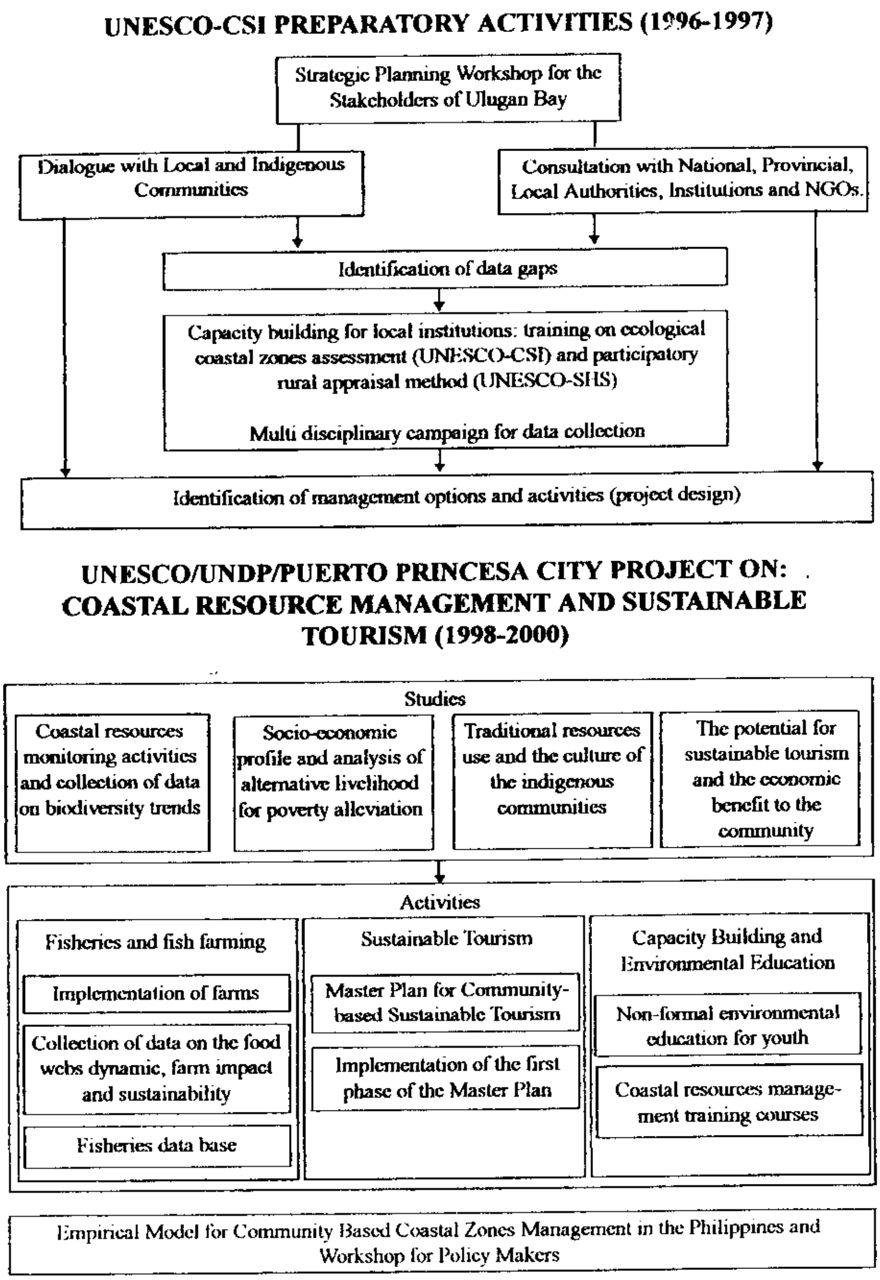

Figure i.2 Project activities from 1996 to 2000

Implementation Steps

1. The project commenced with four studies:
   - Ecological assessment of coastal resources.
   - Study on traditional resources use and the culture of the indigenous communities in Ulugan Bay.
   - Study on the socio-economic profile of Ulugan Bay and analysis of alternative livelihood for poverty alleviation.
   - Study on the potential for Sustainable Tourism in Ulugan Bay and the economic benefit to the community.

2. Following this collection of data the project then focused on the implementation of several activities including:

   Activity 1 – Community-based experimental areas for sustainable fish farming in Ulugan Bay. In collaboration with the City Agriculturist's Office of Puerto Princesa City experimental areas for sustainable fish farming. This activity focused mainly on the comparative growth of *Siganid Sp.* in fish-pens. The project utilized the natural habitat as a culture area through enclosure by nets (2 x 2 x 2 meters). A total of 30 fish-pens were established were established in two areas of the Bay and stocked with varying fish densities (0, 5, 10, 15, 20 number of 5 centimeter fingerlings per cubic meter with three replicates for each density). The pens were constructed on mono-specific seagrass beds of *Enhalus acoroides*. In each pen the density of seagrass plants was made uniform at 100 plants for square meter. The fish then depended mainly on the natural food present in the area, mainly epiphytes on the seagrass. Crab (*Scylla serrata*) fattening areas were also established.

   Aside from providing scientific information on ecological processes such as food webs dynamics and productivity the importance of this activity was to serve as a "window" to the local communities on how to utilize the marine resources in the area for supplemental income without creating any harmful or destructive effect. It further increased their awareness on how to protect, manage, utilize and conserve the resources in the Bay. It also was intended to redirect community efforts from fish catching to fish farming, or a combination of the two activities. Data gathered were intended to guide future considerations for fish farming for the local communities. These can also be a reference for further research studies.

Activity 2 - Establishment of a fisheries database. In collaboration with the City Agriculturist's Office of Puerto Princesa City, and involving local fishermen from all the barangays in the Bay, a database was to be developed to account for the fish catches and effort expended. This system was also to form the base for the fisheries data system for the City and for two other international fisheries projects in the area so that unnecessary duplication and overlaps would be avoided. The intent was to develop only one fisheries data system for the City for fisheries management, consequently the system to be developed had to be compatible with the other systems as they were created. Second was to ensure that there was an appropriate database for a long-term monitoring of the productivity of the Bay.

Activity 3 - Master plan for community-based sustainable tourism. The Master Plan was the result of the collective work from a series of sustainable tourism activities (community consultation, stakeholder workshops and supporting fieldwork). In 1999, Green Globe organized a series of field visits to the Ulugan Bay area. The output of these visits was summarized in the report entitled "*The Potential for Sustainable Tourism in Ulugan Bay*". The main function of this report was to provide the background required for the formulation of the Master Plan. In addition, information contained within this report assisted in the design and implementation of a subsequent stakeholders workshop; the "Workshop for Sustainable Tourism in Ulugan Bay" was held in Puerto Princesa City in June 1999. More data was obtained at the workshop as additional input for the formulation of the Master Plan. All the interested parties and agencies that had a stake in the Ulugan Bay area participated in the Workshop. In the same undertaking, individual meetings were also held with the Councils of the five barangays and two Ancestral Domains during which community representatives took a proactive role in proposing their own initiatives. This Master Plan adopted a 'bottom-up' approach for the development of the planning framework. This planning structure included an examination of the various initiatives proposed at the community-level (micro-scale), and an assessment of the implications of these initiatives in terms of required actions, costs and potential sustainability. These components were then integrated with Puerto Princesa City's wider development and conservation plans (meso and macro-scale). The implementation of the first phase of the master plan directly involved the local communities in the organization and management of tourism.

> *Activity 4 - Non-formal environmental education for youth and training.* In each of the 5 barangays of Ulugan Bay environmental education courses were organized for youth as well as training courses for adults in the fields of coastal zones management. A total of six different training modules were presented in each barangay from initial coastal ecosystem awareness to training on legislative rights of the community in development under the Local Government Code.

Interactions between social and ecological processes are complex in a coastal environment context, and there was inadequate information about how these interactions occur in the Ulugan Bay area. This project was intended to create the necessary *platform* for development of policy and management practices at the community level.

The analysis in this summary includes assessments of coastal resources and small-scale alternative income generating activities (sustainable tourism and fish farms). Both these initiatives require community investigations and understanding of the trends in resource use and their long-term status; an understanding that is a basic requirement for subsequent action. This analysis permits a clear definition of how long-term, sustainable economic activities could be carried out by local communities.

All the data collected and the lessons learned during the implementation of the project were amalgamated into a model for community-based coastal resources management. This empirical model, generated through a multi-sectoral approach, constituted a practical example for sustainable development in coastal areas, one that could be tested in other areas in the Philippines. Furthermore, the information collected during the Project provided practical guidelines to future managers and policy makers. To emphasize the data-policy linkage and input into managerial decisions, a policy and managerial workshop was organized at the end of the project. The main aim of the workshop was to foster open communication of the model to policy makers, and facilitate final input from the communities to emphasize "lessons learned", and further, to enhance the model for possible replication, where appropriate, in other coastal areas of the Philippines.

CHAPTER 1

ECOLOGY OF ULUGAN BAY

M.D. Fortes and S. Fazi

1.1 INTRODUCTION

In the last ten years the Philippines has witnessed an increasing interest in environmental development planning in coastal zones. This interest seeks to achieve a model that integrates environmental needs into economic development. Most land use planning decisions have often been made without proper regard for coastal areas, and have been formulated principally on the basis of economic criteria. This improper regard for environmental factors in development planning has led to significant environmental degradation, irreversible loss of precious ecological and natural resources, and in many instances hazard to life and property, unanticipated social costs, loss of amenity and quality of life (ADB, 1992). In addition, too much concentration on overall economic growth has engendered socio-economic disparities, which in turn have led to the creation of urban slums and their attendant effect on water supply and sanitation. Hence, there is an urgent need to modify development planning to incorporate protection of nature and her resources, as well as the provision of acceptable habitation for even the poorest of the poor (SURP, 1997). Thus, acceptable and comprehensive coastal zone planning has yet to be developed in the Philippines. Such a plan should aim to create sustainable competitive advantages in coastal and marine industries - including the application of science and technology - and so contribute to industrial diversification and new opportunities for employment. In coastal areas economic development should take place with due consideration for the natural environment. The application of scientifically supported interdisciplinary coastal zone planning is a key tool towards realizing this objective.

The present study provides data and information on the ecological status of Ulugan Bay coastal ecosystems (mangrove forests, seagrass beds and coral reefs). It aims to demonstrate the significance and primary importance of thorough ecological assessment as a tool in the coastal zone planning process. The data collected in this study have been used as baseline information for the identification and implementation of socio-economic activities and sustainable community development and for the protection and management of the entire Bay. In Ulugan Bay, we have the chance to set an example for coastal development that balances the economic and social needs of people with the long-term needs of the environment both human and natural.

Ulugan Bay covers an area of approximately 71 km^2, and is located slightly north of the geographical center of the 450-kilometer long island of Palawan, the main land mass at the western part of the Philippines. Palawan separates the South China Sea and the Sulu Sea, stretching its length in a northeast-southwest direction, surrounded by hundreds of smaller islands and islets. In terms of flora and fauna regimes, the island of Palawan resembles its neighbor to the south, Borneo, more than it does other main island groupings of the Philippines. Compared to other parts of the country, the entire province of Palawan is relatively sheltered from typhoons and other extreme weather disturbances. However, in December 1998, the most severe typhoon in memory struck the greater Ulugan Bay area, causing extensive damage to its surrounding forests and coral reefs.

Over 10 rivers empty into Ulugan Bay. The rivers of Kayulo, Umalagan and Bahile empty into the southwest corner of the Bay. Also located in the south are the Baruang, Sia and Eddasen rivers. At the eastern side are the Kamangie, Banog, Otaban and Tagnipa rivers, while at the western side are the Tarunayan and a tributary of Kayulo rivers. In general, Ulugan Bay waters are clear, with a mean horizontal visibility reading of 11.4 m (+ 6.58 S.D.). From the isolines, waters were observed to be "clear" (depth readings greater than 10 m) at the more open, northern half and middle portions of the deeper part of the Bay[1]. Relatively turbid waters (depth readings less than 10 m) were noted at the eastern, exposed sides of Rita Island and the southern and eastern Bay margins up to Madahan. Consistently, the most turbid areas (depth readings less than 5 m) were at the mouths of the rivers inside Tarunayan and Oyster Bay, in small coves near Taipan Point and White Rock Island along the southwestern half of the Bay, and in selected shallow areas off Wood, Baribi, and Magmatong Points along its southeastern half (Fig. 1.1).

The major sources of information in the classification of Ulugan Bay and the surrounding areas were SPOT Multispectral Satellite imageries with a ground resolution of 20x20 m. These SPOT data, captured on 5 March 1992 and 16 May 1997,

[1] The study started with the analysis of chemical-physical characteristic of the water column in order to provide baseline information on the water mass dynamics and characteristics (i.e. turbidity profile).

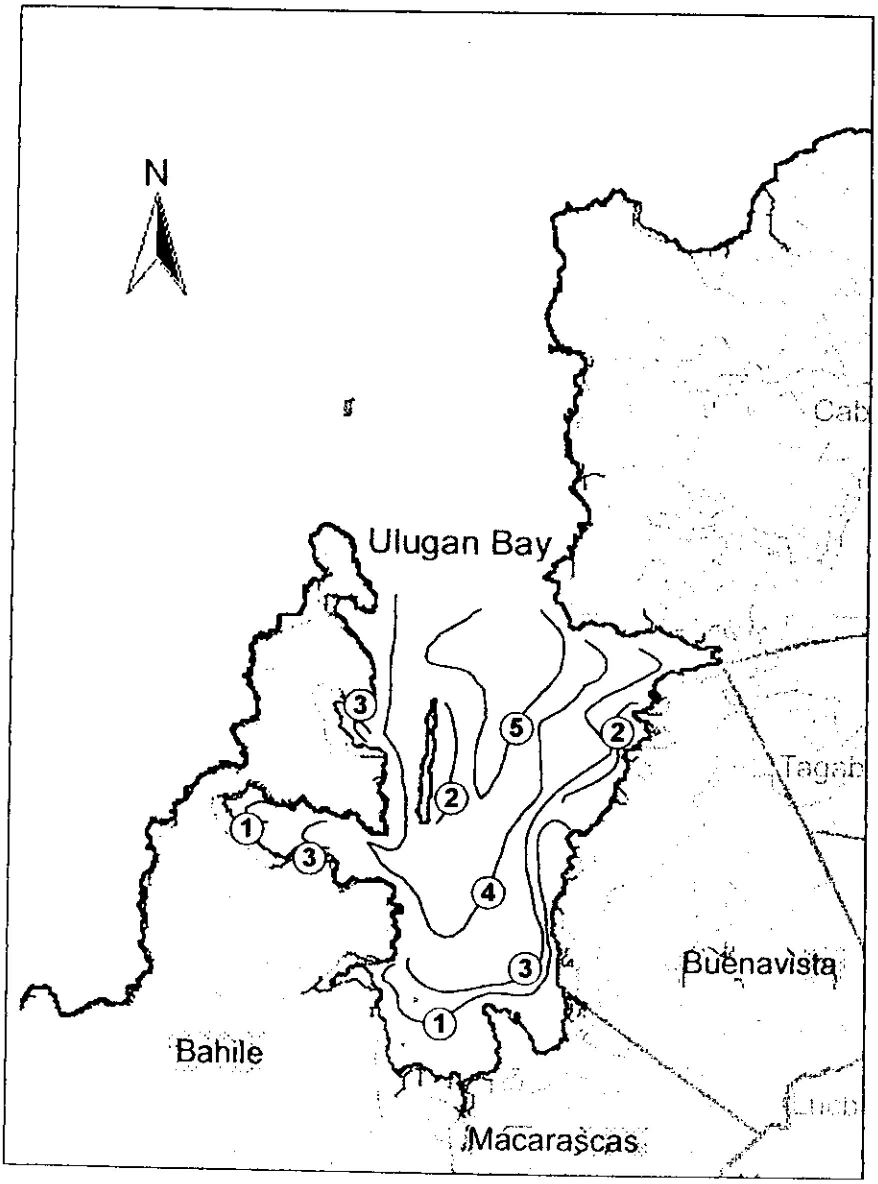

Figure 1.1 Isolines of the turbidity gradient in the Ulugan Bay waters. Secchi Disc depth range: 1 (<5 m); 2 (5 m<x≤10 m); 3 (10 m<x≤15 m); 4 (15 m<x≤20 m); 5 (x≥20 m).

partly obscured by clouds (Fig. 1.2), were provided through an ESCAP/UNEP project. Topographic maps with 1:50,000 scale were used as the base map on the registration and rectification of SPOT satellite imageries. Land use map (1:250,000) and ground verification provided another important source of data. Prior to the image analysis, various preprocessing operations were conducted: 1) The whole scene of SPOT XS imagery was enhanced to allow greater discrimination of cover types and to aid visual interpretation for the 'image-to-map rectification"; 2) Rectification was performed to correspond to the raster image to real world map projections and coordinate systems; 3) The areas of interest were extracted from the rectified whole scene of the SPOT satellite imagery. ER Mapper was the tool used in the processing, rectification and classification of the SPOT satellite imageries. Separation between water and land was done spectrally. Land and water classification was performed independently using unsupervised methods. The classified image of the pilot area was smoothed using the "majority filter" to show the dominant classification. After post classification smoothing, annotation and map composition were performed to create a good quality image map by adding coordinate grids, a scale bar, a legend, a north arrow and other map objects. The land cover map was then printed to scale (Fig. 1.3). A total number of ten classes were generated from level 2 classification. From level 3 classification thirteen classes were generated (Tab. 1.1).

Table 1.1 Land cover classification (see text)

Classes	Area (km^2)	Classes	Area (km^2)
Inland		**Coastal**	
1) Grassland	30.92	7) Fringing reefs and seagrass beds	12.35
2) Forest (mossy, old growth)	25.09	8) Mangrove with > 50% cover	4.41
3) Residual forest (low-medium density)	8.34	9) Mangrove with < 50 % cover	3.49
4) Arable land	5.48	10) Turbid water	3.52
5) Open area	3.29	11) Water body	45.78
6) Built-in area	0.16	12) Clouds - Shadow	

The study sites in the Bay have been chosen from the land cover map, after a preliminary field survey. Representing a cross-section of the prevailing coastal and underwater conditions of the Bay and vicinity, these sites were selected for their ecological importance (i.e. location, a source of larvae or propagules for downstream areas, nursery or spawning grounds), comprehensiveness and high reliability of results (i.e. accessibility, compatibility with existing data, representative of different

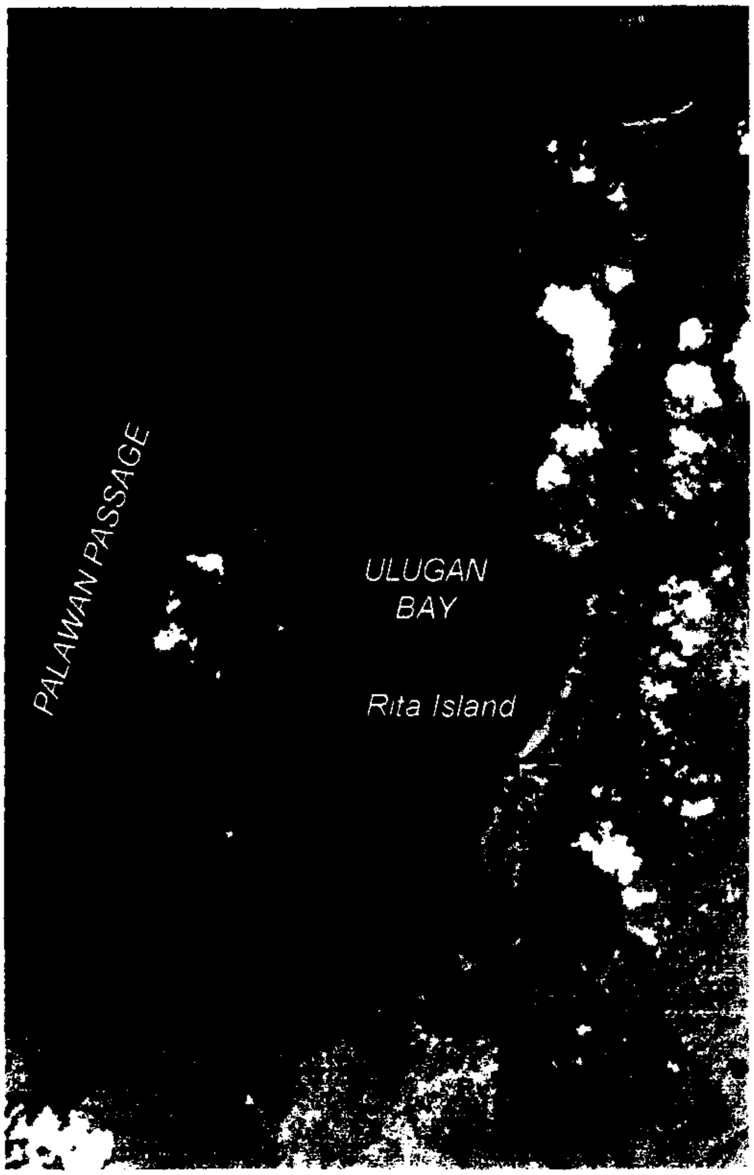

Figure 1.2 Enhanced SPOT satellite imagery
Ulugan Bay and vicinities
Palawan, Philippines

- Mossy Forest (25.09 km^2)
- Low-medium-density forest (8.34 km^2)
- Grassland (30.92 km^2)
- Arable land (5.48 km^2)
- Open area (3.29 km^2)
- Built-up area (0.16 km^2)
- Mangrove > 50% (4.41 km^2)
- Mangrove < 50% (3.49km^2)
- Fringing reefs (12.35 km^2)
- Turbid water (3.52km^2)
- Water body (45.78km^2)
- Clouds
- Shadow

Figure 1.3 Land cover map of the Ulugan Bay and vicinities, Palawan, the Philippines management practices – low/high human impact, social acceptability and degree of local community support). From the northwest down south and to the northeast, the 15 specific study sites and their dominant habitats and associated communities were identified, including two sites out of the Bay (Sabang and St. Paul) (Tab. 1.2, Fig. 1.4).

Table 1.2 The 15 study sites in Ulugan Bay and their associated habitats and communities (* = surveyed,). ● = Mangrove litter fall and growth dynamic).

	Mangrove	Seagrass	Seaweed	Coral reef	Coral fish
Manaburi Cove (site 1)	*		*		
Rita-Manaburi (site 2)		*	*	*	*
Tarunayan (site 3)	*●	*	*		
Oyster Bay (site 4)	*	*	*	*	
Kayulo (site 5)	*				
Umalagan I (site 6I)		*	*	*	*
Umalagan II (site 7)	*				
Bulalakaw (site 8)	*	*		*	*
Macarascas (site 8)	●				
Buenavista I (site 9)	*	*	*	*	*
Buenavista II (site 10)	*				
Tagabinet (site 11)	*				
Tagnipa I (site 12)	*				
Tagnipa II (site 13)	*				
Sabang (site 14)	*		*	*	*
Saint Paul Bay (site 15)			*	*	*

Mangrove areas with greater than 50% cover comprise 4.41 km^2 or 56% of the present mangrove area (7.9 km^2) in the Bay; mangroves with less than 50% cover comprise 3.49 km^2 or 44% of the total. The study sites were selected in order to be representative of both cover categories. The mangroves at Manaburi (site 1), Tarunayan (site 3), Kayulo (site 5), Buenavista (sites 9-10), Tagabenit (site 11) and Tagnipa (sites 12-13) belong to the first category and according to preliminary survey results. This cover category is roughly characterized by a density range of 20-180 trees/500 m^2. Mangroves from Oyster Bay (site 4), Umalagan (site 7), and Bulalakaw (site 8), with less than 50% cover, are roughly characterized by a density range of 40-90 trees/ 500 m^2. It should be noted that Sabang (site 14) is not included in the satellite imagery. But since the mangroves in this site are the densest and the most pristine, it is safe to assume that their cover is more than 50%.

In relation to the coral reefs and seagrass (including seaweeds), the specific study sites were parts of the fringing reefs in the Bay that comprise 12.35 km^2. This figure is about 24% larger than was previously reported (Walters, 1996). But whether this figure suggests an improvement in the cover after two years or simply an artifact of collection, is an important subject for further study. It should be noted that the figure used in the present study was supplied by the latest satellite imagery, while the smaller figure was the result of a cruder approximation.

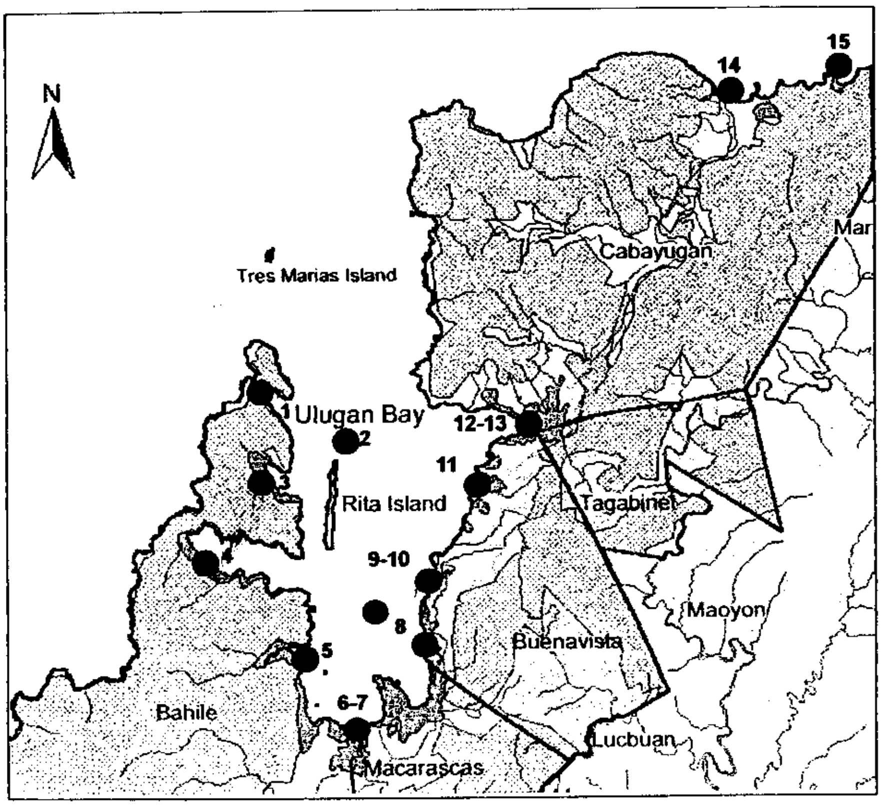

Figure 1.4 Study sites in Ulugan Bay.

1.2 MANGROVES

1.2.1 Methodology

Community structure: The mangroves were assessed at twelve sampling sites located in the most representative mangrove areas of the Bay. Five 500 m^2 quadrats were established randomly at each site. Within each quadrat data on the following parameters were collected: number of trees per species, *diameter at breast height* (dbh), number of cut and dead trees and number of seedlings and saplings.

Two sites in Ulugan Bay were chosen to assess the mangrove litter production, the decomposition rate and the export of organic matter (Sites 3 and 8 bis). Both the areas are dominated by *Rhizophora apiculata* and *R. mucronata*.

Leaf litter: Leaf litter production was estimated using 1 m^2 litter traps of 1 mm^2 mesh size net sewn to wooden frames. Five replicates of traps for each tree species and for each site were suspended below the canopy and beyond the level of the highest tide. Litter was collected monthly, sorted into components (leaves, fruit, flowers, wood) and dried (72 h, 600C). Sub-samples were ashed (6 h, 550oC) to determine the percentage of Organic Matter Content (OMC) for each component.

Decomposition rate: Decomposition rate of mangrove leaves was assessed using the litter bag technique. Litter bags were filled with leaves of *R. apiculata* (16.8 g - ash free dry weight, AFDW) and *R. mucronata* (15.8 g AFDW) collected from the trees just before they dehisced. Two different mesh sizes (1 mm^2 and 16 mm^2) were used to assess the role of macro-fauna in leaf decomposition. Bags were randomly tied in the forest floor and collected (five replicates for each collection) after one and two months. The collected leaves were dried and ashed as above to determine the percentage of OM. The loss of organic mass from litter bags was used as a measure of detritus processing rate. Decomposition curves were traced following the exponential decay model (Olson, 1963; Petersen and Cummins, 1974), $W_t = W_0 e^{(-kt)}$ where W_t is the weight of material left from initial W_0 after time t, and K is the decay constant (instantaneous decay rate). The decay constants were calculated by fitting a negative exponential regression. The litter half-life was calculated as $t_{1/2} = \ln 2 / K$ and turnover = 1/K (Gallardo and Merino, 1993).

Tidal transport: Tidal transport of mangrove litter inside the Bay was assessed using four traps made of nylon nets of 1 mm^2 mesh size. These traps were placed at the mouth of water channels, just before the water started to rise. The traps were removed when water reached the lowest tidal mark. Collected litter was dried and ashed as above to determine the percentage of OM.

Growth dynamics of mangrove seedlings/saplings: 50 among at least 250 transplanted seedlings/saplings of *Rhizophora mucronata* in Macarascas (site 6Bis) were marked (tagged). These were the objects of the monitoring process, which focused on the plants' demographic dynamics, i.e., changes in height (cm), number of internodes, number of branches, leaves, and roots. Observations were also made on the health of the saplings in relation to the impacts of the seaweed and seagrass debris that decayed while attached to the plants, presumably causing stunting and eventual death.

1.2.2 Results and Discussion

Community structure

In Ulugan Bay the mangrove community shows an average density of 84.2 trees/ 500 m^2. It is mainly dominated by *Rhizophora apiculata*. Among the ten most dominant tree species the following ranking was established in order of decreasing density: *Rhizophora apiculata* (56.4%), *Rhizophora mucronata* (20.3%), *Bruguiera gymnorrhiza* (14.1%), *Aegiceras floridum* (3.8%), *Xylocarpus granatum* (2.5%), *Sonneratia alba* (1.3 %), Unidentified (0.4%), *Bruguiera cylindrica* (0.2%), *Ceriops tagal* (0.2%), *Xylocarpus moluccensis* (0.1%) (Tab. 1.3).

Table 3.1 Average mangrove density (individuals/500m^2)

Sites	1	3	4	5	7	8	9	10	11	12	13	14	Av	%
R. apiculata	28	12	29	19	15	31	24	44	94	179	95		47.5	56.4
R. mocrunata	2	1	29	7	39	3	5	3	58	7	5	46	17.1	20.3
B. gymnorrhiza	7	8	26	26	6	6	9	10		2	7	36	11.9	14.1
A. floridum						1	35	2					3.2	3.8
X. granatum	3		14									8	2.1	2.5
S. alba						6	14	1					1.8	1.3
unknown	3												0.3	0.4
B. cylindrica							2						0.2	0.2
C. tagal	2												0.2	0.2
X. moluccensis												1	0.1	0.1
Total	45	21	98	52	60	47	89	60	152	188	107	91	84.2	

The overall distribution of trees in *diameter at breast height* (dbh) classes shows a predominance of young trees, with dbh values less than 10 cm (Fig. 1.5 a). Only one tree, a Xylocarpus granatum recorded at Sabang, had a dbh value of over 70 cm.

The finding that the mangrove community in Ulugan Bay is dominated by small-sized trees could indicate the occurrence of harvesting of bigger-sized trees.. In certain areas in Ulugan Bay, the local population uses mangroves as fuel-wood. Republic Act 7161, however, prohibits any form of cutting of mangroves. Charcoal of species of *Rhizophora* has high heating value of 6,833 calories/gram. A socio-economic survey shows that about 25% of all households in Ulugan Bay use mangrove charcoal as their main source of fuel (Walters, 1996; see Chapter 3).

Although the extent of harvesting (indicated by the density of cut trees) represents on average only 2% of the total mangrove density, it varies among sites, ranging from 0 to 28%. In addition, harvesting is not homogeneous amongst the dimensional classes. Local communities seem to cut relatively more of the larger (15%) than of the smaller (2 %) size-classes (Fig. 1.5 b-c). This anthropogenic perturbation could be one of the factors keeping the mangrove community in an early successional stage with a dominance of small-sized trees.

The abundance values of the seedlings reflect their potential for recruitment and hence, their rate of colonization or re-colonization of a given area. In Ulugan Bay seedling populations were assessed at all locations, revealing *Bruguiera gymnorrhiza* to have the most abundant seedlings with an average density of 78.2 individuals/ $500m^2$. The other species have the following density: *Rhizophora apiculata* (53.6), *Rhizophora mucronata* (45.1), *Aegiceras floridum* (12.6) and *Sonneratia alba* (10.0).

Saplings are older than seedlings, indicating their ability to survive the prevailing conditions for a period of 1-3 years after the seedling stage. Again, *Bruguiera gymnorrhiza* exhibited the highest total abundance at 60.8 individuals/$500m^2$. A ranking similar to that recorded for seedlings was established for the remaining species. The ratio of seedlings to saplings is generally slightly lower than 1. This would suggest that during the period of study, recruitment is greater than mortality in the overall development of the mangrove system. A possible conclusion is that the anthropogenic perturbation is at a level that could still allow high resilience (i.e. fast recovery) of the system.

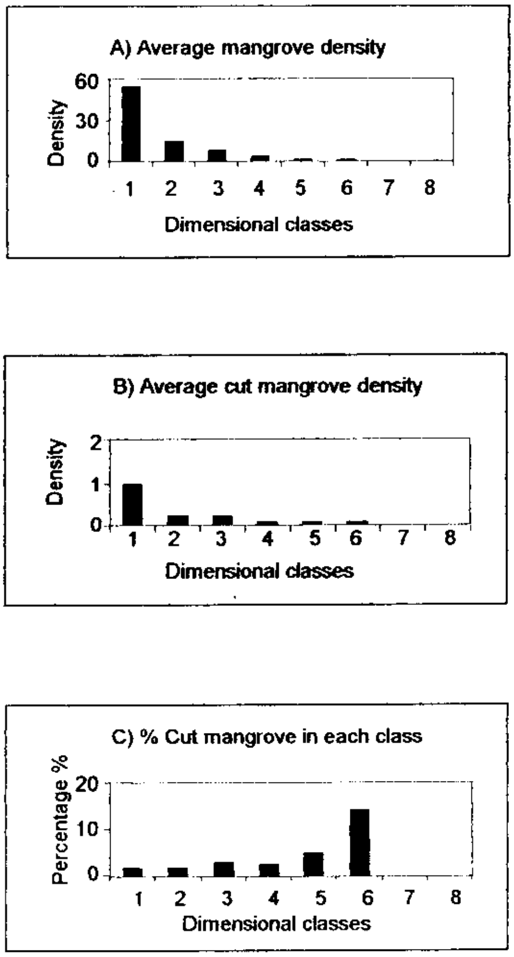

Figure 1.5 A) Average distribution of mangroves in dimensional classes. Density is expressed in number of individuals per 500 m^2.

B) Average distribution of cut trees in dimensional classes. Density is expressed in number of individuals per 500 m^2.

C) Percentage of cut trees in each dimensional classes.

Class 1(0-10cm - diameter breast hight - dbh); class 2 (10-20 cm); class 3 (20-30 cm); class 4 (30-40 cm); class 5 (40-50 cm); class 6 (50-60 cm); class 7 (60-70 cm); class 8 (>70 cm).

The mangrove density, diversity and distribution of trees in dimensional classes varied between the sampling sites and even between localities within each site (Fig. 1.6 - 1.7). Variations in distribution seem related to the degree of human impact. In all the study sites that are close to human habitation, (i.e. Bulalakaw, Buenavista, Tagnipa and Tagabinet), or those strongly affected by tree cutting (Manaburi), the majority (60-97%) of the trees are ranked in the first (smallest) class (0-10 cm dbh). This dominance by small-sized trees could indicate that trees cut for local households play an important role in mangrove community structure. We assumed the human impact could be measured primarily by the evidence of cut trees and secondly by the distance to human settlement. The general trend is that mangrove density increases as human impact decreases (from 45 individuals/500m^2 in Manaburi to 188 individuals/500m^2 in Tagnipa I). On the other hand, the results show that species richness decreases from 6 to 2-3 species and diversity (Hs index) from 1.3 to 0.1 as human impact decreases. This interesting pattern of highest species richness in the more disturbed areas could result in a variant of the "intermediate disturbance hypothesis", which holds that species diversity is often highest in areas where intermediate levels of disturbance act to "maintain local diversity by preventing the elimination of inferior competitors" (Connel, 1978; Karlson and Hurd, 1993).

In contrast, at sites further removed from human settlements (Kayulo and Umalagan)[2] or at sites under protection regimes (Oyster Bay and Sabang), trees generally had attained bigger trunk diameters and greater heights and were relatively evenly distributed in terms of dbh values. The distribution among classes is much more homogeneous (first class 19-50%). In these areas mangrove abundance ranges between 21 and 98 individuals/500 m^2, species richness 2 to 5 species, and diversity (Hs index) from 0.7 to 1.5.

Litter production, tidal transport and decomposition

Litter fall data show that *R. mucronata* had the mean value of 2.80 gOM/m^2/day (site 3) and 2.35 gOM/m^2/day (site 8). *R. apiculata* had the mean value of 2.63 gOM/m^2/day (site 3) and 2.36 gOM/m^2/day (site 8). The magnitude of litter fall is comparable with the values reported by various authors in the region (Tab. 1.4). Leaves represent 75-77% of the whole litter while fruit and flowers 13-15 % and

[2] An exception is site 9 which is in close proximity to the village of Buenavista, but it seems not to be affected by human impact.

wood 8-11%. The trend in litter fall shows a peak in June and in February-April, showing that the onset of rainy and dry season could have initiated abscission in mangrove trees (Fig. 1.8).

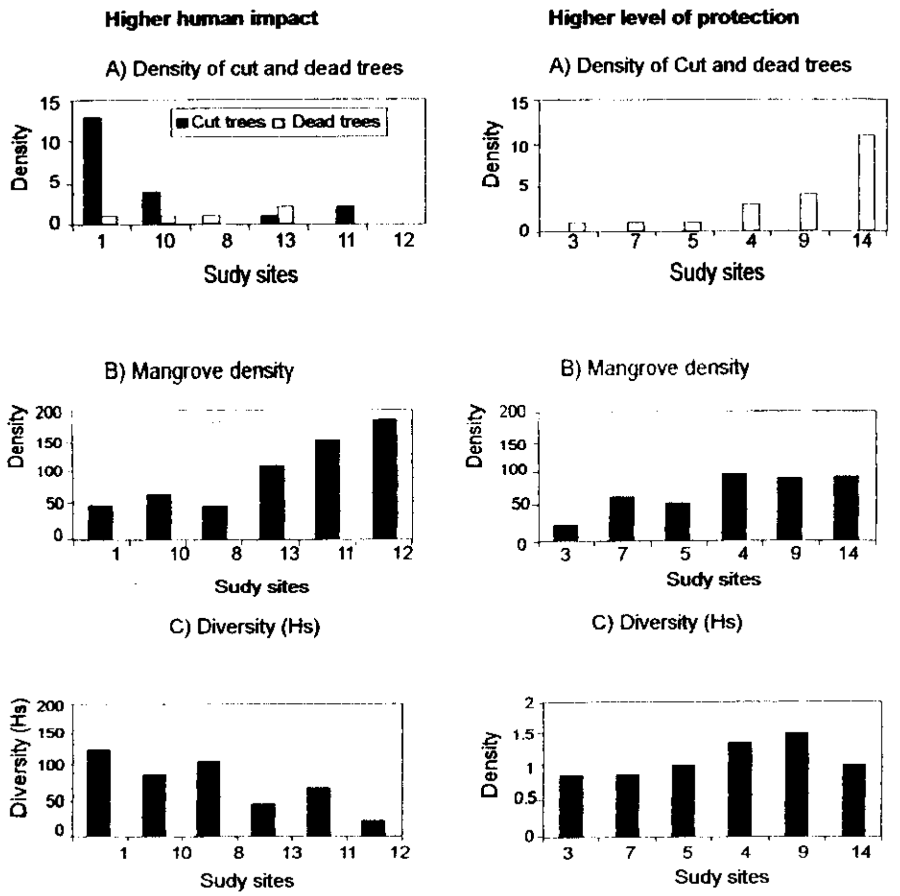

Figure 1.6 A) Average density of cut and dead trees in each study site. The sites with a high human impact are ranked based on a decreasing density of cut trees. Density is expressed in number of individuals per 500 m².
B) Average density of mangroves in each study site. Density is expressed in number of individuals per 500 m².
C) Diversity (Shannon index - Hs).

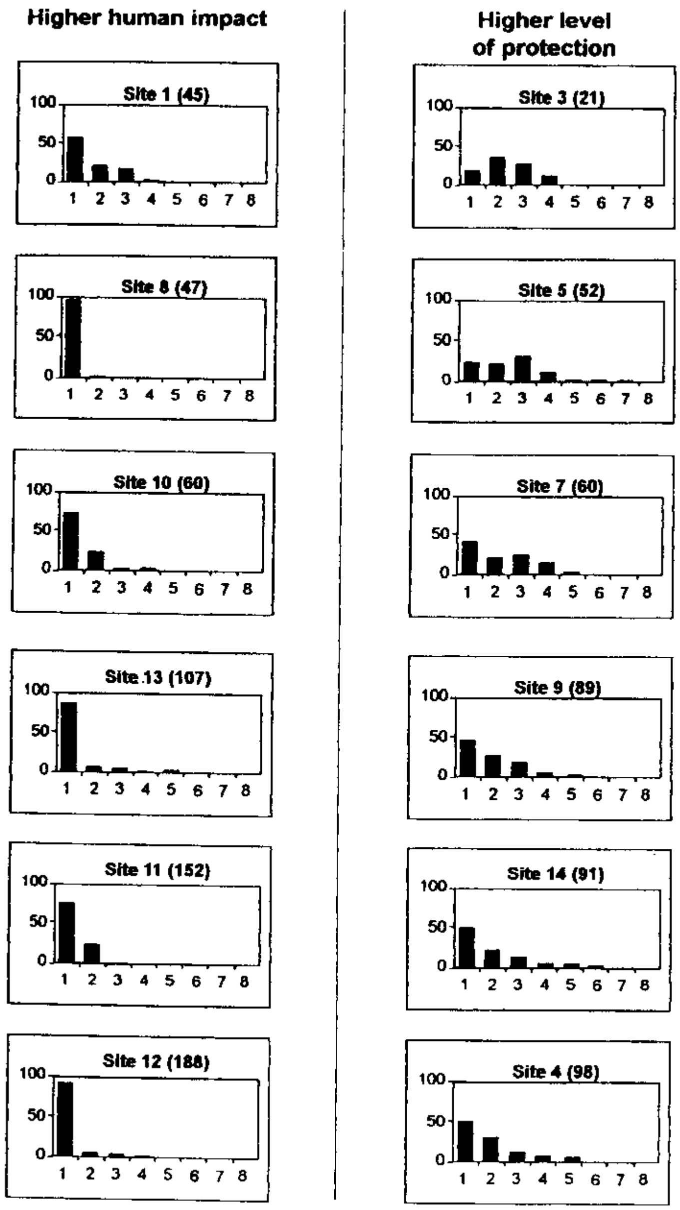

Figure 1.7 Percentage distribution of mangroves in dimensional classes in each study sites. Class 1 (0-10 cm - diameter at breast height - dbh); class 2 (10-20 cm); class 3 (20-30 cm); class 4 (30-40 cm); class 5 (40-50 cm); class 6 (50-60 cm); class 7 (60-70 cm); class 8 (>70 cm). The average density is reported in parenthesis (ni/500 m^2).

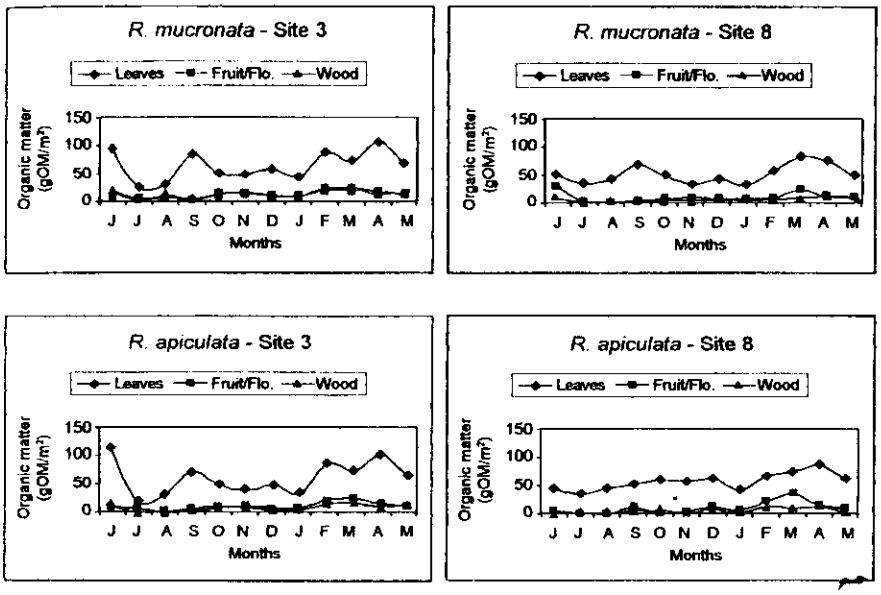

Figure 1.8 Average litter fall in two study sites (Site3 and Site 8 bis) trough the year. Data are expressed in gram of organic matter (gOM) per square meter.

Table 1.4 Mangrove litter fall values recorded in the Region (adapted from Fortes 1989).

	Site	**Dominant species**	**Litter productivity $gOM/m^2/day$**	**Sources**
Philippines	Ulugan Bay	*Rhizophora - Bruguiera*	0.24 - 3.23	Quimpang Unp. data
		Rhizophora - Bruguiera	0.66 - 2.20	Fortes 1989
	Pagbilao Bay	*Rhizophora - Ceriops*	0.48 - 2.38	Fortes 1989
	Banacon	*Rhizophora*	1.38 - 2.40	Fortes 1989
	Bais Bay	-	0.68	De leon et al. 1989
Malaysia	Selangor	*Avicennia*	1.15	Soepadmo & Padi '89
	Kemalang	*Rhizophora*	1.90	
		Bruguiera	2.13	
Thailand	-		0.34 - 3.61	Aksornkoac et al. '89
Indonesia	Grajagan	-	2.02	Atmadja and Surojo 1989
	Ujung Kulon	-	1.75	
Australia	Missionary Bay	-	1.6 - 2.85	Bunt et al. 1979

In both study sites the results of the study on tidal transport show an average net export of leaf litter from the mangrove areas. On average 1,931 gOM in site 3 (3,206 *out* - 1,275 *in*) and 1,962 gOM in site 8 (3,599 *out* - 1,637 *in*) are exported during each tidal cycle. The computed net litter export on average is 1.51 $gOM/m^2/$ day and it represents about 60% of the whole litter production.

The results on litter decomposition show that in both sites the weight loss over time best fit a negative exponential model and leaves of *R. apiculata* decompose faster than those of *R. mucronata*. However, following Petersen and Cummins (1974) classification, both species are in the fast decomposition rate category (average K = 0.036) (Tab. 1.5). The difference between the weight loss of the litter bags protected from macro-invertebrate detritivore colonization (fine mesh) and non-protected litter bags (large mesh) shows that the activities of macro-invertebrate result in a faster decomposition of mangrove detritus. The half-life of the non-protected detritus is on the average 30% lower than that of protected detritus. The detritus weight loss is relatively faster in site 3 and this difference could be attributed to micro-organism metabolism rather than to the macro-invertebrate colonization.

Table 1.5 Percent of original biomass and decomposition constants for litter bags incubated in Ulugan Bay mangrove areas during the three months of study. K is calculated from $(X/X0) = e^{-kt}$; half-life = 0,693/K; turnover = 1/K; n = 5 litter bags per collection date. In the fitted model all the initial litter is present at t=0.

	Species	Mesh size (mm)	Remaining biomass (%)	Exponentil model			Half-life (days)	Turn over (days)
					R^2	K		
Site 3	*R. apiculata*	1	12.9	y=16.31e-0.034x	0.998	0.034	20.38	29.41
		16	7.6	y=17.97e-0.042x	0.992	0.042	16.50	23.81
	R. mucronata	1	16.3	y=15.21e-0.030x	0.996	0.030	23.10	33.33
		16	7.0	y=16.12e-0.044x	0.999	0.044	15.75	22.73
Site 8	*R. apiculata*	1	19.5	y=15.73e-0.027x	0.982	0.027	25.67	37.04
		16	8.1	y=16.31e-0.041x	0.999	0.041	16.90	24.39
	R. mucronata	1	20.2	y=15.29e-0.026x	0.997	0.026	26.65	38.46
		16	8.1	y=16.27e-0.041x	0.998	0.041	16.90	24.39

Litter fall, tidal transport and decomposition rate provide an index of mangrove productivity (Lee, 1989) and allow an understanding of the role of a mangrove ecosystem in the productivity of coastal waters. Using our derived data, it is possible to construct a leaf litter budget in the study areas (Fig. 1.9). Our results show that tides, micro- and macro-faunal removal greatly influence the fate of leaf litter.

The high leaf export suggests that this forest is tidally dominated as this is also reflected by the inundation data (inundation period: 30 to 55% per day). The magnitude of leaf export (59.4%) is within the range (36-78%) reported by Gong and Ong (1990). Hence about 59.4% of the litter production (2.54 gOM/m^2/day) is exported as Large Particulate Organic Matter (LPOM), while the remaining 40.6% is decomposed *in-situ*. Frequent inundation could also explain the fast decomposition of mangrove leaves. Mangrove leaves in a rapidly flushed environment also appear to decay more rapidly than those in slowly flushed environments (Boto and Bunt, 1981; Twilley et al., 1986; Flores-Verdugo et al., 1990; Camilleri, 1992). Frequent inundation therefore accelerates mangrove decomposition (microbial decomposition, leaching and macro-faunal consumption of litter) facilitating export of Particulate and Dissolved Organic Matter (POM and DOM). Considering the amount of tidal export both in terms of leaves (LPOM) as well as POM and DOM resulting from insitu decomposition, this forest acts as an important exporter of nutrients that would enhance overall productivity of coastal waters (Odum and Heald, 1972, 1975 a b).

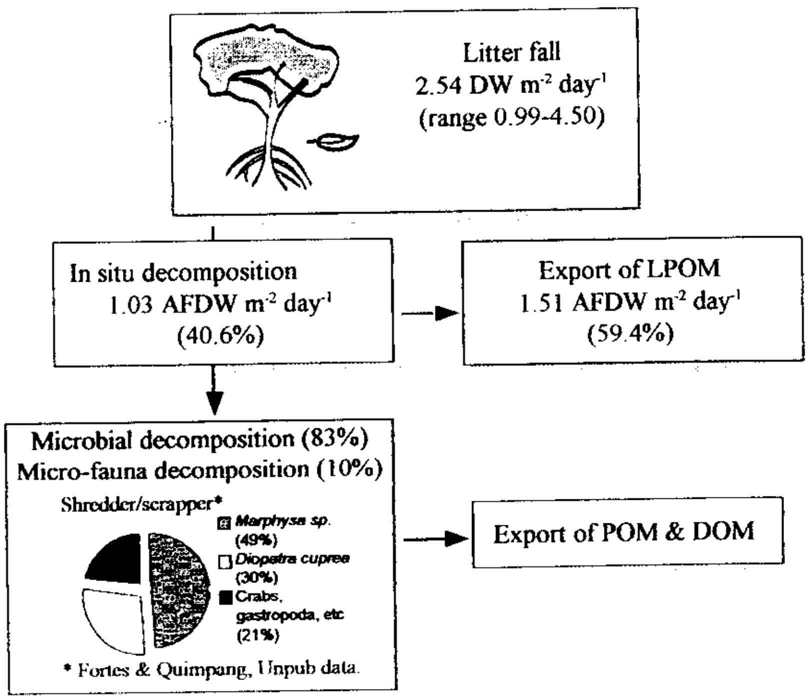

Figure 1.9

Our results also show the importance of macro-detritivore metabolism in speeding up the decomposition of mangrove detritus. They further demonstrate the importance of mangrove production in supporting the detritus-based food webs in Ulugan Bay. In 1999 a study on the dynamics of organic matter was carried out in the mangrove area of Buenavista particularly focusing on macro-invertebrate consumption of leaves[3]. This study shows a dominant role of two polychaete (shredders) *Marphysa sp.* and *Diopatra cuprea*.

Growth dynamics of mangrove seedlings/saplings

The results of the monitoring activities on the mangrove seedlings/saplings are useful in developing a model for predicting the resilience and recovery of mangrove communities after a disturbance. In the period from August 1999 to January 2000 our results show that on average the height of the 5-6 year-old plantings is 85.5 cm. The mean number of internodes was 43.85, while the mean number of other parts were as follows: branches 9.22; leaves 86.07; and roots 9.55. During the 8-month period of study (August 1999 - March 2000) the number of internodes and branches increased with time (ANOVA, $p<0.05$), at a rate of about 1 internode per month. From May to August 2000, 35 of the 50 seedlings/saplings tagged indicate that after 3 months, there was a net decrease in the height of the plants, in the number of internodes (from 45.08 to 43.00) and branches (from 9.72 to 7.40). It is interesting to note that during the August monitoring, a more pronounced decay of the upper portions of the seedlings/saplings was observed. This was due primarily to the similarly decayed fronds of seaweed (*Sargassum sp.*) and seagrass detritus that became entangled with these upper plant parts. In addition, there was an observable infestation both by insects and fungus-like mass of whitish tissue that covered the leaves at these upper parts. These two forms of 'disturbance' appear significant in reducing the number of branches as well as that of the height of the plants (from 86 to 80) and the number of leaves (from 86 to 64). It is interesting to note that the internodal lengths, a natural marker of the growth rate all along the life-time of the seedlings, ranged from 0.5-12 cm (average 1.24 - 5.40 cm). This variability in the internodal lengths indicates a marked differential growth rate that could be influenced by local environmental conditions (i.e. seaweed/seagrass detritus, infestation).

[3] Data on macro-invertebrate consumption collected by V.T. Quimpang and M.D. Fortes. Techniques: stable carbon isotope ratio (Faculty of Environmental Research of the University of Utah); leaf tracing and tethering method; litter bags; microcosm experiments (Palawan National Agricultural College).

1.3 CORAL REEFS AND REEF FISHES

1.3.1 Methodology

Coral Reefs: In the assessment of coral reefs, the line intercept transect (LIT) was used (English et al., 1994). Line intercept transects are used to assess the sessile benthic community of coral reefs. Along 150-m transect lines laid at the 5 m isobath, the community was characterized using six lifeform categories. These provided a morphological description of the reef. The six categories were recorded on data slates by divers who swam along lines placed roughly parallel to the reef crest at the desired depths along three 33.33 m transect lengths (TL). In a 150-m line, the three TLs were the first-, middle-, and end-segment of the line. They served as the replicates for a particular reef. For future monitoring, the location of each site was recorded and marked on the reef. A team of at least 3 personnel was required - 2 divers, and a person in the boat. All observers were familiar with the definitions of each lifeform and they spent 30-45 minutes in the water at the beginning of each field trip, comparing and standardizing their interpretations of the various lifeforms.

Coral Reef Fish Visual Census: Coral reef fish populations were assessed by visual census of the fishes along 150-m transects. The transects were censused during daylight hours using SCUBA and done in conjunction with the Line Intercept Transect (LIT) for corals. Fish counts were made every 5 m along the line with a width of 10 m. All fish present within the belt transect were identified, counted and their standard lengths estimated (in cm). Juvenile fish were also monitored using the same method but with a narrower width of 2 m to facilitate observation.

Where applicable, diversity indices such as Shannon-Wiener Index of diversity and its related indices were determined (Zar, 1984). Community similarity was estimated using Sorensen's Index (SSI).

1.3.2 Results and Discussion

Coral reef

Overall, live *Acropora* and *non-Acropora* covered on average 41% of the reef, dead corals cover 21.6%, while soft corals were the least dominant group. Sand, silt and rocks covered on average 24% (Tab. 1.6).

Comparing the study sites, healthy coral communities were relatively more abundant at the sites of Buenavista, Bulalakaw, and St. Paul. At St. Paul, *non-Acropora* was particularly prevalent. The lowest values of live coral cover were found at Oyster Bay (18.9 %) and Umalagan (26.2%) probably due to their proximity to the mainland where siltation is heaviest. It is interesting to note that in general, live hard corals dominate the eastern portion of the Bay, topped by St. Paul, Bulalakaw, and Buenavista. Rita-Manaburi at the northwestern section similarly exhibited high live hard coral cover. On the other hand, dead corals dominated the western sections, as exemplified by Oyster Bay and Umalagan.

On the whole, the corals of Ulugan Bay are at a relatively late stage in the successional process, rather than a predominantly transitional phase. This was indicated by observations such as the preponderance of hard corals in contrast to the relatively low abundance of soft forms. This finding was particularly marked at the more protected sites of Oyster Bay and Umalagan, where soft coral forms were all but absent.

A general trend was noticeable wherein the branching, digitate or tabulate forms of corals were relatively more abundant than the massive or sub-massive forms at the cleaner or more exposed sites such as Buenavista, Bulalakaw, Sabang, St. Paul and Rita-Manaburi. This contrasted sharply with the more protected sites, such as Oyster Bay and Umalagan, where the more massive and sub-massive forms dominated. This observation is consistent with the general statement that the larger surface area in branching corals is an adaptive mechanism designed to help the coral cope with the lower level of nutrients and the stress imposed by crowding and shading from neighboring coral species at the more exposed sites (Alino, personal communication). Correspondingly, massive corals are better adapted to more protected, silted environments. In extending these arguments, it is often stated that the relative proportion of these two main coral forms (branching and massive) at a given site can be an indicator of the degree of siltation of that site.

Table 1.6 Percent cover of different life form categories along coral transects.

Life form category	Site 2 Man	Site 4 Oys	Site 6 Uma I	Site 8 Bul	Site 9 Bue I	Site 14 Sab	Site 15 Spa
Live *Acropora*	**13.3**	**8.8**	**4.4**	**40.2**	**34.4**	**14.1**	**39.6**
Branching	5.3	8.2	4.3	8.9	4.4	1.4	20.4
Digitate	1.1	-	0.1	2.5	16.3	0.4	2.2
Encrusting	0.6	0.5	-	-	-	-	0.1
Submassive	0.3	0.1	-	2.2		-	-
Tabulate	6.1		-	26.7	13.7	12.2	16.9
Dead *Acropora*	-	**8.0**	**0.8**	**3.8**	**1.1**	**0.6**	-
Branching	-	8.0	0.8	2.6		-	-
Tabulate	-	0.1	-	1.2	1.1	0.6	-
Live Non-*Acropora*	**16.9**	**10.1**	**21.8**	**14.2**	**11.5**	**15.9**	**45.9**
Branching	0.6	-	1.2	0.1	1.2	1.9	3.8
Digitate	-	-	0.3	0.1	-	-	0.1
Encrusting	10.8	-	0.0	5.3	4.1	5.3	3.3
Foliose	0.7	-	0.2	0.5	0.8	0.2	22.6
Massive	2.8	8.4	6.3	5.2	2.9	5.3	7.1
Submassive	2.0	1.8	12.9	0.7	1.2	1.5	8.9
Mushroom	-	-	0.1	2.2	1.2	1.7	0.2
Heliopora	-	-	0.5	-	-	-	-
Millepora	-	-	0.4	-	-	-	-
Dead Non-*Acropora*	**18.4**	**28.9**	**18.0**	**23.6**	**17.4**	**19.5**	**6.0**
Soft coral	**1.1**	-	**0.5**	**1.7**	**12.5**	**10.7**	**3.4**
Others	**0.1**	**5.7**	**4.2**	**1.3**	**1.1**	**0.8**	
Algal assemblage	**4.0**	**8.1**	**6.2**	**3.9**	**2.8**	**15.7**	**2.9**
Seagrass, *Halophila*	-	**2.5**	**3.1**	-	-	-	-
Abiotic	**46.2**	**27.9**	**41.0**	**11.4**	**19.2**	**22.5**	**2.2**
Sand	45.5	10.2	22.1	3.1	15.9	18.2	2.0
Silt	-	17.5	-	-	-	-	-
Water	0.7	0.1	18.9	8.3	3.3	4.3	0.2
Live coral cover	30.1	18.9	26.2	54.4	45.9	30.0	85.6
LCC index*	fair	poor	fair	good	fair	fair	excellent
Dead coral cover	18.4	36.9	18.8	27.4	18.5	20.2	6.0
Condition index**	0.105 fair	-0.449 poor	-0.099 fair	0.200 good	0.119 good	-0.198 poor	0.845 very good

* (Gomez et al. 1991): poor = 0-24.9%; fair = 25-49.9%; good = 50-74.9%; excellent = 75-100%.
** (Manthachitra 1994): log (live coral cover ÷ total cover of coral related components); very poor = < -0.062; poor = -0.062 to -0.176; fair = -0.175 to 0.176; good = 0.177 to 0.602; very good = > 0.062.

Comparing the results of the 1998 and 1999 surveys (Fig. 1.10), there was a general decrease in the cover of hard corals in the Bay. This is more pronounced in Oyster Bay (site 4) and Bulalakaw (site 8) where the 8-month period recorded a 16% and 20% decrease, respectively. Umalagan (site 6) exhibited a 5% decrease in the cover of hard corals, while an insignificant increase was recorded in Rita-Manaburi (site

2) and Buenavista (site 9). There was a general increase in dead coral cover in the Bay (8% in Buenavista, 7% in Bulalakaw, 6% in Oyster Bay). In the case of soft corals, and with the exception of Buenavista, there were significant increases in their cover, with that in Bulalakaw as the most remarkable (13%) and Oyster Bay (10%). It should be noted that the entire coral community in the Bay is still recovering from the typhoon, which ravaged the area in December 1998. Hence the general decrease in hard coral cover, especially at the more exposed eastern sections of the Bay. In addition, the recovery process is preceded by a rapid colonization by the soft corals, an early stage (pioneers) in the ecological development of disturbed reefs.

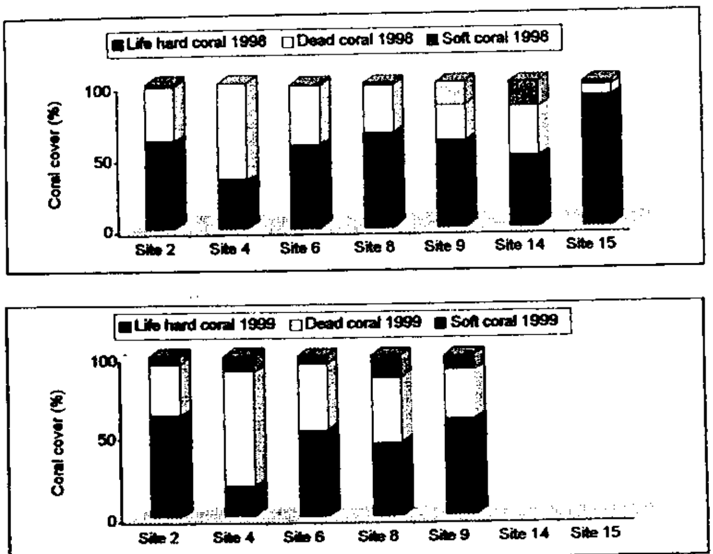

Figure 1.10 Relative percentages of hard, soft and dead coral cover at each site in Ulugan Bay in 1998 and 1999.
No monitoring was undertaken in Sites 14-15 in 1999.

Coral reef fishes

Fish communities are a major resource of coral reefs. They play an important role in coral reef ecosystems (e.g. the role of grazers controlling algae growth), and are commercially important for fisheries as well as for tourism.

In our study, the assessment of reef-associated fish was conducted at six sites. A total of 3,000 individual fish were recorded. They represented 63 species, 35 of which are of commercial value (Tab. 1.7). Of the 25 families recorded, *Labridae*, *Pomacentridae* and *Chaetodontidae* were represented by the highest number of species with 10, 9 and 8, respectively. This finding is consistent with similar studies performed elsewhere in the Philippines (Alino, 1994; Nanola et al., 1994).

Comparing the six sampling sites, our results show the highest diversity of the fish community in St. Paul and Bulalakaw (Hs= 2-2.2). These sites have a low number of species (22) but a more even distribution of fish among the various species. Interestingly, in these two sites the reef shows the highest value of Life Coral Index and Reef Condition Index. In Sabang and Rita-Manaburi, fish community shows the highest similarity (SSI=59%) and present the highest number of species (29) and low diversity (Hs = 1.6-1.7). Evenness values were significantly reduced by the dominance of a few species (Sabang: Abudefduf sp., Rita-Manaburi: Pterocaesio diagramma and Pomacentrus sp.). Offered the highest degree of protection from waves and wind among the sampling sites, and located adjacent to thick mangrove vegetation, Umalagan had the lowest number of individuals and the weakest association with the other sites. However, some similarities were noted with neighboring Bulalakaw, and comparison between the two sites showed a similarity index of 56%. Interestingly the reef in Umalagan also shows low values of Reef Condition Index. These results emphasize the relationship between the condition of the benthic sessile community and the fish community (Fig. 1.11).

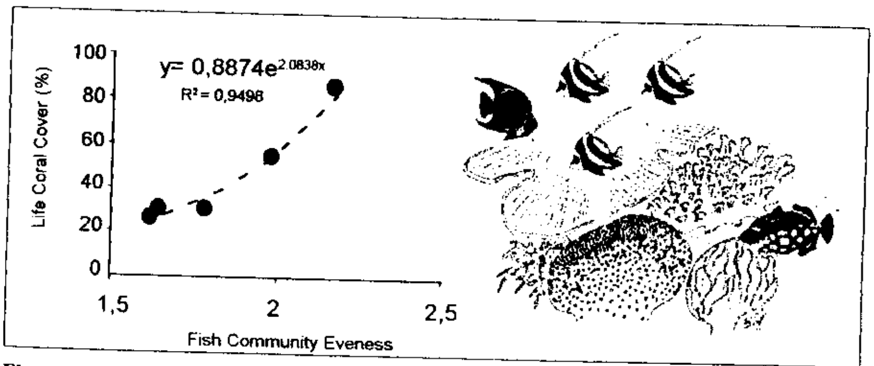

Figure 1.11 Relation between life coral cover (%) and fish community evennes E(H). Only in site 9 this relation was not found

Table 1.7 Fish visual counts in Ulugan Bay along 50 m transects at various study sites. The total number of individual fish, the number of species, the Shannon-Weiner Diversity Index (H') and Evenness (E(H')) for each site are listed. Commercially important taxa (*) and the trophic group of each taxon are indicated.

Family	Trophic groups**		Sites					
			2	6	8	9	14	15
Acanthuridae	a	*Acanthurus gahhm**	9			6	10	1
Acanthuridae	a	*Prionurus* sp.*	1					
Apoginidae	bc	*Apogon* sp.*		10	30	500		
Apogonidae	bc	*Cheilodipterus quinquelineatus*			10		1	
Aulostomidae	de	*Aulostomus chinensis*	2					
Balistidae	cef	*Sufflamen fraenatus*	6			1	2	2
Bleniidae	t	*Aspidontus taeniatus*					3	
Caesionidae	acf	*Caesio cuning**	10		5		25	
Caesionidae	acf	*Pterocaesio diagramma**	550					
Carangidae	predator	*Carangoides dinema**					1	
Chaetodontidae	bcdfg	*Chaetodon lineolatus*				3		
Chaetodontidae	bcdfg	*Chaetodon* sp.		2	2	4		1
Chaetodontidae	Gi	*Chaetodon trifascialis*	3					6
Chaetodontidae	hgif	*Chaetodon fagabundus*	2		3	5	1	
Chaetodontidae	c	*Forcipiger longirostris*			1			
Chaetodontidae	gu	*Heniochus* sp.				2		2
Chaetodontidae	gu	*Heniochus varius*				1		
Ephippidae	fue	*Platax orbicularis*		3				
Haemulidae	k	*Plectorhinchus chaetodonoides**		1				1
Holocentridae	B	*Myripristis* sp.*			6		5	3
Labridae	cnlm	*Cheilinus chlorourus**	12	4	3	2	1	
Labridae	cnlm	*Cheilinus undulatus**	1					
Labridae	cnlm	*Cheilio inermis*	1				2	
Labridae	cnlm	*Choerodon anchorago**		2	1	2		
Labridae	cnlm	*Coris pictoides*			2			
Labridae	cnlm	*Halichoeres* sp.	28				6	
Labridae	cnlm	*Labroides dimidiatus*	4			6	5	7
Labridae	cnlm	*Thalassoma lunare**	20		3	3	21	15
Labridae	cnlm	*Thalassoma lutescens**		1				1
Labridae	cnlm	*Thalassoma* sp.*			13	6	1	
Lethrinidae	dn	*Lethrinus lentjan**					1	
Lutjanidae	dea	*Lutjanus decussatus**				1		5
Lutjanidae	dea	*Lutjanus fulviflamma**					1	5
Lutjanidae	dea	*Lutjanus vitta**					1	
Mullidae	c	*Parupeneus barberinoides**	1					
Mullidae	c	*Parupeneus* sp.*	4				1	
Mullidae	c	*Upeneus moluccensis**	3					
Mullidae	c	*Upeneus tragula**	1			5	2	3
Nemipteridae	ca	*Scolopsis affinis**	11		1	5		
Nemipteridae	ca	*Scolopsis bilineatus**		2	6		8	
Nemipteridae	ca	*Scolopsis ciliatus**	1					
Pempheridae	Bb	*Pempheris* sp.*					8	
Pomacentridae	Bbf	*Abudefduf notatus*					35	
Pomacentridae	Bbf	*Abudefduf sexfasciatus*						54
Pomacentridae	Bbf	*Abudefduf* sp.	121	80	70	240	310	67
Pomacentridae	Bbf	*Amphiprion frenatus*	1					1
Pomacentridae	acf	*Chromis caudalis*						
Pomacentridae	fd	*Chrysiptera parasema*			150			
Pomacentridae	acf	*Dascyllus trimaculatus*		8	5		3	
Pomacentridae	fad	*Neoglyphidodon* sp.	10	20	33	25	36	49
Pomacentridae	fv	*Pomacentrus* sp.	164	12	15	5	3	10
Scaridae	o	*Scarus dimidiatus**				1		

Scaridae	o	*Scarus* sp.	48	1			9	1
Serranidae	Bbd	*Epinephelus fasciatus**			1	2		
Serranidae	Bbd	*Plectropomus maculatus**	1		2			6
Siganidae	Fpq	*Siganus fuscescens**					30	
Siganidae	f	*Siganus virgatus**	1	2	2	2	4	
Synodontidae	r	*Synodus variegatus**	1			1		
Zanclidae	s	*Zanclus cornutus*	3			3		5
Number of individuals			1020	148	364	831	536	250
Number of species			29	14	22	24	29	22
Shannon-Weiner Diversity Index, H'			1.650	1.657	2.066	1.199	1.805	2.209
Evennes, E(H')			1.637	1.613	1.977	1.185	1.779	2.167

** Trophic groups: a. planktivore; B, large zooplankton; b, small zooplankton; c, small benthic invertebrates; d, small crustaceans; E, fish, e, small fish; F, filamentous algae; f, algae; G, *Acropora polyps*; g, coral polyps; h, small anemones; i, coral mucus; j, polychaetes; k, sand-dwelling invertebrates; l, wide variety of invertebrates; m, toxic, prey e.g. crown-of-thorns, boxfish, sea hares; n, mollusks, o, algal film growing on coral rocks; p, leafy algae, q, seagrass; r, voracious predator of small fish; s, primarily on sponges; t, tubeworms, demersal fish eggs; u, other invertebrates; predator, eats fish, mollusks, crustaceans, etc. in various sizes.

1.4 SEAGRASS

1.4.1 Methods

Structure and Growth Rate. Data on seagrass were gathered inside 50x50 cm quadrats placed at regular intervals along selected transects. The latter were placed perpendicular to the shore, representing prevailing gradients in water depth, substrate, and exposure to wind and waves. The structure of the plant communities was assessed in terms of their composition, abundance, and status in relation to prevailing habitat conditions. In addition to % frequency and cover, density (no. of shoots per unit area, a more reliable index of abundance in discrete communities), was also used. Because of the inherent heterogeneity in the morphology of the species, frequency and/or density rating were used in the case of species with discrete habits (e.g. can be counted individually).

A series of photographs were taken periodically of representative quadrats using a Nikonos V underwater camera. The photographs not only allow speedy collection of data in the field, but also provide a permanent record of the quadrat, which is useful for long term monitoring of growth, mortality and recruitment (Gittings et al., 1990). Monitoring of seagrass over time using successive observation and photography can also be a useful technique for detecting sediment smothering. This technique was used by Rogers (1990) in monitoring coral colonies.

1.4.2 Results

In the Bay two distinct types of seagrass communities are present: In the silted southern part of the Bay the seagrass communities were markedly dominated by only one species (*Enhalus acoroides*), a species known to be resistant to high levels of siltation, while in areas with clearer, less silted waters highly diverse mixed seagrass communities were found

Seven species of seagrass were identified from the study sites in Ulugan Bay. This number comprises 40% of the total number of seagrass species recorded in the Philippines and Southeast Asia, and 18% of that in the whole world. Species dominance in seagrass was site-specific. *Halodule uninervis* was the densest at 875.8 individuals/m^2. This was recorded at Buenavista. *Syringodium isoetifolium* from the same site followed with 491.3 individuals/m^2 *Cymodocea rotundata* (337.3 individuals/m^2) from Manaburi was third overall in density, followed by *Thalassia hemprichii* from Umalagan with 4 individuals/m^2.

Comparing data from all seagrass study sites, it appears that there was no significant change in the composition of the seagrass from February 1999 to March 2000 (Tab. 1.8). All seven species were found in the Bay throughout the study period. *Enhalus acoroides* was found in all the six sites. In Buenavista, all 7 species were found throughout the study period and in March *S. isoetifolium* was flowering profusely. During this month, the seagrass were highly epiphytized by the red seaweed, *Liagora farinosa*.

In terms of diversity, Buenavista and Tarunayan exhibited the highest number of species (7). This was followed by Rita-Manaburi with six, Oyster Bay with four, Umalagan, with three, and Macarascas with one. In terms of frequency, E. acoroides markedly dominated the sites (frequency range = 12.3%, February, in Buenavista, to 72.1%, February, in Umalagan). The small often sand-occluded seagrass, *Halophila ovalis*, had the lowest (range = 0.2%, October, in Tarunayan, and November in Buenavista, to 2.1% at the latter site).

Six of the 7 species showed distribution patterns that appeared to be dictated both by site conditions and periods of the year. Hence, *C. rotundata* appeared to favor the summer months at the more exposed, coralline sites of Rita-Manaburi and Tarunayan. However, it showed no temporal variability in Buenavista, occurring throughout the entire period of the study, and with remarkably consistently high frequency of occurrence. It was not recorded at the three other sites in the Bay.

T. hemprichii and *C. serrulata* exhibited similar occurrences (throughout the entire period of the study) and only in sites which are relatively exposed to surf, nearer the mouth of the Bay (Rita/Manaburi, Tarunayan, Oyster Bay, and Buenavista).

Halophila ovalis showed a similar pattern of distribution except that, with slight site-specific variations, it appeared to favor only periods that were cooler thus providing a transition to the warmer months. It should be noted, however, that the sampling for frequency of occurrence focused only on the presence/absence of the species as seen through the water column and at the surface of the vegetation. It is known that *H. ovalis* thrives relatively well in the 'understories' of the bigger species and even underground. They are therefore not normally seen by ocular surveys.

Table 1.8 Seagrass frequency in Ulugan Bay. ENHA, *Enhalus acoroides*; CYRO, *Cymodocea rotundata*; THAL, *Thalassia hemprichii*; CYSE, *Cymodocea serrulata*, HOVS, *Halophila ovalis*; HALU, *Halodule uninervis*; SYRI, *Syringodium isoetifolium*. Ns = no samples.

	ENHA	CYRO	THAL	CYSE	HOVS	HALU	SYRI
Site 2							
Feb 1999	65.2	0.3	7.4	12.4	0.1	0.2	–
May	58.3	2.1	9.1	27.2	0.2	1.3	–
Aug	67.2	0.2	11.4	19.4	0.7	–	–
Oct	61.4	–	6.2	21.1	1.2	–	–
Nov	53.1	–	8.3	13.2	0.2	–	–
Mar 2000	39.2	1.4	6.3	8.2	0.4	2.4	–
Site 3							
Feb 1999	34.3	–	4.2	9.2	0.3	–	–
May	51.2	–	1.4	0.7	–	0.4	–
Aug	47.4	0.4	7.2	0.4	–	–	–
Oct	37.7	–	6.2	4.3	–	–	0.2
Nov	52.1	–	2.2	7.2	0.2	–	–
Mar	ns	ns	ns	ns	ns	ns	ns
Site 4							
Feb	12.3	–	0.3	11.1	0.4	–	–
May	23.2	–	0.7	5.3	0.2	–	–
Aug	18.1	–	0.3	2.2	–	–	–
Oct	20.2	–	1.2	9.3	–	–	–
Nov	16.2	–	0.9	6.3	–	–	–
Mar 2000	15.3	–	1.3	4.2	0.2	–	–
Site 6							
Feb 1999	72.1	–	–	–	–	–	–
May	67.2	–	–	–	–	–	–
Aug	57.3	–	–	–	–	–	–
Oct	48.2	–	–	–	–	–	–
Nov	43.1	–	–	–	–	–	–
Mar 2000	28.4	–	1.4	–	0.4	–	–
Site 8							
Feb 1999	54.4	–	–	–	–	–	–
May	62.1	–	–	–	–	–	–
Aug	43.2	–	–	–	–	–	–
Oct	52.1	–	–	–	–	–	–
Nov	43.4	–	–	–	–	–	–
Mar 2000	37.2	–	–	–	–	–	–
Site 9							
Feb 1999	36.4	31.0	21.1	22.5	1.7	11.1	0.5
May	31.1	22.4	16.3	15.3	2.6	9.2	1.7
Aug	33.7	17.2	12.7	25.0	0.3	3.7	2.1
Oct	41.3	9.3	15.2	19.5	1.3	7.4	0.6
Nov	33.6	26.3	21.1	19.2	0.7	5.2	0.2
Mar 2000	30.0	19.2	9.1	31.1	0.4	4.2	3.2

Halodule uninervis consistently demonstrated its 'pioneer' nature, being present at the shallowest portions of the sites. Its seasonality was not as pronounced as the other five species, favoring both the transition period as well as the summer months. However, it was not found at the more protected sites and at any time during the study.

S. isoetifolium had a very limited distribution, being found only in Tarunayan in October. It was, however, found in Buenavista throughout the entire period of the study.

From the data, it is interesting to note that the distribution of the seagrass species amongst the sites in the Bay follows a pattern wherein more protected sites had fewer species. However, their relative frequencies were much higher. On the other hand, those from more exposed sites had more species, but their frequencies were much lower. This demonstrates the classical inverse relationship between diversity and dominance, the latter being represented by relative density (RD).

From the above results, it appears that the Bay, as represented by the seagrass from the six sites, is characterized by varying stages of ecological development. These stages likewise represent the varying degrees of perturbation, natural or man-made, to which these sites are being subjected. Hence, the vegetation progresses from the apparently most stable, highly diverse mixed seagrass community at Buenavista and Rita/Manaburi to the lowly diverse one at Tarunayan (*Enhalus acoroides* and *Thalassia hemprichii*, *Cymodocea serrulata*) and Oyster Bay (*Cymodocea serrulata*, *Thalassia hemprichii*, *Halodule uninervis*, *Halophila ovalis*), to the even less diverse community at Macarascas and Umalagan (*Enhalus acoroides*). It should be noted that Umalagan and Oyster Bay are deeper indentations of Ulugan Bay, hence, relatively more protected from waves, with substrates which are more muddy. On the other hand, Tarunayan, Buenavista, and Manaburi are more frequently exposed to wave action and with coarser sediment substrates.

1.5 SEAWEEDS

1.5.1 Methods

As in the case of the seagrass, data on seaweeds were gathered inside 50x50 cm quadrats systematically placed along the transects at six sites in the Bay. These sites are: Manaburi, Rita Island (south), Oyster Bay, Umalagan, Buenavista, and Bulalakaw. The structure of the benthic communities were assessed in terms of their composition, abundance, and status in relation to the prevailing habitat condition. In addition to % frequency and cover, density (no. of shoots per unit area) was also used. Because of the inherent heterogeneity in the morphology of the species, frequency and/or density rating were used in the case of species with discrete habits (e.g. can be counted individually); on the other hand, cover was used in the case of species with a 'sheathed' morphology, blanketing the entire quadrat, or those which cannot be counted individually e.g. *Sargassum sp.*

1.5.2 Results

Seaweed communities at the study sites were closely associated with seagrass and coral reefs, i.e., recorded along transects where these latter habitats were surveyed. From the nine sites where corals and seagrass were assessed, 13 different species of seaweeds were found at the seagrass sites, while 8 species were recorded at the coral reef sites. Four species belonging to *Rhodophyceae* (red algae) were found. These were *Amphiroa fragilissima*, *Laurencia sp.*, *Liagora farinosa*, and *Ceratodictyon spongiosum*. On the other hand, six species of *Chlorophyta* (green algae) and seven species of *Phaeophyta* (brown algae) were found. It should be noted that the record of the seaweeds may not have been complete as seaweeds have different habitat requirements and they were surveyed at sites dominated by seagrass and corals.

The three studies undertaken within the period May 1999 - March 2000 showed the presence of at least 56 species of macrobenthic algae in Ulugan Bay. The algae were categorized under the following groupings: *Cyanophyceae* (bluegreen algae), 1 species; *Chlorophyceae* (green algae), 26 species; *Phaeophyceae* (brown algae), 16 species; and *Rhodophyceae* (red algae), 26 species (Tab. 1.9).

Table 1.9 Seaweed species found in Ulugan Bay. (SD, sub-dominant; D, dominant)

Species	May 99	Nov 99	Mar 00
CYANOPHYCEAE (bluegrass, 1)			
Brachytrichia sp.	x	x	x
CHLOROPHYCEAE (greens, 26)			
Acetabularia dentata			x
A. major	x		
Acetabularia sp.	x		x
Anadyomene plicata	x		x
Bornetella sp.	x	x	x
Bryopsis plumosa	x		
Caulerpa brachypus	x		x
C. cupressoides		x	
C. lentillifera		x	x
C. serrulata	x		x
C. sertularoides			x
Chaetomorpha antenina	x		
Chaetomorpha crassa	x	x	
Codium bartlettii (?)			x
Dictyosphaeria cavernosa			x
Halimeda macroloba	x	x	x
H. opuntia	x	x	x
H. tuna	x	x	x
H. velasquezii	x	x	x SD
Microdycton sp.	x		
Neomeris annulata	x	x	x
N. van-bossae	x	x	x
Spongomorpha sp.	x	x	x
Udotea argentea	x	x	x
U. orientalis	x		x
Valonia ventricosa	x		
PHAEOPHYCEAE (browns, 16)			
Colpomenia sinuosa			x
Dictyopteris sp.			x
Dictyota cervicornis			x
D. dichotoma	x	x	x
D. divaricata	x	x	x
Hormophysa cuneiformis	x SD	x SD	x SD
Hydroclathus clatharus	x	x	x
Lobophora variegata		x	x
Padina australis	x SD	x SD	x D
P. japonica			x
P. minor	x	x	x SD
Padina sp.			x
Sargassum polycystum	x	x	x
Sargassum sp.	x D	x D	x D
Turbinaria conoides	x	x	x
T. ornata	x SD	x SD	x

RHODOPHYCEAE (reds, 26)			
Acanthopora muscoides			x
A. specifera			x
Actinotrichia fragilis			x
Amansia glomerata	x	x	x SD
Amphiroa foliacea	x		x
A. fragilissima	x	x	x
Ceratodictyon spongiosum	x	x	
Corallina sp.			x
Galaxaura oblongata			x
G. subfruticulosa (?)			x
Gelidiella acerosa	x	x	x
Gracilaria coronopifolia	x	x	x
Hypnea cervicornis	x		
H. boergesenii			x
H. valentinae	x		
Hypnea sp.			x
Laurencia cartilaginea	x		x
Laurencia flexilis	x SD		x
L. obtusa	x		x
L. palisada	x		
L. papillosa	x		
L. parvipapillata			x
L. tronoi	x		x
Liagora farinosa			x
Mastophora rosea	x	x	x
Tolypiocladia calodictyon	x		
Total (69)	47	30	56

Another site in Oyster Bay was surveyed in March 2000. This was because of the report from the local inhabitants that indicated that the area is the source of a seaweed delicacy, 'lato' (*Caulerpa lentillifera*). Indeed, beds of the species were found close to the mangroves. These were highly silted. Estimated mean frequency was high (62.3% in 10 quadrats).

Interestingly, the results point to a certain degree of seasonality in the occurrence of the macrobenthic algae. The colder, wetter season represented by November is characterized by the presence of a significantly lower number of species (30) when compared to the warmer, drier months of May and March (with 47 and 56 species, respectively). While this might be true, the total biomass of the seaweeds, particularly contributed by the browns, could be more significant during the former period. This is consistent with the known seasonal or temporal ecology of the seaweeds from both tropical and temperate latitudes (Kinne, 1970). Hence, the trend in biodiversity in as far as the seaweeds are concerned suggests a shift to higher dominance by a few well adapted species (*Sargassum spp.*, *Hormophysa*, *Padina*) as the year approaches the colder, wetter months. True to the tropics, the summer months from March to April yield the highest biodiversity in most other marine communities (Kinne, 1970).

On a per-site basis, the following sequence of sites with decreasing number of seaweed species results: Manaburi (51 spp), Buenavista (37 spp), Rita Island (21 spp), Oyster Bay (13), Umalagan (12 spp), Bulalakaw (3 spp).

As in the case of the seagrass species, the local distribution of seaweeds showed a pattern that reflected the influence of the natural substrate and the degree of exposure to wind and waves. The north (western and eastern) sections of the Bay yielded significantly greater number of species when compared to the southern portions. Hence, sites with more varied substrates (e.g. sandy, rocky, coralline) and which are relatively moderately exposed to waves yield greater number of species. This was true for the Manaburi, Buenavista, Rita Island sites. On the other hand, sites which are distinctly muddy (hence, affording little opportunity for seaweeds to attach themselves) and which are relatively more protected yield smaller number of component species. This is true for Oyster Bay and Umalagan (12 spp). Bulalakaw, while rocky coraline, is a reef promontory exposed to sun and wind during low tides, could hence support only small cryptic, not many macrobenthic, seaweeds.

Some of the seaweeds recorded are known to be of economic importance (Tab. 1.10 This points to their potential in adding income to the coastal population if the resources and their uses are properly tapped and managed.

Table 1.10 Seaweeds in Ulugan Bay with known economic value

Species	Economic Use/Importance
Caulerpa	human food; medicine; antifungal, lowers blood pressure
Caulerpa racemosa	
Caulerpa sertularoides	
Codium arabicum	human food
Codium edule	
Dictyospheriae cavernosa	medicine, antimicrobial
Halimeda spp.	with growth regulators (auxin, gibberelin, cytokinin)
Dictyota dichotoma	human food; source of phenols, vitamins, folic and folinicacids
Padina australis	human food; source of alginic acid
Sargassum spp.	human food; source of algin, auxin-like substance; controls heavy metal (Pb, Cd) pollution
Turbinaria sp.	human food; source of algin, minerals
Laurencia spp.	human food; source of agar, carbohydrates, medicine, antifungal, antibacterial

1.6 SYNTHESIS

The study here presented provides information on Ulugan Bay coastal ecosystems: mangrove forests associated with tidal flats, seagrass beds and coral reefs (Fig. 1.12). In Ulugan Bay there are about 7.90 km^2 of mangroves with three dominant species: *Rhizophora apiculata*, *R. mucronata*, and *Bruguiera gymnorrhiza*. This area accounts for 15% of the total mangroves in the Philippines and 50% of the mangroves in Palawan. The results of this study show that human impact currently affects the structural characteristics of mangrove ecosystems. As harvesting by local population acts as a "selective perturbation" which mainly affects the older trees, the mangrove community is structurally dominated by small-sized trees. This anthropogenic perturbation strongly affects the eastern part of the Bay. The trees in the western side of the Bay, subjected to lower human pressure, and in protected areas (i.e. those included in the Puerto Princesa National Park and Natural World Heritage Site), have attained bigger dimensions and mangrove communities reach a more stable state.

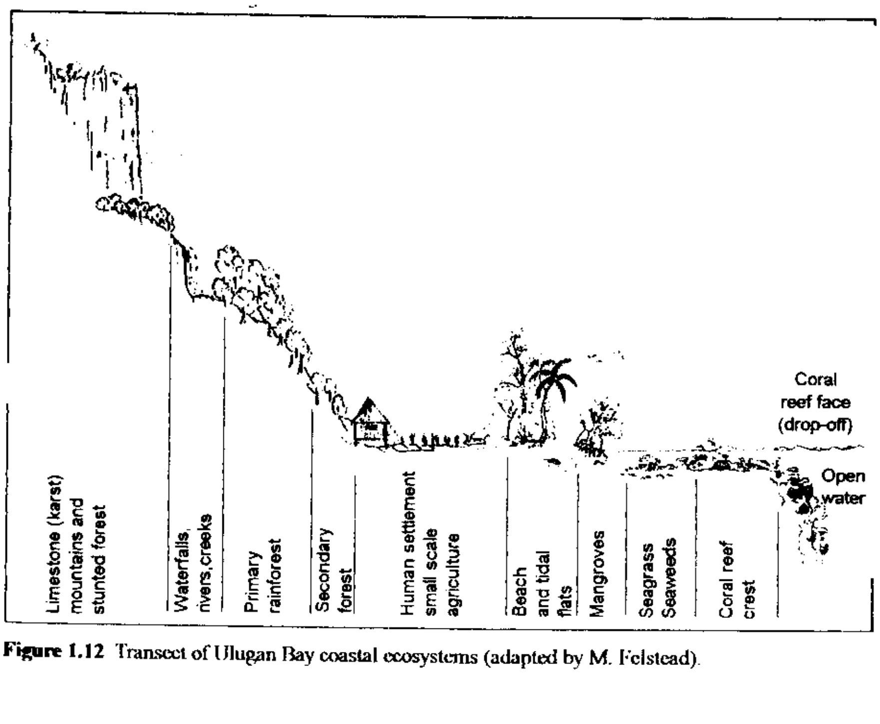

Figure 1.12 Transect of Ulugan Bay coastal ecosystems (adapted by M. Felstead).

On the other hand, the diversity pattern of highest species richness in the more disturbed areas shows that anthropogenic disturbance in Ulugan Bay is still at an intermediate level. Moreover, the mangroves in Ulugan Bay show a high potential for recruitment and this fact allows us to postulate a high resilience of the system. The ratio of seedlings to saplings is generally slightly lower than 1 showing that recruitment is greater than mortality in the overall development of the mangrove system. The relatively fast seedling growth also supports this hypothesis.
The mangrove ecosystem in Ulugan Bay is tidally dominated. In such a flushed environment, organic matter export is high (59%) and *in-situ* decomposition comparatively fast. Considering the amount of tidal export both in terms of leaves (LPOM) as well as POM and DOM resulting from *in-situ* decomposition, this forest acts as an important exporter of nutrients. Our results further demonstrate the importance of mangrove production in supporting the detritus-based food webs in Ulugan Bay.

Coral reefs and seagrass beds currently cover an area of 12.35 km^2. As a general trend, we found that a negative relationship exists between the number of species of seaweeds, seagrass, and corals and the degree of siltation in the Bay.

Coral reefs in very good condition where found only outside the Bay (St. Paul) while in areas of the Bay with clearer, less silted waters (northwest, northeast and east), healthy coral stands and high species diversity were noted (in good, fair/good conditions). Coral recovery was also apparently faster in these parts with soft coral being the pioneer species. This contrasted with the more protected and silted sites (south, southwest) where dead corals (in poor, fair/poor conditions) and the massive and sub-massive forms dominated. This observation was also true for seagrass and seaweeds wherein, in areas where they were found together, higher species diversity in one community was coupled with a lower diversity in the other. This is primarily because of their different ecological requirements. In the silted southern part of the Bay the seagrass communities were markedly dominated by only one species (*Enhalus acoroides*), a species known to be resistant to high levels of siltation, while in areas with clearer, less silted waters highly diverse mixed seagrass communities were found (Fig. 1.13).

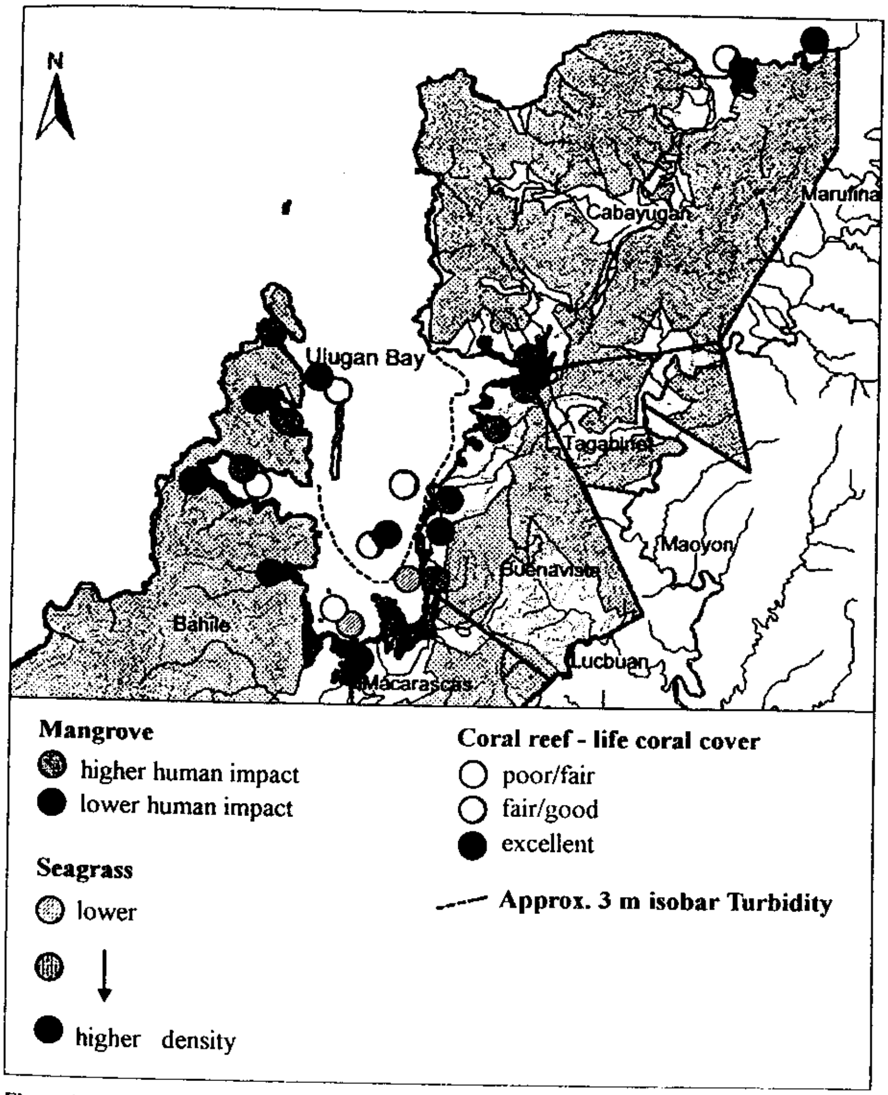
N
Cabayugan
Marufina
Ulugan Bay
Tagabinet
Maoyon
Buenavista
Bahile
Lucbuan
Macarascas
Mangrove
higher human impact
lower human impact
Seagrass
lower
higher density
Coral reef - life coral cover
poor/fair
fair/good
excellent
Approx. 3 m isobar Turbidity

Figure 1.13

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