JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
DEPARTMENT OF TOURISM (DOT), PHILIPPINES

THE STUDY ON ENVIRONMENTALLY SUSTAINABLE TOURISM DEVELOPMENT PLAN FOR NORTHERN PALAWAN IN THE REPUBLIC OF THE PHILIPPINES

Supplemental Report No. 1

Marine Environment of Northern Palawan

March 1997

JICA Study Team

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1. Physical Environment

1.1. Geography

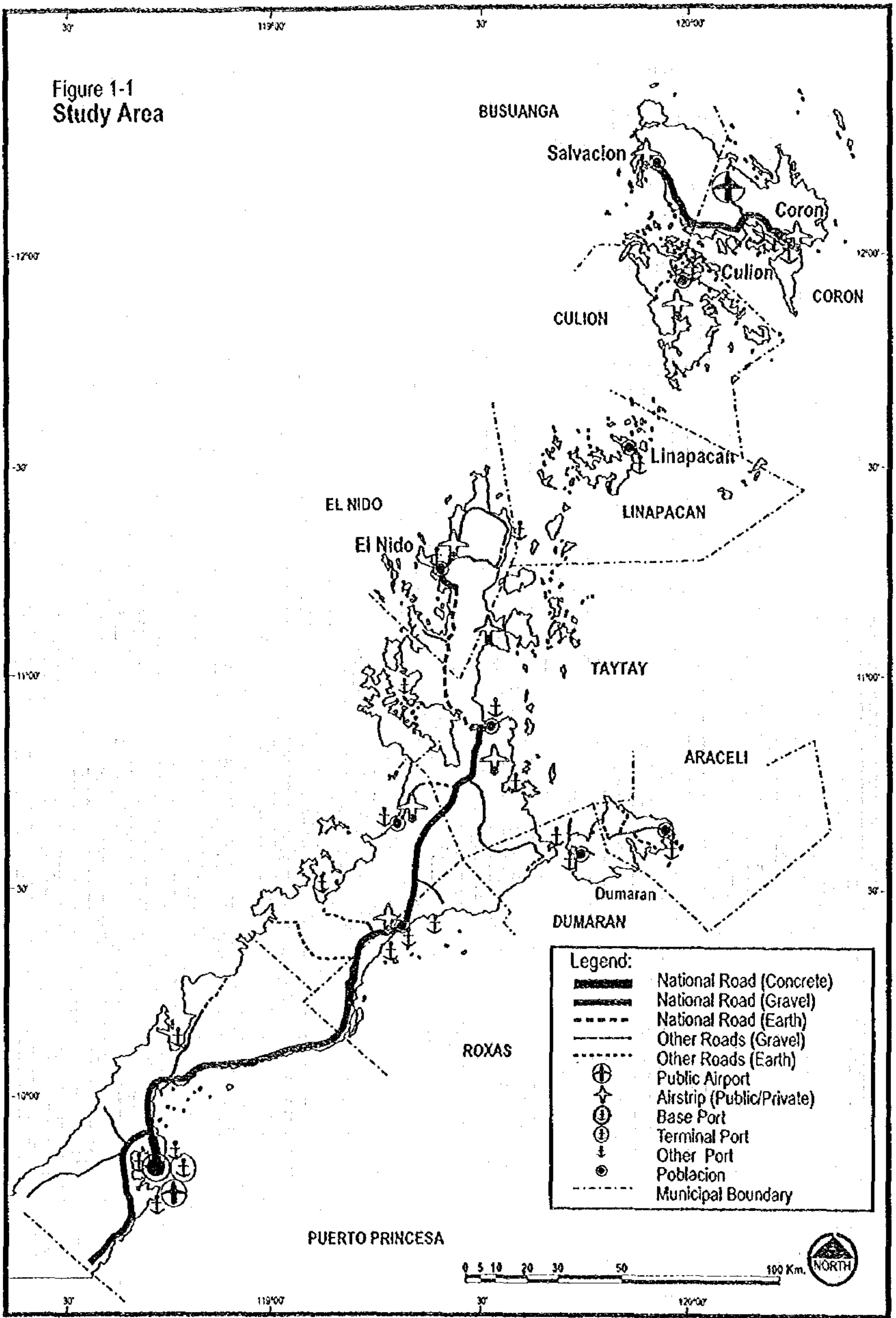
Palawan reclines between Mindoro Island and North Borneo and is about 240 km. southwest to Manila, lying approximately 8-12° north and 117 -121° east. It is an archipelago of 1,780 islands and islets with an area of 14.896 km² and length of 650 km. The main island is 440 km long and 8.5 - 42 km and is divided into east and west coasts by a chain of tall mountains that runs through its entire length.

The study area, shown in Figure 1-1, consists of the main island, the Calamian island group and numerous small islands and islets which are almost all fringed by coral reef. There is a wide shelf water area on the west coast and northern east coast of the study area, while a smaller shelf area is found on the southern east coast.

1.2. Geology

Unlike the rest of the archipelago, Palawan is classified as a table zone due to the marked absence of seismic activity in the region (Gervasio, 1966). Northern Palawan and the neighboring islands are predominately made up of upper Paleozoic (280 million ybp) to lower Mesozoic (195 million ybp) rocks and their metamorphosed equivalents. The oldest identified rock sequence is the metamorphic rocks of Barton and possibly northern Honda Bay. These were determined to be late Paleozoic, i.e., about 280 million ybp The various limestone deposits already deposited when the Palawan continental block collided with what was then the Philippine archipelago are:

- the El Nido limestone, the oldest deposit, (referred to as the Minilog Limestone, Late Permian approximately 260 million ybp);
- the Coron and Sangat Islands (probably Early Jurassic to late Triassic, 195 million ybp);
- the Maytoguid and Pabellion (Eocene, about 38 million ybp);
- St. Paul's Bay limestone (Lower Miocene, about 22 million ybp)



Source: Study Team

Making up the Calamian group of islands is chert belonging to the Liminagcong Formation, dated to be middle Triassic (about 225 million ybp). This consists largely of hematite bearing chert with radiolarians in several horizons and may account for the reddish tinge of the soil in the islands.

The only indication of sea level fluctuation in is the presence of ancient wave cut structures estimated to have been about 2 to 5 m above the present level. However, the recent evolution of the Palawan shoreline may be attributed to the rising of the sea level at the end of the glacial period. The resulting geomorphology is archipelagic with numerous embayments and isolated small islands.

Isolated stacks, rock islets and bluffs indicate shoreline retreat due to erosion. Deposition, on the other hand, has developed limited coastal plains, mangrove swamps, sands cays and beaches.

1.3. Climate

The principle air streams influencing Palawan are the Northeast Monsoon and Southeast monsoon. The Northeast Monsoon prevails over the Philippines from October to March and peaks from January to February. The Southwest Monsoon occurs form April to August, occasionally persisting up to November. The transition between the two monsoons is generally dominated by the North Pacific Trade Winds which blow form a easterly direction.

According to the meteorological statistics (1961 - 1990), the average annual temperature in Puerto Princesa City is about 27°C and is distributed almost uniformly throughout the year. Relative humidity is likewise almost uniform with an annual average of around 85 percent (Table 1-1, Figure 1-3).

The average annual rainfall is about 1530 mm. The wettest month is November with an average monthly rainfall of almost 250 mm. while the driest month is February which receives an average of only about 15 mm of rainfall. More than 90 percent of rainfall is received during the wet season (refer to Table 1-1 and Figure 1-2).

Table 1-1 Average Monthly Rainfall (1961-1990) in Puerto Princesa City

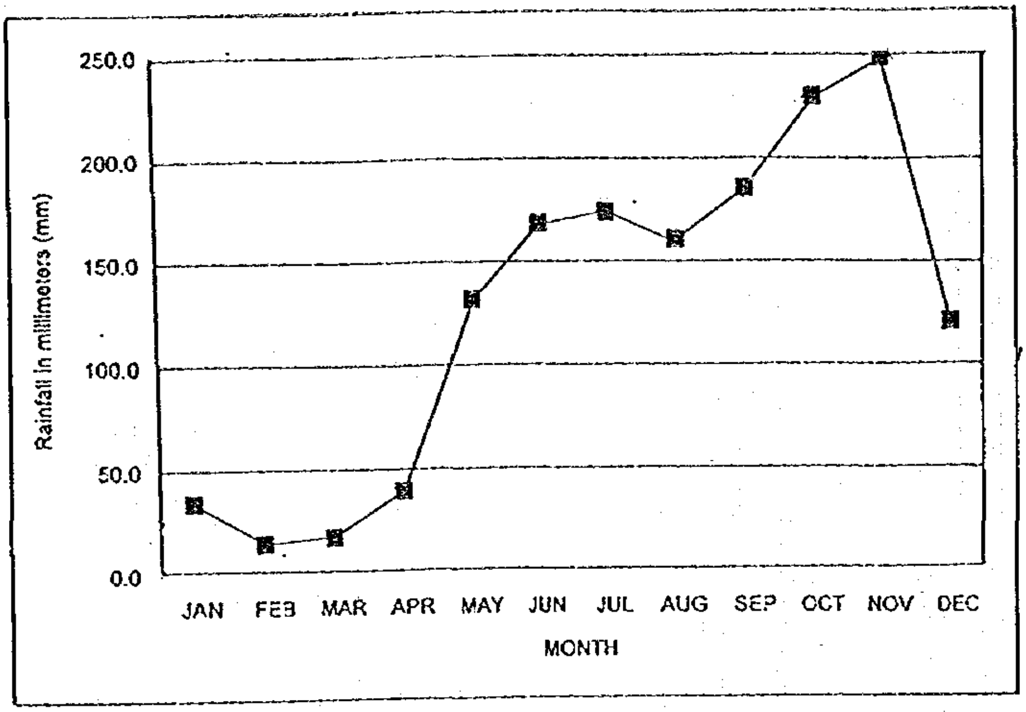
	Temperature (°C)				Relative Humidity (%)				Rainfall (mm)			
	1961-90	1994	1995	1996	1961-90	1994	1995	1996	1961-90	1994	1995	1996
Jan.	26.5	26.6	27.2	27.0	84.5	83	80	83	33.8	4.2	3.0	59.8
Feb.	26.6	27.2	26.6		83.5	81	79		14.7	trace	3.1	
March	27.3	28.0	27.8		81.0	78	78		17.8	4.2	2.3	
April	28.3	27.8	28.8		79.5	80	80		39.8	59.2	6.1	
May	28.4	28.5	27.8		82.0	82	85		132	137.1	91.1	
June	27.6	27.4	28.2		85.5	81	89		168:8	136.2	166.1	
July	27.3	27.4	27.6		87.0	81	90		174.5	96.1	127.5	
Aug.	27.3	27.5	27.6		87.0	88	91		160.6	207.7	216.3	
Sept.	27.3	27.4	27.6		86.5	86	87		186.1	243.5	120.0	
Oct.	27.3	27.1	27.1		86.5	80	83		230.2	177.3	383.2	
Nov.	27.2	28.1	27.5		86.5	79	87		248.5	1.3	270.5	
Dec.	26.9	27.4	26.9		85.0	81	88		120.6	53.5	359.4	
Annual/Age.	27.3	27.6	27.6		84.5	81.7	84.8		1,528	1,120.4	1,748.6	

Source: PAGASA Weather Station, Puerto Princesa City

1.4. Topography

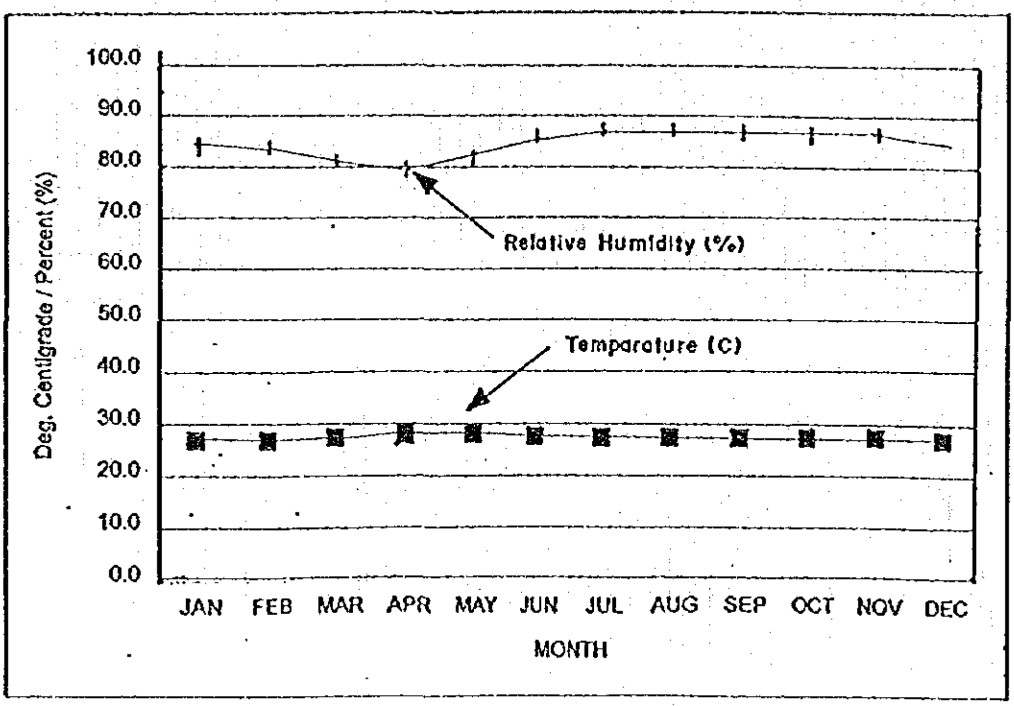
The land of the study area can be characterized by a steep slope. The tallest mountain is Cleopatra's needle (1,585 m), the peak of which is 20 km from a river mouth (refer to Figure 1-4). This means rain water can instantly flow down the river. Hence, the terrestrial environment or activities on land have a close relationship to the marine environment.

Figure 1-2 Average Monthly Rainfall (1961 - 1990) in Puerto Princesa City



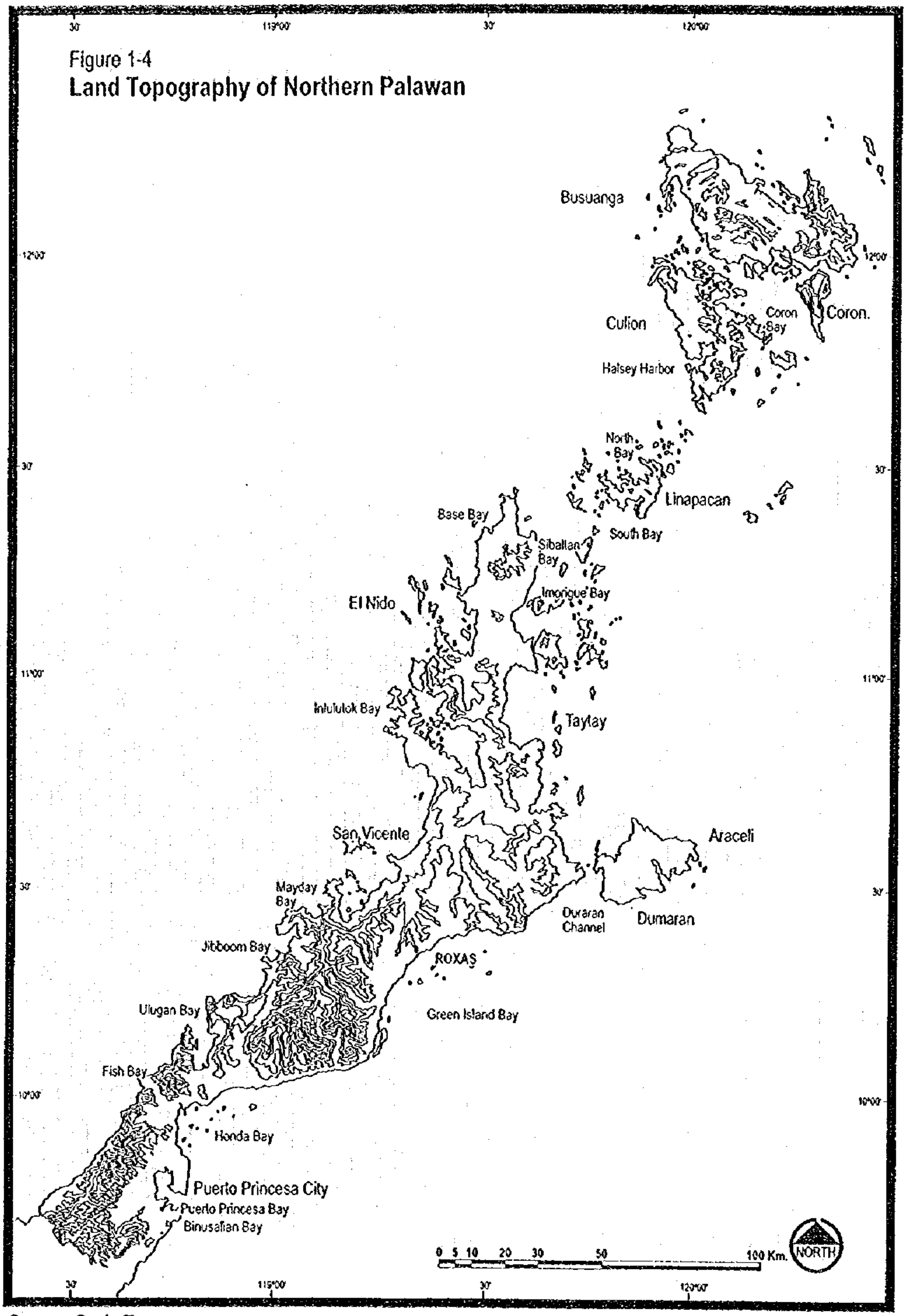
Source: PAGASA Weather Station, Puerto Princesa City

Figure 1-3 Average Monthly Temperature (C) & Relative Humidity (%) in Puerto Princesa City



Source: PAGASA Weather Station, Puerto Princesa City

Figure 1-4
Land Topography of Northern Palawan



Source: Study Team

Sea bottom topography is shown in Figure 1-5. A 50-meter deep contour, which is the expected maximum limit for reef building coral, lies far offshore except for the southernmost part of the study area, where narrow shelf water area is edged by steep slope. Many submerged protuberances made of coral reef exist in the shelf water area surrounding the entire study area. These protuberances are situated 35 - 50 km offshore on the west coast forming a submerged bank, while those on the east coast are in the near-shore area.

1.5. Coastal Features

The coastlines of the study area were observed through the aerial survey. In addition, secondary data was also used. For the purposes of this study, the shoreline of northern Palawan and near-shore features are grouped according to the following classification:

Beach Features:	Sand	Offshore Features:	Substrate:
	Rocky		Sand, Mud
	Mangrove		Reef Flats:
	Karst / Cliff		Shoals Cays

1) Eastern Coastline, Mainland Palawan

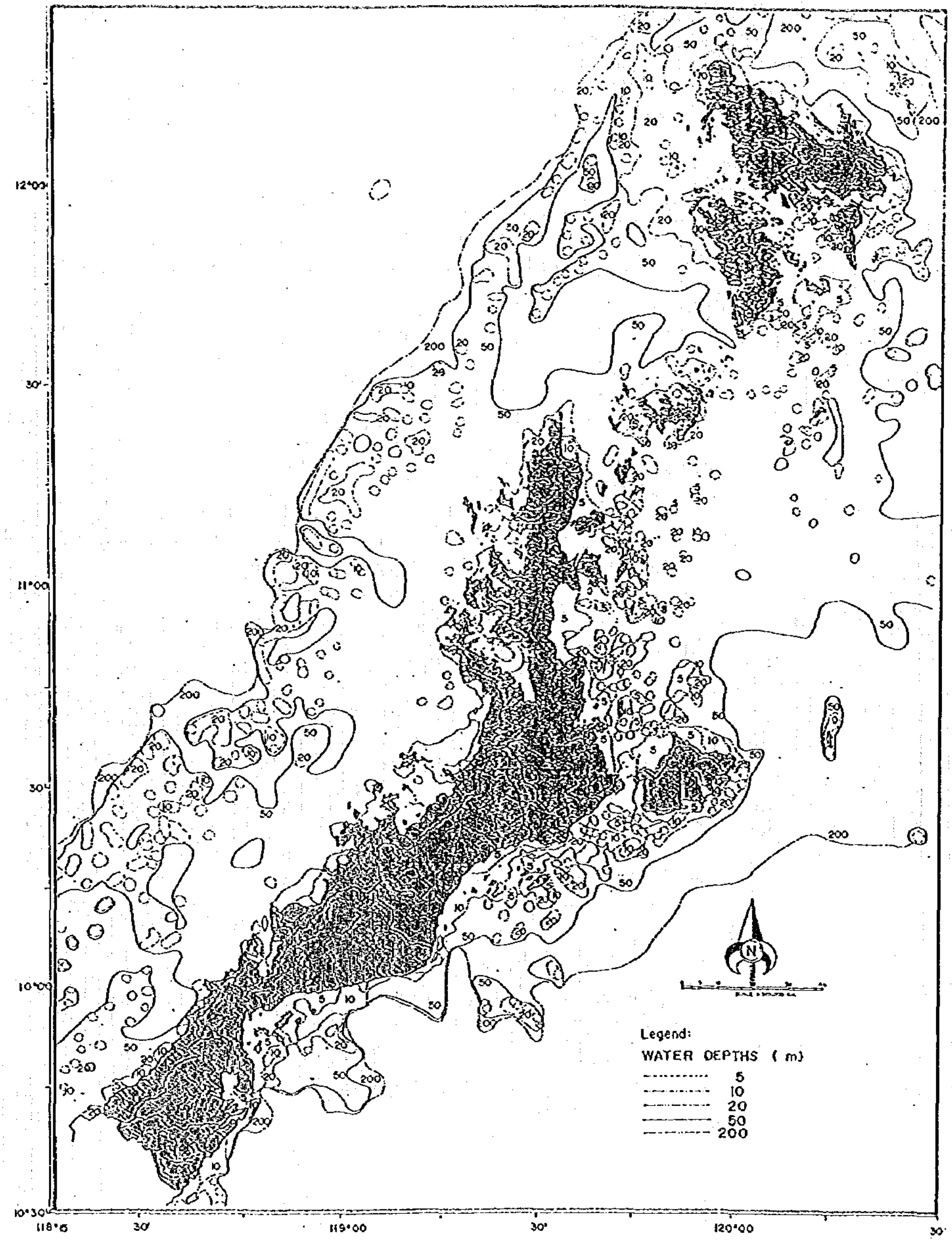
From the southern terminus of the study area (Barangay Inagauan) up to Green Island Bay, the coastline is relatively regular, dominated by slightly concave (bright) Honda Bay and Green Island Bay. Northwards, the coastline assumes a more irregular pattern with embayments and rocky headlands. The most prominent coastal features are the numerous bays that line the northeastern seaboard of the mainland:

Dumaran Passage	Mesecoy Bay
Green Island Bay	Taytay Bay
Honda Bay	Shark Fin Bay
Puerto Princesa Bay	Bentowan Bay

(1) Coastal Floodplains

Coastal floodplains in this sector of the study area are present in few areas along the eastern coastline and are found along the coast of Roxas and the estuarine of Barbacan River. The coastal floodplain is important for agricultural purposes and for settlement. In Roxas, they were once the site of silica sand mining but with the cessation of mining, the pits remain uncovered and fill with water during rainy season. Some are reportedly used for aquaculture.

Figure 1-5 Sea Bottom Topography of Northern Palawan Coastal Area



(2) Mangrove Shoreline

The shoreline of the north eastern part of mainland Palawan is dominated by mangrove vegetation. Major mangrove stands in this sector are found in Puerto Princesa Bay, Honda Bay, Dumaran Passage, Shark Fin Bay and Taytay Bay. Puerto Princesa Bay, Maytiguid Island and Dumaran are exceptional since their coastlines are almost purely lined by mangrove. The mangrove of Dumaran Island shows very little sign of disturbance. In contrast, large tracts of mangrove forest have been converted to fishponds in Puerto Princesa Bay, Honda Bay (Tagburos) and Taytay Bay (in decreasing intensity). In some sites along the coast of Puerto Princesa Bay mangroves have been cleared to make way for swimming areas fronting tourist resorts. Mangrove island are ubiquitous in Honda Bay and Green Island Bay. The largest of these islands are the North Verde and South Verde off the coast of Tinitian.

(2) Sand Beach

A long stretch of beach formation can be found along the coastline of Roxas, between Tandayak and Babuyan Rivers and the fringe of the coastal floodplain off Barbacan river. Towards Tinitian, the shoreline narrows down and is dominated by rocky headlands and bluff interspersed by narrows zones of sand beaches. A narrow strip of sand beach is also present along the eastern side of the peninsula in Puerto Princesa Bay.

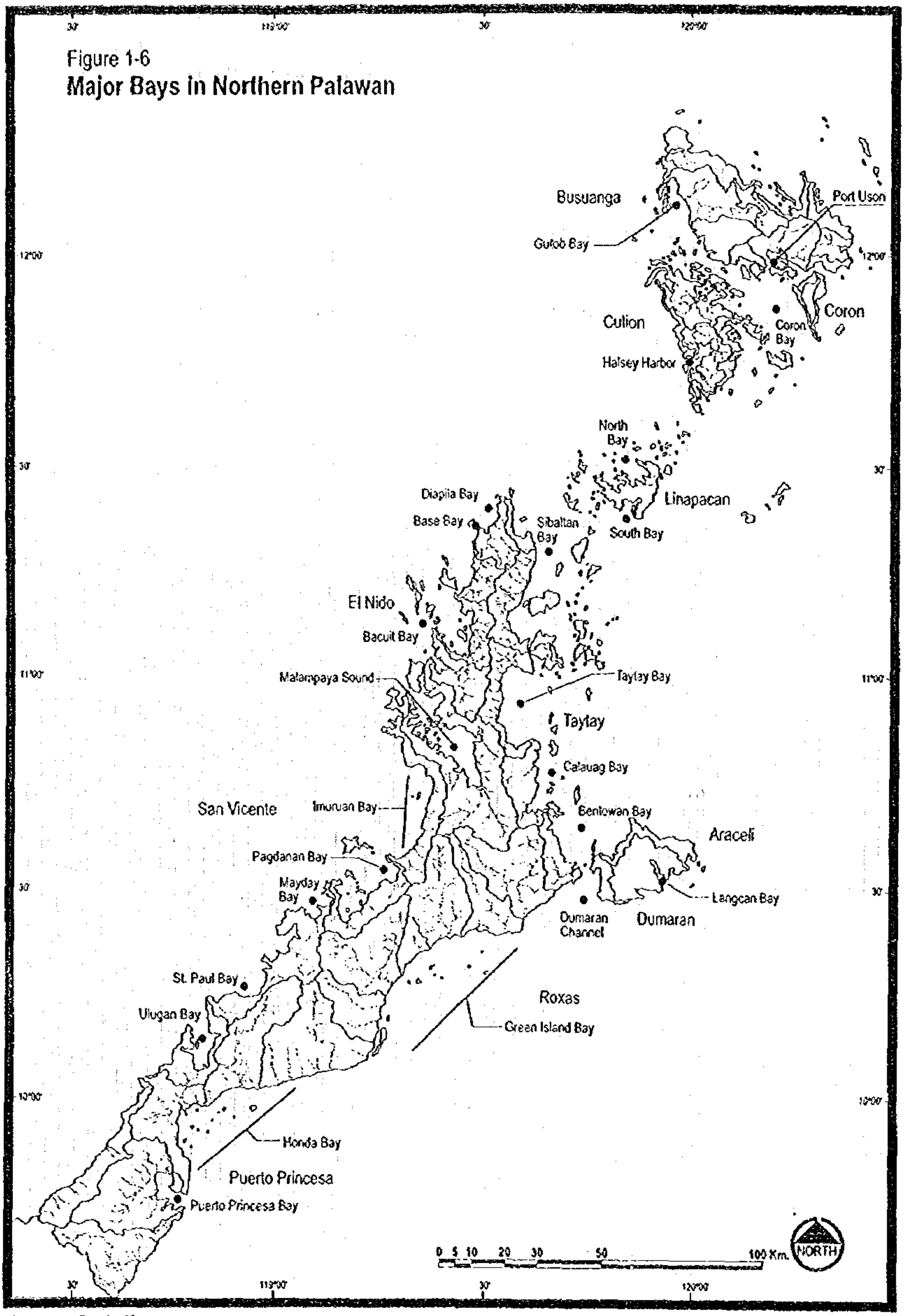
Offshore, sand beaches are present in small islands especially along embayments. Sand in the offshore islands and cays is creamy white in color. On the other hand, beach sand on the mainland shoreline has a brownish tinge due most likely to siltation.

(4) Offshore features

Reef flats occur extensively along the northeastern coastline of mainland Palawan from Honda Bay up to Mesecoy Bay in the northern end of the mainland. It is conspicuously absent along the northern part of Honda Bay where the shelf narrows.

Shoals and sand cays are present in Honda Bay but are more extensive in the northern area from Green Island Bay and beyond. Tidal lagoons are noticeable in some of the shoals such as the Fraser Island in Honda Bay. The shoals and reef flats are important to aquaculture activities, such as seaweed farming and fisheries, of coastal dwellers. As observed during the aerial survey, fish corrals are present on the shoals. The *atog*, a fish trap wherein a rock barrier is used, has been observed in several areas including the reef off Araceli in Dumaran Island.

Figure 1-6
Major Bays in Northern Palawan



Source: Study Team

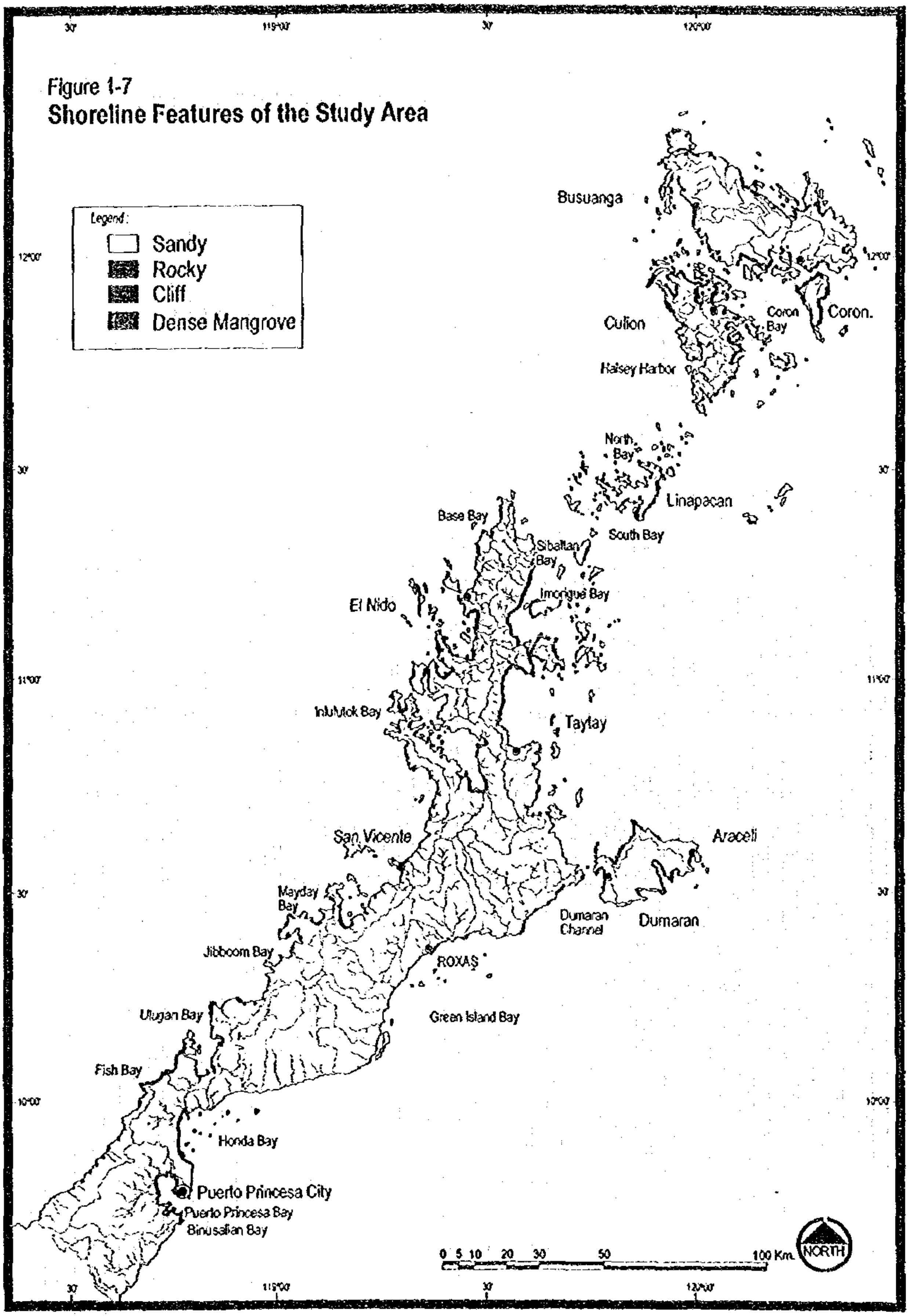


Figure 1-7
Shoreline Features of the Study Area

Source: Study Team

(5) Other Interesting Coastal Features

Lake Manguao in Taytay is an interesting feature. Although it is now isolated from the sea, it seems that Lake Manguao is one of the bodies of water that was isolated due to damming as a result of sediment deposition and possibly volcanic processes. It is the only fresh water lake in the study area and the whole of Palawan.

2) Northwestern Coastline, Mainland Palawan

From north to South, the coastline of mainland Palawan progressively becomes highly irregular. Unlike the northeastern side, mangrove and reef flats are less prominent. In addition, along the western coastline the most extensive sand beach can be found in Imuruan Bay; it has a combined length of more than 15 km. This beach is almost continuous except for some headlands that interrupt the sand formation.

Bays and coves are also among the large scale coastal features of the northwestern seaboard. These include the following:

Bacuit Bay	Mayday Bay
Base Bay	Pagdanan bay
Diapila Bay	Port Barton
Imuruan Bay	St. Paul Bay
Jibbom Bay	Ulugan Bay
Malampaya Sound	

Prominent peninsulas in the western coastline are: the Bolabod Peninsula in Bacuit; Capoas Peninsula that separates Malampaya Sound from Imuruan Bay; and the Baboy Daraga Peninsula in Port Barton.

(1) Coastal Floodplains

Typical of Palawan, coastal floodplains in the western coastline is also limited. Significant areas of floodplains are found in Bacuit Bay, southern most part of Malampaya Sound and Imuruan Bay.

(2) Mangrove Shoreline

Extensive mangrove shorelines along the western coastline are located in Bacuit Bay, Malampaya Sound and Ulugan Bay. The most extensive mangrove formation is found in the estuarine of Abangon and Alicalian Rivers within Malampaya Sound and in Dagaldagal to the foothills of Bolabod Range. Mangrove formations in other parts of the western coastline are mostly narrow strips that line the shore.

(3) Sand Beach

Extensive sand beach formation along the western coastline is present in Imuruan Bay where the shoreline is concave and fairly regular, and punctuated at certain points by headlands. The longest beach is Enarayan Beach with a length of about 5 km. Total aggregate length of sand beach in Imuruan Bay is 15 km. Other significant sand beaches in its side of mainland Palawan are scattered in Bacuit Bay, Pagdanan bay, Port Barton and the smaller bays of Jibboom, Marufinas and St. Paul Bay. Farther southwest of Ulugan Bay sand beaches are present in small coves that are found at the western foothills of Beaufort Range.

(4) Rock and Karst Shoreline

Coastal topography of Bacuit Bay is rather uncommon. The small islands of Bacuit Bay are mostly limestone that display tower karst topography. Typically, the shoreline of the islands of Bacuit Bay are characterized by high cliffs and narrow wave platform. As such, sand beaches occur sparingly in the small islands and are present most often as pocket beaches at the foot of the limestone cliff. Boulder piles at the foot of the cliff are observable in a few places. In addition, isolated stacks are common in the bay indicating the active process of shoreline retreat due to erosion. Conspicuous rocky coastline surrounds the foothills of the Capoas Peninsula, Mt. Bloomfield and adjoining mountain range.

(5) Other Interesting Features

Interesting features along the western coastline are the lagoons and caves of El Nido as well as the subterranean river of St. Paul Bay.

3) Linapacan - Culion - Busuanga

The Linapacan - Culion - Busuanga region is an aggrupation of islands. The biggest of these are Busuanga and Culion. Shorelines of these islands are very irregular with numerous small islands and islets. Numerous small bays characterize the coastal area. The most prominent of these are the following:

Linapacan Island	North Bay, South Bay
Culion Island Group	Halsey Harbor, Igay Bay, Nabacbacan Bay
Busuanga-Coron Islands Group	Bintuan Bay, Canibong Bay, Coron Bay, Coron Harbor, Gutob Bay

Topography of the islands is predominantly low to moderately elevated rolling hills. The highest elevation in this region is found in Coron Island with a maximum elevation of almost 600m asl. In most areas, the hills about the shoreline giving rise to rocky shoreline.

(1) Coastal Floodplains

Coastal floodplains are very few and occur as patches along the coast. The only significant floodplains in the region can be found in the western coastline of Busuanga Island. These coastal plains are now occupied by the settlements of Busuanga and Concepcion.

(2) Mangrove Shoreline

Mangrove forest covers a sizable extent of the northern and eastern coastlines of part of Culion and of southern Busuanga Island. Large patches are also found on the northern side including Calauit. The *northern and eastern shoreline of Culion and smaller islands are almost* exclusively lined by mangrove vegetation. Due perhaps to the sheltered environment of northeastern Culion, shoreline development is apparently in its incipient stage. Other areas where mangrove is quite extensive are the estuarine inside Halsey Harbor.

(3) Sand Beach

In contrast to the small islands of northern Culion, the small islands of Linapacan, southern side of Coron Bay (the islands of Culion, e.g., Tampel and Ditaytayan) and the small islands of Gutob Bay (e.g., Panlaitan, West Nalaut, Talampuhan, Dibotanay, etc.) are fringed with short stretches of white sand beaches. Sand beaches are quite extensive in Calauit and parts of the shoreline of Gutob Bay (mainland Busuanga), specifically in the vicinity of the poblacion of Busuanga. Sand beaches are also prominent are the islands of Galoc and the northwestern part of Culion Island. Sand beaches in the area are noticeably tinged with a reddish color, probably due to the iron rich soil of the islands.

(4) Karst and Rocky Shoreline

Karst shoreline is displayed by the two limestone islands of Tangat and Coron located in Coron Bay. Topography of these islands is very small compared to the small islands of Bacuit Bay. Narrow wave platforms are occupied by very limited pocket beaches and the majority of the coastline of Coron Island is fringed by cliff.

The southwestern shoreline of Culion is predominantly fringed by rocky shoreline with intermittent narrow sand beaches bounded landward by bluffs. Similar shoreline features are observed in the northern shoreline of Busuanga. The strong linearity of the rocky coastline of Cabilauan Island and northern Busuanga is apparently influenced by a strong geologic fault that runs parallel to the coastline.

(5) Offshore Features

Shoals and reef flats are common in Coron Bay and Gutob Bay but not as widespread as those in northern mainland Palawan.

(6) Other Interesting Features

As in Bacuit Bay, interesting features in the region are the series of brackish lagoons found in Coron Island.

4) Oceanographic Condition

(1) Tides

Tides in the Philippine waters can be characterized into three types :

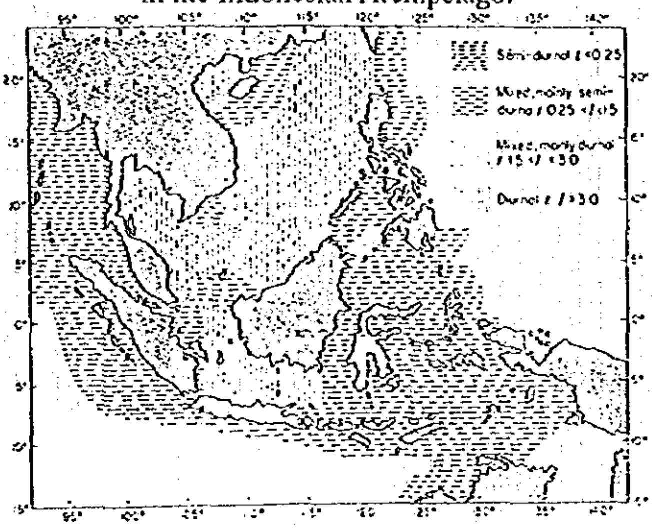
1. Semi - diurnal unequal tide : two high and two low tides in each lunar day with successive high tides and successive low tides of different heights.

2. Mixed, dominant semi - diurnal type: two high and low tides in each lunar day with regimes of one high tide and one low tide for the same time interval.

3. Mixed, dominant diurnal type: one high tide and one low tide in a lunar day when the tide range is large and two tidal maxima and minima when the tidal range is small.

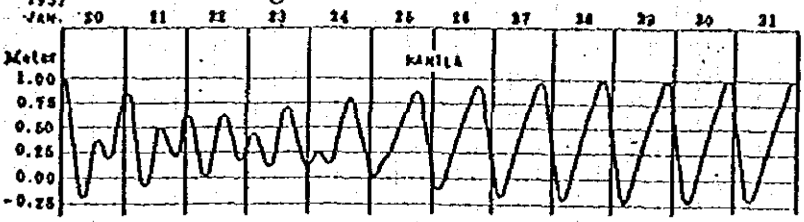
On the western coast of Palawan, mixed dominant diurnal tides predominate, while dominant semi-diurnal tides can be observed on the eastern coast of Palawan (Figure 1-8).

Figure 1-8 Ratios indicating the character of the tides in the Indonesian Archipelago.



Source: The Encyclopedia of Oceanography, Reinhold Pub. Co.

Figure 1-9 Tide curves for Manila



Lunar data: Max. N. declination, Jan 14th; full moon, 16th; on equator, 20th; last quarter, 23rd; max S. declination, 26th; new moon, 31st; on equator, Feb. 3rd.

Source: 1996 Predicted tide and current Tables, DENR / NAMRIA

The tidal range at stations in Palawan varies from 1.0m to 1.4m as shown in Table1-2

Table 1-2 Tidal Differences and Constants

NAME OF STATION	LAT. NORTH DEG.	LAT. NORTH MIN.	LONG. EAST DEG.	LONG. EAST MIN.	TOTAL DIFFERENCES: TIME: HIGH WATER	HIGH WATER HR.	HIGH WATER MIN.	LOW WATER	LOW WATER HR.	LOW WATER MIN.	HEIGHT: HIGH WATER	HIGH WATER METER	LOW WATER	LOW WATER METER	MEAN METER	DIURNAL METER	METER
					120 DEG. EAST MERIDIAN TIME												
PALAWAN AND VICINITY					REFERENCE STATION, MANILA												
•TINITIAN, GREEN ISLAND BAY	10	4	119	21	+	0	40	+	0	40	+	0.34		0.00	....	1.34	0.67
•ULUGAN BAY	10	5	118	45	-	0	5	-	0	5	+	0.21		0.00	....	1.22	0.61
•FORT BARTON	10	28	119	8	-	0	10	-	0	10	+	0.21		0.00	....	1.22	0.61
•ARACELI, DUMARAN ISLAND	10	33	119	59	+	0	15	+	0	15	+	0.40		0.00	....	1.40	0.70
•BOAYAN ISLAND	10	34	119	11	-	0	5	+	0	1	+	0.12		0.00	....	1.13	0.55
•PALY ISLAND	10	42	119	42	+	0	15	+	0	15	+	0.40		0.00	....	1.40	0.70
TAYTAY	10	50	119	31	+	0	15	+	0	15	+	0.40		0.00	....	1.40	0.70
•ALLIGATOR BAY, MALAMPAYA SOUND	10	52	119	17	-	0	4	+	0	2	+	0.06		0.00	....	1.07	0.55
•BOLALO BAY, MALAMPAYA	10	56	119	14	-	0	7	-	0	14		0.00		0.00	...	1.01	0.49
•BATAS ISLAND	11	10	119	36	+	0	10	+	0	10	+	0.40		0.00	....	1.40	0.70
•BACUIT	11	11	119	23	+	0	20	-	0	29	x	0.97	x	0.97	....	0.98	0.49
•SAN NICOLAS, LINAPACAN ISLAND	11	27	119	49	-	0	5	-	0	5	+	0.27		0.00	....	1.28	0.64
•NORTHWEST BAY, LINAPACAN ISLAND	11	28	119	46	-	0	5	-	0	5	+	0.24		0.00	....	1.25	0.61
•SAN MIGUEL, LINAPACAN ISLAND	11	30	119	52	+	0	10	+	0	10	+	0.34		0.00	....	1.34	0.67
•HALSEY HARBOR, CULION ISLAND	11	47	119	58	+	0	5	+	0	5	+	0.21		0.00	....	1.22	0.61
•CULION, CULION ISLAND	11	53	120	1	+	0	5	+	0	5	+	0.37		0.00	...	1.37	0.67
•CORON, BUSUANGA ISLAND	12	1	120	12	+	0	10	+	0	10	+	0.37		0.00	...	1.37	0.67

NAME	GEOGRAPHIC POSITION DEG.	MIN.		ELEVATIONS IN METERS ABOVE MEAN LOWER WATER (MLLW): Bench Mark	Mean High Water (MHW)	Mean Sea Level (MSL)	Mean Low Water (MLW)	Mean Higher High Water (MHHW)
MANILA	14	35	N	4.021	0.585	0.475	0.10	1.003
	120	58	E					

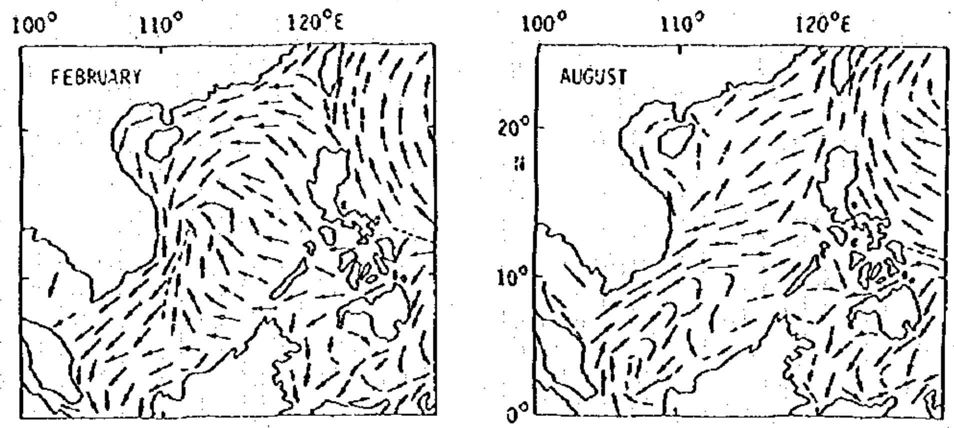
Source: 1996 Predicted tide and current Tables, DENR / NAMRIA

(2) Current

Horizontal atmospheric pressure variations are the primary driving force of water circulation. Since the monsoons are characterized by their high constancy, complete reversals and regularity of appearance, and variations in water circulation are expected to parallel those in the atmosphere.

On the western side of the Philippine Islands, the influence of the monsoons on the water circulation is pronounced. During the northeast monsoon, a cyclonic pattern of surface water movement develops in the interior of the South China Sea with a southerly flow along the western boundary and a northwesterly flow along the western coast of Palawan and Luzon. During the southwest monsoon, water movement in the South China Sea generally flows northeasterly through the Strait of Taiwan and the Luzon Strait. In the Sulu Sea, a westward flow in the south and an eastward flow in the north cause an anticyclonic pattern of water movement.

Figure 1-9a Summer and Winter Surface currents in the South China Sea (Fairbridge, 1996)



Source: The Encyclopedia of Oceanography, Reinhold Pub. Co. N.Y

It is obvious that residual coastal currents are mainly driven by both wind waves. These currents seem to have an average velocity of less than 1 knot (50 cm / sec) according to diving surveys.

3. Coastal Process

Interviews with resort staff in El Nido, Apulit Island, and Dimakya Island were conducted as quantitative data revealing the change of shoreline was not available.

In Pangulasian Island, beach erosion was observed in the southern area, while an apparent depositional area was found in the eastern end. This suggests that sand transport resulted from the southwestern monsoon of the area.

On the other hand, in Dimakya Island on the northern coast of Busuanga, the northern and eastern coastlines showed erosion and deposition on the southern and western coasts. The sand transport in the northern coast of the study area can be attributed to the northeastern monsoon.

The northeastern monsoon also caused sand transport on the eastern coast of Apulit Island. Observation from the air showed that large waves during the monsoon caused the formation of sand bars on the hidden side of islands and the peninsula. Hence, remarkable sand transport is caused by both the prevailing monsoon and a shelter effect of land from waves.

2. Water Quality

Temperature and salinity are essential parameters for assessing the environment. Sea water temperature in the coastal waters of Palawan shows little seasonal variation of around 29°C. Salinity distribution, on the other hand, reveals that temperatures are higher during the northeast monsoon and lower in southeast monsoon. This is due to the distribution pattern of water mass mainly resulting from wind and seasonal variation of precipitation. It is expected that the largest variation occurs near the coast where water quality seems to be pristine. This is evidenced by data that have been obtained in the coastal waters of Dimakya Island and in the western waters of Busuanga, Palawan (Table 2-1).

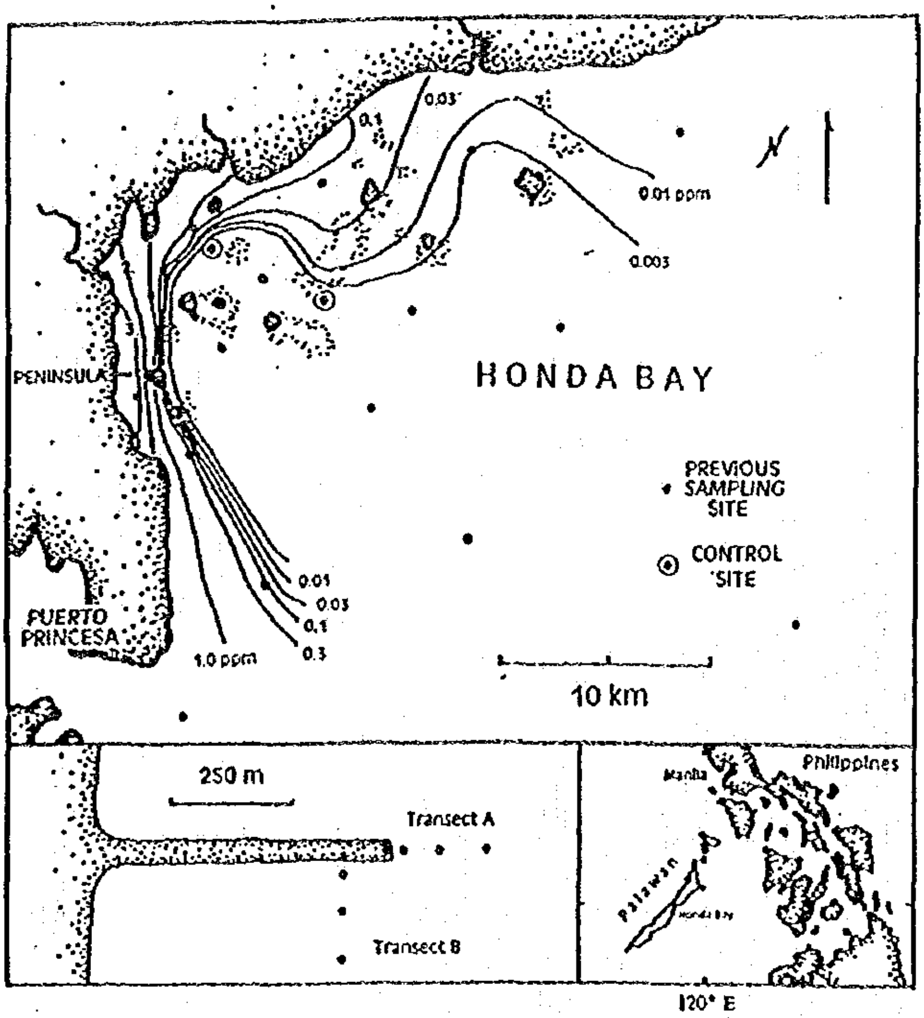
Figure 2-1 Water quality of sea area around Palawan Island

Parameter	Coastal water of Dimakya Island	Western Waters of Busuanga Coastal	Western Waters of Busuanga Offshore
Temp. (°C)	29.0 - 29.5	-	-
Sal.	33 - 34	35	35
pH	-	8.4 - 8.5	8.4 - 8.5
DO (mg/l)	5.5 - 6.6	-	-
BOD (mg/l)	2.5 - 6.3	-	-
NO_3 - N (mg/l)	ND[1] - 0.02	ND	ND
PO_4 - P (mg/l)	0.031 - 0.048	ND	ND
Oil & Grease (mg/l)	1.0 - 9.3	ND	ND
Total Coliform (MPN/100ml)	<20 - 80	-	-
Fecal Coliform (MPN/100ml)	<20 - 80	-	-
Copper (mg/l)	0.005	-	-
Lead (mg/l)	0.06 - 0.07	-	-
Zinc (mg/l)	-	<0.01 - 0.10	<0.01 - 0.15

Source: "Environmental Impact Assessment for Club Paradise Resort"; "Baseline Environmental Study for the Drilling of OCION 3 and 4 wells"
[1]ND - not detected

This fairly good condition may be owing to the absence of major sources of pollutants, e.g., industries and dense human settlement, except for in the City of Puerto Princesa. Another water quality test regarding mercury pollution caused by mining is done by DENR in Honda Bay located in the eastern coast of the city of Puerto Princesa. The result of this work has not been reported yet. As for sediment samples, however, Benoit et al. (1994) reported that cinnabar (HgS) mine tailings used in the construction of a 600 m long peninsula caused serious pollution. A sample collected in the peninsula showed a maximum concentration of mercury of 570 ppm. Transported by natural processes, mercury pollution on sediments could be seen in a coastwise direction from the peninsula (Figure 2-2). As the HgS is transported away, it is rapidly altered into more bioavailable forms. This should be noticed as a significant parameter threatening the ecosystem and human health.

Figure 2-2 Distribution of Mercury Concentration in Sediment



Map of Honda bay showing concentration of mercury in surface sediments. Contours were calculated by SURFER software program using Kringin algorithms. Data used in preparing this figure included measurements from the current study and values contained in Kapuan et al. (1982a) (filled circles). Insets show a detail of the peninsula including the sampling location for transects A and B, and the location of Honda Bay.

3. Biological Environment

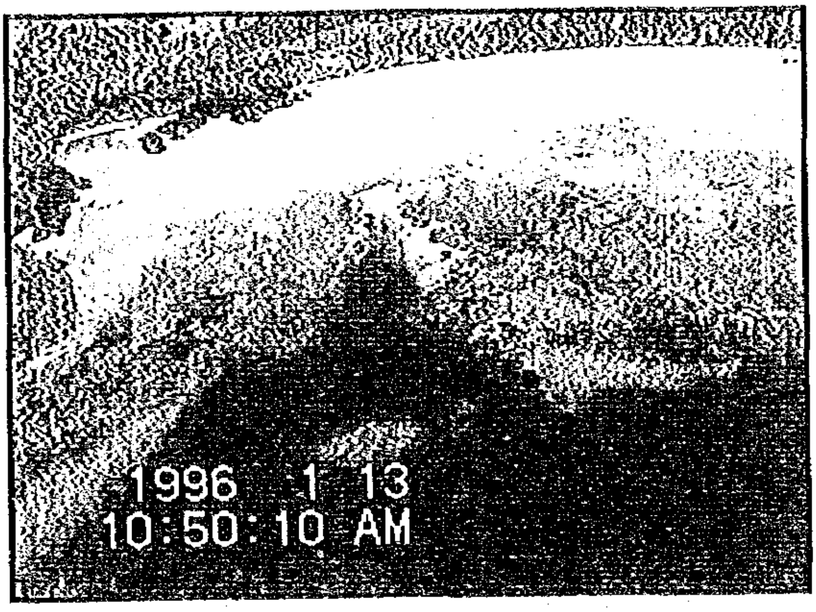
3.1. Coral

An aerial survey and diving survey were conducted January, 1996. Flight routes and diving sites are shown in Figure 3-2 and 3-3. Coral reef was evaluated through aerial observation first for the shallow water area of the entire Northern Palawan area. The grade of coral reef in terms of the healthiness of the coral community was given using five rankings as shown in Figure 3-1a-f and defined as follows:

Figure 3-1a Rank A: Healthy Coral Community

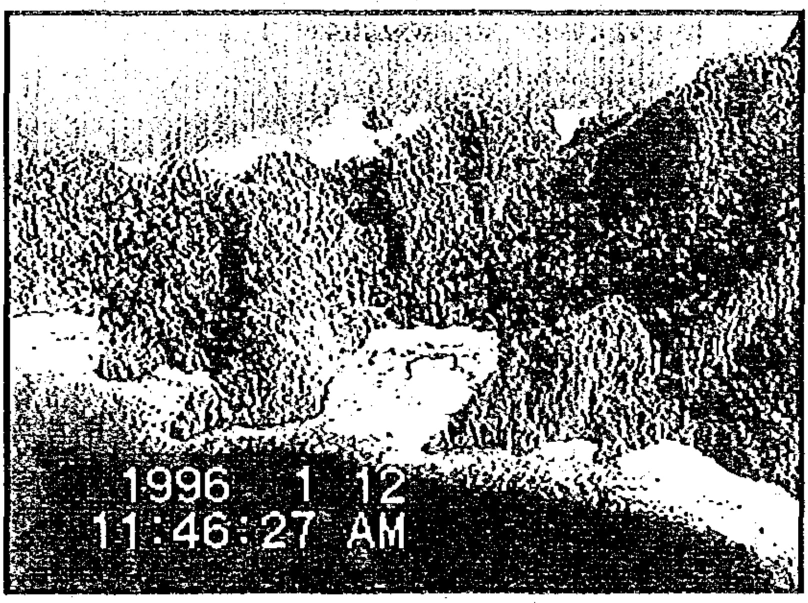
Healthy coral community with no indication of disturbance. This type of coral reef looks dark purplish gray or dark grayish brown extending from the inner reef to the reef edge with vivid marginal line. Grayish white dead coral reef is seldom seen.

Figure 3-1 (b) Rank B: Fairly Healthy Coral Community



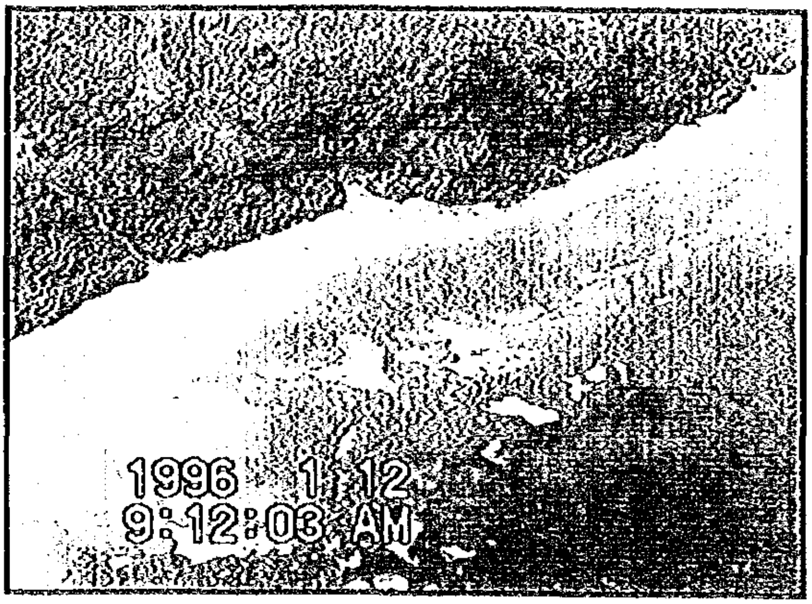
Fairly healthy coral community. Some indication of disturbance. Estimated dead coral coverage of less than 25%. Color of reef looks like rank A. Many cracks, however, are found because of dead coral showing whitish color.

Figure 3-1(c) Rank C: Largely Disturbed Coral Community



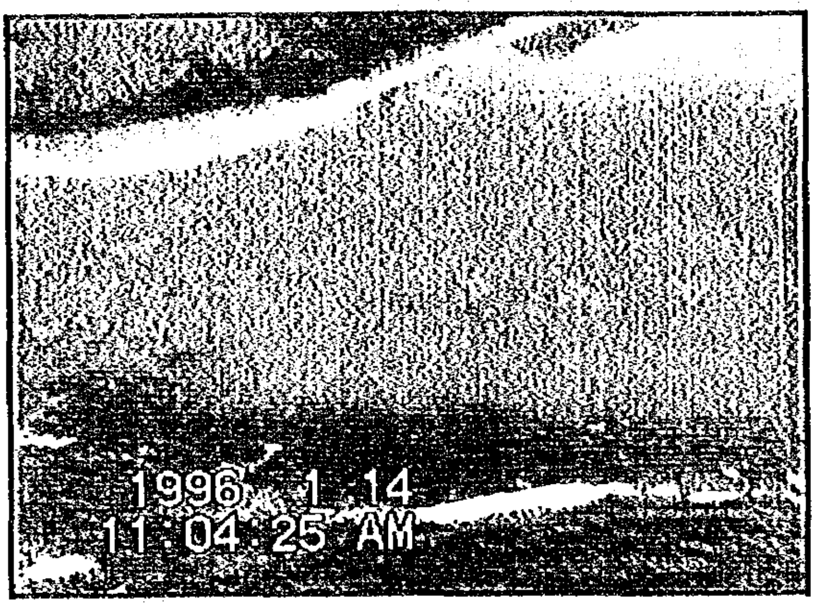
Largely disturbed. Estimated dead coral coverage of 25 - 75. Coral communities are small and patchily distributed. The marginal of living coral is clear and is easily identified by contrast with whitish coral or reddish seaweed bed.

Figure 3-1 (d) Rank D: Severely Disturbed Coral Community



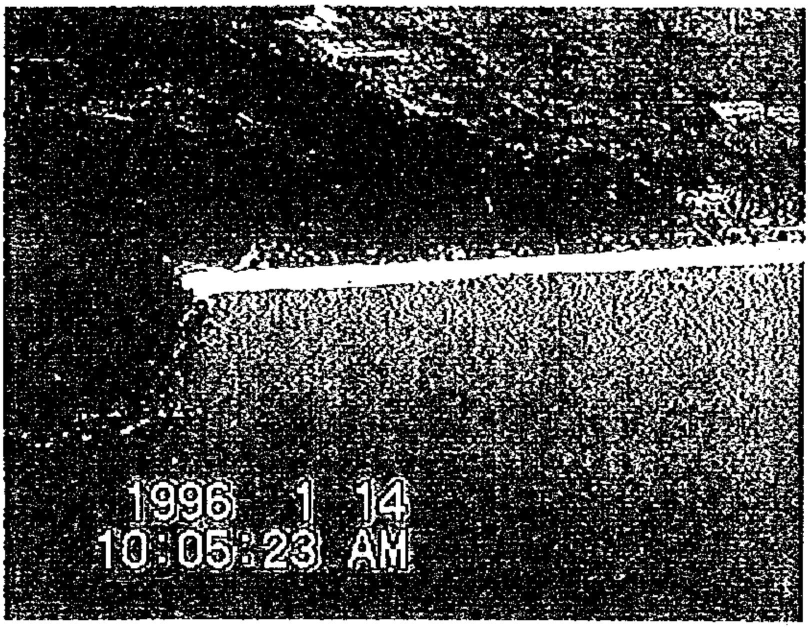
Severely disturbed. Estimated dead coral coverage of more than 75%. Whitish dead coral or reddish seaweed bed predominates. Though formation of coral reef can still be recognized, detailed structure can not be observed anymore.

Figure 3-1 (e) Rank E: Almost Destroyed Coral Community



Almost destroyed. Often covered with seaweed. Though the shape of coral reef can still be recognized, detailed structure can not be observed anymore, due to collapse of the fine structure of reef. The reef area looks flattered.

Figure 3-1f Rank F: No Coral Reef



1) Calamian Islands

On the north coast of Busuanga Island and west coast of Culion Island, higher ranks were given, showing a little disturbance of human activities owing likely to the small population and big waves which prevent human access to the area. Coron Island is also surrounded by healthy coral reef, which may be a result of the still intact natural environment. Similar terrestrial conditions were also observed in Tangat Island. The diving survey, however, clarified that the coral reef has been destroyed by dynamite fishing in places. Though the high growth rate and consequent restoration of coral reef can be expected for certain coral species, it must still be cautioned that all highly evaluated coral may also have damage from blasting and that the formation of the entire coral reef ecosystem may take decades. Some coral reefs in the passage between Busuanga and Culion Island which is an intensive pearl farming zone is already dead and seaweed is becoming dominant.

2) East coast of the main island

The southern part of the east coast of mainland, i.e. the City of Puerto Princesa and Roxas Municipality, have little healthy coral reef except for around small offshore islands in Honda Bay and Green Island Bay. The coast of Dumaran, Taytay and El Nido municipalities are almost all covered with seaweed beds based on coral reef. This catastrophic change from coral - dominant to seaweed - dominant ecosystems appears to have occurred only a few years ago. Araceli Municipality has healthy coral reef due to the same reasons as in the north and east coasts of Busuanga Island.

3) West Coast of the Main Island

Only Bacuit Bay, El Nido and St. Paul Bay, and the City of Puerto Princesa have small portions of healthy coral reef. Other parts of the coast consist of dead coral reef and beaches where reef building coral can not survive. Coral species identified through diving surveys at five sites in Northern Palawan is listed up in Table.3-1. Table 3-2 presents the Coral Reef Condition data for five diving sites that were surveyed for living and dead coral, major coral colonies, seagrass and algae, water temperatures and salinity, etc.

3.2. Seaweed / Seagrass

Aerial observation and diving verification for seaweed/seagrass distribution were done simultaneously with the coral reef investigation. Distribution of seaweed and seagrass beds is shown in Figure 3-4. Except for beaches, almost the entire coast is habitat for seaweed, which attaches and grows on stable substrate, such as rocks, grave and coral reef. Sargasso is the most abundant group in the study area. Seagrass beds which develop on shallow sand sea bottom and which Dugong and green sea turtle feed on, were found in places in the coast of the Calamian group of islands and east coast of the main island as well as Dumaran Island. There were only a few seagrass beds in the west coast of the main island.

3.3. Reef associated organisms

Reef associated fish were investigated through diving surveys and secondary data. Table3-3 cites the identified reef associated fish from Northern Palawan coastal waters. Number of fish seemed to be low compared to other coral reef regions, such as the Great Barrier Reef and the Okinawa Islands. Crown of thorns (*Acanthaster planci*) was not found at any site, though an indication of its grazing on coral, which seemed to have occurred more than five years before, were recognized at sites of the St. Paul Subterranean Park and Culion Island.

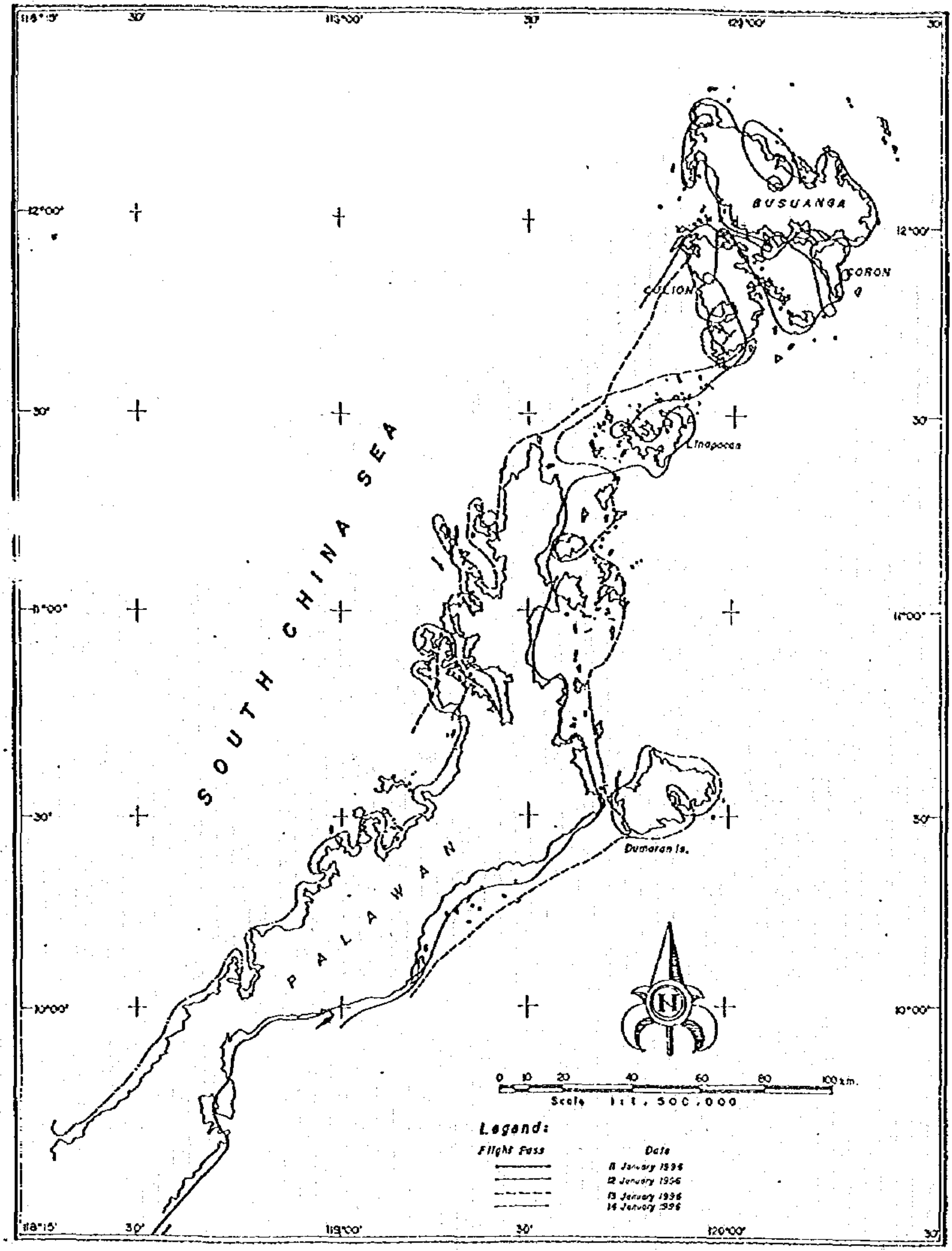
3.4. Mangrove

Mangrove plays an important role in coastal marine ecosystems. The roots of mangrove consolidate the soil so as to protect the marine environment from nuisance due to turbid water dispersion. Furthermore, mangrove forest provides many kinds of organisms with habitat and nursery grounds.

The aerial survey was conducted for the purpose of assessing the status of the mangroves in the study area simultaneously with coral reef and seagrass/seaweed investigations. An actual observation from the air was supplemented by analysis of the numerous photographs and video tapes taken during the survey. Secondary data was also used to chronicle the change of the distribution of mangrove forest.

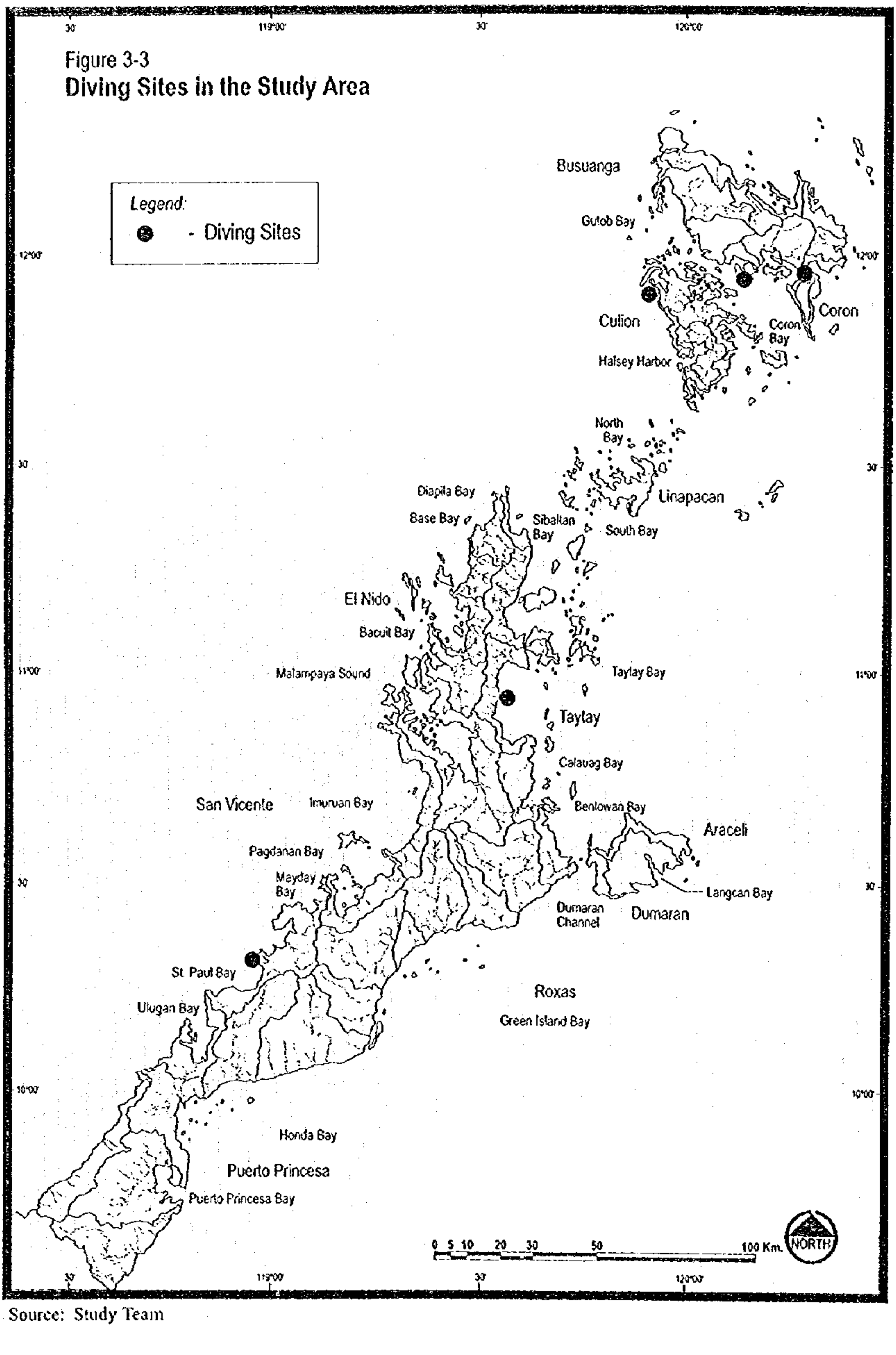
As described before, the shoreline of the northeastern part of the main island is dominated by mangrove vegetation. Major mangrove forest can be seen in Puerto Princesa Bay, Honda Bay, Dumaran Passage, Shark Fin Bay, and Taytay Bay (Figure 3-6). Comparison with previous data (Swedish Space Corporation, 1988) suggests that the mangrove forest were expanding in the area.

Figure 3-2 Flight Routes by Aerial Survey

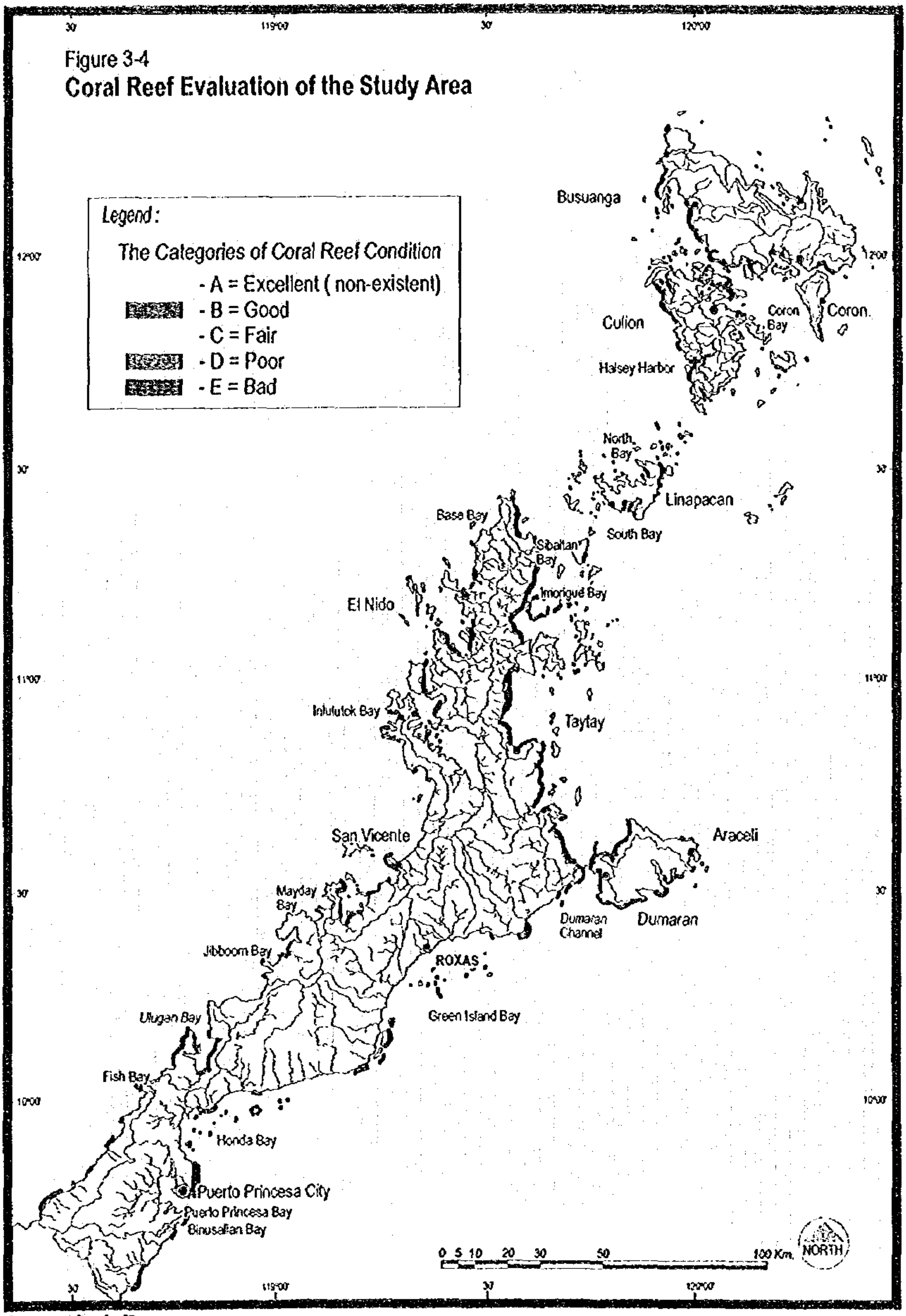


Source: Marine Survey, Study Team

Figure 3-3
Diving Sites in the Study Area



Source: Study Team



Source: Study Team

Table 3-1 List of Coral Recorded at Survey Areas

(* present, L Colony diameter > 1m, M microatol or large monospeciphic stand)

Family	Genus	Colony form	Species	St Paul	Tayley Bay	Coron Is	Tangat Is	Culion Is
Astrocoeniidae	*Stylocoeniella*			*				
Pocilloporidae	*Pocillopora*			*		*	*	*
	Seriatopora			*	*	*	*	*
	Stylophora			*				
Acroporidae	*Montipora*	encrusting		*	*	L	*	L
	Montipora	laminar		M		*	L	
	Montipora	arborescent		L			*	M
	Acropora	tabular		M	L	L	L	L
	Acropora	arborescent		M		L	L	M
	Acropora	corymbose		L	*	*	*	*
	Acropora	caespitose					*	*
	Acropora	digitate						*
	Acropora	encrusting		*				*
	Acropora	bottle-brush					L	
	Acropora		*Acropora palifera*			L	L	*
	Astreopora			*	*	L	*	*
Poritidae	*Porites*	massive		L	L	L	L	M
	Porites	arborescent		*	L	L	M	M
	Goniopora			*	L	L	*	*
	Alveopora					*		
Siderastreidae	*Psammocora*			L		L	*	
	Coscinaraea				*			
Agariciidae	*Pavona*				*	L	L	L
	Leptoseris			*	*	*	L	
	Coeloseris				*	*	*	*
	Pachyseris				L	L	L	
Fungiidae	*Heliofungia*		*Heliofungia actiniformis*		*	*	*	*
	Fungia			*	*	*	*	*
	Herpolitha			*	*		*	
	Polyphyllia			*		*		*
	Sandalolitha			*		*		
	Podabacia					*		
Oculinidae	*Galaxea*			*	*	*	L	*
Pectiniidae	*Echinophyllia*			*	*	L	*	*
	Physophyllia				*	*	*	
	Pectinia			*	*	L	*	*
Mussidae	*Cynarina*						*	
	Lobophyllia			*	L	L	*	*
	Symphyllia			*	*	L	*	L
Merulinidae	*Hydnophora*				*			
	Merulina			*	L	L	L	*
Faviidae	*Caulastrea*				L			
	Favia			*	*	*	*	*
	Favites			*	*	L	*	*
	Goniastrea			*	*	*	*	*
	Platygyra			*	*	L	*	*
	Leptoria			*			*	
	Oulastrea						*	
	Diploastrea					*	L	
	Leptastrea						*	*
	Cyphastrea			*	*	*	*	*
	Echinopora				*		*	*
Caryophylliidae	*Euphyllia*			*	L	*		
	Plerogyra				*	*	*	
	Physogyra					*	*	L
Dendrophylliidae	*Turbinaria*			L		L	*	L
Tubiporidae	*Tubipora*		*Tubipora musica*	L			*	
Helioporidae	*Heliopora*		*Heliopora coerulea*	*	L			M
Milleporidae	*Millepora*	arborescent		L	L			
	Millepora	laminar		L		*		

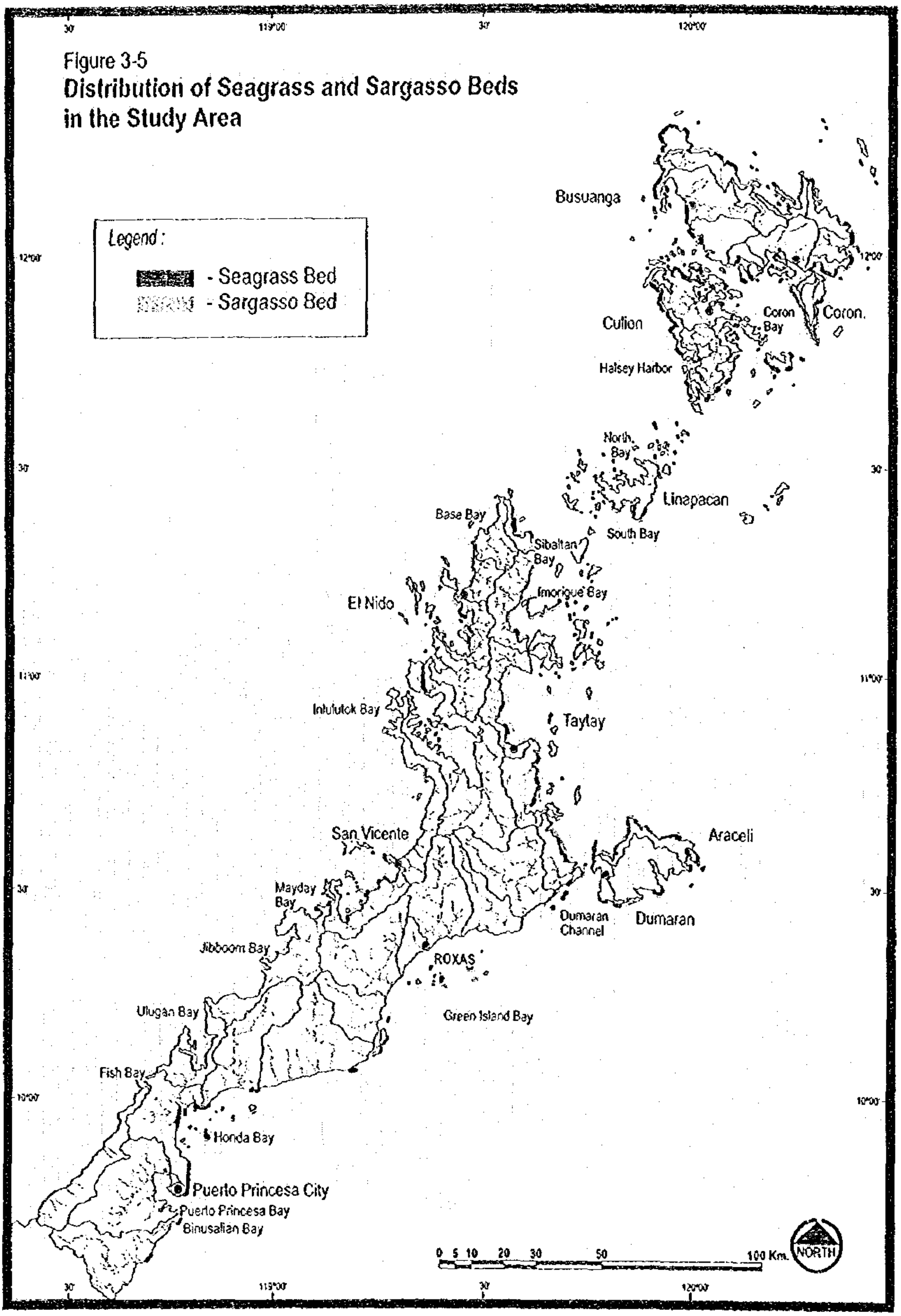
Source: Study Team

Table 3-2 Data of Coral Reef Condition by Marine Survey

(* present)

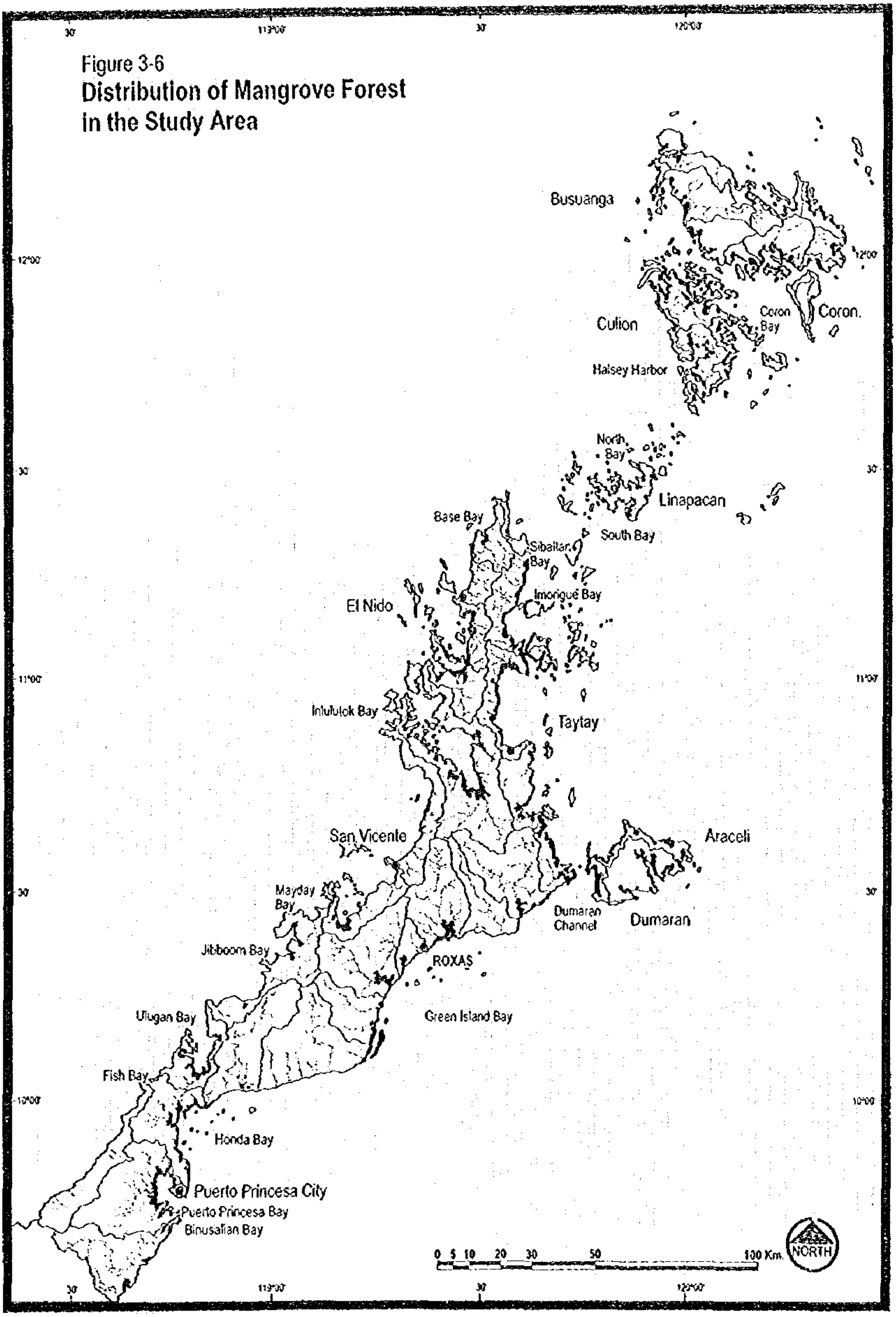
Survey site	St Paul		Taytay bay		Coron Is.		Tangat Is.		Culion Is.	
Date	27 Jan 1996		29 Jan 1996		30 Jan 1996		30 Jan 1996		31 Jan 1996	
Depth of Survey area (m)	0-3.0	3.0-5.0	0-3.0	3.0-7.0	0-2.0	2.0-6.0	0-2.0	2.0-6.0	0-2.0	2.0-6.0
Living coral covered (%)	<10-25	<10-50	<10-25	50-75	25-50	25-75	<10-10	25-75	50-90	75-80
Dead coral covered (%)	0-25	<10-25	<10-25	10-25	<10-25	<10-25	<10-10	10-25	20-40	<10-20
Large coral colony or microatol										
Montipora encrusting					*	*				
Montipora laminar	*							*		
Montipora arborescent	*								*	
Acropora tabular	*				*	*	*	*	*	
Acropora arborescent		*			*	*		*	*	
Acropora palifera					*	*		*		
Porites massive	*		*		*	*	*	*	*	
Porites arborescent				*		*		*	*	
Pachyseris								*		
Lobophyllia						*	*			
Merulina					*	*				
Diploastrea								*		
Echinopora								*		
Physogyra									*	*
Turbinaria		*				*				*
Heliopora				*					*	
Millepora arborescent	*			*						
Large dead coral colony										
Seriatopora				*						
Acropora tabular					*	*		*	*	*
Acropora arborescent					*				*	
Acropora corymbose					*	*		*		
Porites arborescent				*				*		
Crown of Thorns *Acanthaster planci*	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent
Evidence of Dynamite Fishing	slight		none		moderate		severe		moderate-severe	
Soft Coral coverd (%)	<10	0	<10	<10	25-75	10-25	<10-10	<10-10	<10-20	<10-10
Sea Grass coverd (%)	<10	0	0	0	0	0	0	0	25-50	0
Common Sea Grass species										
Enhalus acoroides	*								*	
Thalassia hemprichii	*									
Halophila ovalis	*								*	
Halodula pinifolia									*	
Halodula uninervis									*	
Cymodocea serrulata									*	
Algae coverd (%)	<10-80	<10-90	75-100	<10	<10	<10	50-75	<10	<10-50	<10
Common Algal species										
Padina spp.	*	*						*		
Turbinaria ornata	*						*		*	
Cystoseira prolifera	*						*		*	
Sargassum spp.	*	*	*				*		*	
Siltation	thin	thin	heavy	heavy	thin	medium	none	thin	none	thin
Water transparence (m)	7.0		>7.0		9.7		16.0		>11.0	
Water color	vivid blue green		vivid blue green		deep greenish blue		deep greenish blue		deep greenish blue	
Depth (m)	10.5		7.0		21.0		24.0		11.0	
Water temperatures (°C) Depth (m) 0	27.4		28.2		28.0		28.2		27.8	
0.5	27.4		28.2		28.0		28.2		27.8	
1	27.3		28.2		28.0		28.2		27.8	
3	27.1		28.2		28.0		28.2		27.7	
5	27.0		28.2		28.0		28.2		27.5	
Bottom	27.0		28.1		27.9		28.2		27.3	
Salinity Depth (m) 0	33.5		33.4		33.4		33.4		33.4	
0.5	33.5		33.4		33.4		33.4		33.4	
1	33.5		33.4		33.4		33.4		33.4	
3	33.5		33.3		33.4		33.4		33.4	
5	33.5		33.3		33.4		33.4		33.4	
Bottom	33.5		33.4		33.4		33.4		33.4	

Source: Study Team



Source: Study Team

Figure 3-6
Distribution of Mangrove Forest in the Study Area



Source: Study Team

3.5. Fishery Resources

1) Fishery Production

Fishery production in the whole province revealed little change annually ranging from 69,000 - 79,000 metric tons in 1989 - 1993. (Table 3-3). Municipal fishery production occupies 70 - 80% of total production and is presented in Table 3-4. Major municipal fisheries operating within less than 15 km of shore are found in Coron, El Nido, Taytay, and Busuanga, and in Puerto Princesa City, while commercial fishing is mainly based on Aborda and Coron municipalities. Aquaculture production of the Province of Palawan is summarized in Table 3-5. Major species for aquaculture are Milkfish and seaweed (Euchcuma). Grouper and lobster are caught for commercial use.

Table 3-3 Fishery Production of the Whole Province of Palawan, 1989 - 1993

(Metric Ton)

Item	1989	1990	1991	1992	1993
Production (MT)	74,025	74,905	79,030	69,012	78,684
Commercial	27,047	16,957	17,555	12,817	21,188
Slipmouth			974	1,946	
Roundsead			1,438	3,566	
Cavalla			520	957	
Indian Sardines				2,078	1,101
Anchovies				1,579	3,330
Others				6,228	10,288
Municipal	46,978	57,948	61,475	56,067	56,757
Marine Municipal	46,887	57,791	61,353	55,947	56,757
Cavalla				5,322	5,526
Threadfin Bream				5,512	4,244
Grouper				5,282	2,705
Crevalle				9,074	2,342
Anchovies				3,308	1,062
Others				27,449	40,878
Inland Municipalities		91	157	122	120
aquaculture				128	739
Brackish Water					
Fishpond				128	38
Milkfish				128	38
Prawn				128	38
Others					
Mariculture					
Seaweed		4,217	3,548	4,590	

Source: DA, BAS

Table 3-4 Fishery production by municipality

Municipality (yr) Fishpond		Commercial Fishing	Total	Motorized	Non-motorized	Fishpond
Linapacan	(1990)	12,040.88	973.30	820.00	153.30	
Araceli	(1998)		365.97	175.95	190.02	
Busuanga	(1988)		2,439.20	1,796.00	643.20	
Coron	(1988)	4,125.80	5,122.00	3,932.00	1,190.00	
Dumaran	(1988)	26.73	1,466.00	673.00	793.00	7.50
El Nido	(1988)		2,682.20	1,754.40	927.80	
Puerto Princesa City	(1988)	140.56	2,323.00	1,535.00	788.00	25.80
Roxas	(1988)	162.19	2,148.00	1,572.00	576.00	7.50
San Vicente	(1988)	68.02	1,019.79	847.38	172.41	
Taytay	(1988)	21.52	2,475.75	1,912.50	563.25	

Sources : Department of Agriculture, Bureau of Agricultural Statistics,
Palawan PCSD, "Municipal Data", 1994

Table 3-5 Aquaculture Production Characteristics of the Province of Palawan

Production:	1990	288 MT
	1991	288 MT
	1992	300 MT
	1993	447 MT
	1994	395 MT
Major Species:	Seaweed, lobster, milkfish, pearl, grouper, freshwater fish	
Productivity		
Fish pond	Ave. Annual Productivity	350 MT
	Ave. Yield	1.0 MT/ha/yr
Seaweed Farming	Ave. Annual Productivity	20,000 MT
	Ave. Yield	20 MT/ha/yr
Fishery Intensity		
Fishpond	Area	288ha
Seaweed Farming	Area	1,000 ha
	No. of Operators	400
Pearl Farming	No. of Operators	4

Source: "Status of Fisheries in Region IV, Palawan with Emphasis on Business Opportunities" BFAR, 1995

2) *Fish / shellfish species caught*

Major species caught of commercial fishing in Palawan waters include sardines, mackerel, bonito, slipmouth, round scad and squids. As for municipal fisheries, various fish , such as tuna, sardines, scads, anchovies, grouper, snapper, squids, octopus, mackerel, crevalle, lobster and siganids, are commonly caught. Table 3-6 cites the list of fish / shellfish species for fisheries of municipalities in Northern Palawan.

Table 3-6 List of Marine Fish Occurring Around Northern Palawan

(O present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Acanthuridae	*Acanthurus bleekeri*	O								
	A. lineatus	O		O	O	O		O		
	A. nigricans							O	O	
	A. nigricauda							O		
	A. nigrofuscus	O				O		O	O	
	A. nigroris	O							O	
	A. striatus							O		
	A. thompsoni								O	
	A. triostegus					O		O	O	
	A. sp.1							O		
	Ctenochaetus striatus	O							O	
	C. strigosus								O	
	Naso brevirostris	O							O	
	N. brachycentron			O				O	O	
	N. hexacanthus	O								
	N. lituratus			O				O	O	
	N. thynnoides								O	
	N. unicornis							O		
	N. sp.1							O		
	Paracanthurus hepatus								O	
	Zebrasoma scopas	O		O	O	O			O	
	Z. veliferum							O	O	
Apogonidae	*Apogon angustatus*							O		O
	A. aureus		O		O					
	A. bandanensis				O					O
	A. bifasciatus									O
	A. compressus		O		O					
	A. macrodon							O		O
	A. trimaculatus				O					
	A. sp.1			O				O		
	A. sp.2									O
	A. sp.3									O
	Archamia fucata							O		
	A. zosteropora		O	O	O					O
	Cheiloderus macrodon				O					
	C. quinquelineatus				O					O
	Shpraeramia nematoptera		O		O			O		O
	S. orbicularis				O					
Aulostomidae	*Aulostomus chinensis*	O							O	
Balistidae	*Balistapus undulatus*								O	
	Balistoides viridescens			O					O	
	B. sp.1				O					
	Psudobalistes flavimarginatus	O								
	Rhinecanthus aculeatus							O		
	R. verrucosus			O				O		
	Sufflamen chrysopterus	O		O		O		O	O	
Belonidae	*Tylosurus sp.*							O		
Blenidae	*Cirrhipectes sp.*					O				
Caesionidae	*Caesio caerulaurea*									O
	C. caerulaureus	O			O		O			
	C. cuning	O			O		O	O	O	O
	C. chrysozonus	O								
	C. erythrogaster		O		O					
	C. lunaris								O	
	C. pisang	O								
	C. teres								O	
	C. sp.1			O						
	C. sp.(juvenilr)				O					
	Pterocaesio chrysozonus				O					
	P. diagramma	O						O	O	
	P. marrii						O			
	P. tile	O						O		

Table 3-6 cont.

(O present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Carangidae	*Carangoides bajad*								O	
	C. fulvoguttatus									O
	C. sp.1		O	O					O	
	C. sp.2				O					
	C. sp.3						O			O
	Caranx sp.								O	
	Seriola rivoliana								O	
Centriscidae	*Aeliscus strigatus*	O			O					O
Chaetodontidae	*Chaetodon adiergastos*							O		
	C. anchorago				O	O				
	C. auriga	O		O		O		O		
	C. baronessa	O		O			O	O	O	
	C. bennetti						O			
	C. citrinellus	O								
	C. cyanodus				O					
	C. kleinii	O				O	O	O	O	
	C. lineolatus							O		
	C. lunula	O		O						
	C. madagascariensis	O								
	C. melannotus							O		
	C. mesoleucus				O					
	C. modestus	O								
	C. ocellicaudus							O		
	C. octofasciatus	O	O	O	O		O			O
	C. ornatissimus	O							O	
	C. plebeius							O		
	C. punctatofasciatus								O	
	C. selene								O	
	C. semeion								O	
	C. speculum							O		
	C. trifascialis			O				O		
	C. trifasciatus	O	O	O				O	O	
	C. vagabundus			O		O			O	
	C. xanthurus								O	
	C. sp.1							O	O	
	Chelmon mulleri				O					
	C. rostratus	O	O		O	O	O	O		O
	Coradion chrysozonus						O			
	Heniochus acuminatus	O								
	H. chrysostomus	O					O	O		
	H. intermedius	O								
	H. monoceros	O						O		
	H. singularius							O	O	
	H. varius	O					O		O	
Cirrhitidae	*Paracirrhites arcatus*		O							
	P. forsteri		O							
Engraulidae	*Stolephorus indicus*				O					
Ephippidae	*Platax orbicularis*	O								
	P. pinnatus	O	O				O			
	P. sp.							O		
Fistulariidae	*Fistularia petimba*	O							O	
Gobiidae	*Ptereotris evides*								O	
Haemulidae	*Plectorhinchus chaetodontoides*								O	
	P. diagrammus	O						O		
Hemigaleidae	*Triaenodon obesus*	O								
Holocentridae	*Flameo sammara*				O					
	Myripristis berndti								O	
	M. kuntee	O								
	M. violacea									O
	Neoniphon sammara							O	O	
	Sargocentron ruber	O								
	S. spiniferum							O	O	

Table 3-6 cont.

(O present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Kyphosidae	*Kyphosus sp.*							O		
Labridae	*Anampses caeruleopunctatus*	O				O				
	A. meleagrides								O	
	Bodianus bimaculatus								O	
	B. mesothorax	O		O	O				O	O
	B. sp.								O	
	Cheilinus celebicus	O	O	O	O	O	O	O		
	C. chlorourus			O		O	O	O	O	
	C. diagrammus						O	O		
	C. fasciatus	O		O	O		O	O	O	O
	C. octotaenia								O	
	C. trilobatus							O		
	C. undulatus	O			O			O		
	C. unifasciatus				O			O	O	O
	Cheilio inermis			O		O				
	Choerodon anchorago	O		O			O	O	O	O
	Cirrhilabrus cyanopleura				O					
	C. temminckii				O				O	
	Coris auricularis								O	
	C. aygula					O				
	C. gaimard	O				O		O	O	
	Coris schroederi			O		O	O	O		O
	C. variegata							O		
	C. sp.					O			O	
	Diproctacanthus xanthurus				O		O	O		O
	Epibulus insidiator							O		O
	Gomphosus caeruleus								O	
Labridae	*Gomphosus varius*	O			O	O	O	O	O	
	Halichoeres centiquadrus				O					
	H. chloropterus				O		O			
	H. hoeveni				O					
	H. hortulanus					O	O	O	O	O
	H. marginatus					O		O		
	H. melanochir	O								
	H. melanurus	O		O	O	O	O	O	O	O
	H. melapterus	O		O						
	H. nebulosus					O		O		
	H. prosopeion								O	
	H. purpurescens						O	O		O
	H. scapularis				O			O		
	H. trimaculatus							O	O	O
	H. sp.								O	
	Hemigymnus fasciatus					O		O	O	
	H. melapterus				O	O		O	O	O
	H. sp.								O	
	Hologymnosus doliatus								O	
	Labrichthys unilineatus			O		O		O		
	Labroides bicolor								O	
	L. dimidiatus	O	O	O	O	O	O	O	O	O
	L. melanurus								O	
	L. sp.								O	
	Macropharyngodon meleagris	O		O		O	O	O	O	
	M. negrosensis					O				
	Novaculichthys taeniourus						O			
	Ophthalmolepis lineolatus								O	
	Parocheilinus octotaenia			O	O		O	O		
	Pteragogus cryptus			O		O				
	Stethojulis interrupta							O		
	S. strigiventer			O			O	O		
	S. trilineata					O		O		
	Thalassoma hardwicke			O	O	O	O	O	O	
	T. janseni								O	

Table 3-6 cont.

(O:present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Labridae	*Thalassoma lunare*	O	O	O	O	O	O	O	O	O
	T. lutescens								O	
	T. trilobatum					O				
	T. sp.								O	
Lethrinidae	*Gymnocranius macrodon*								O	
	Lethrinus erythropterus				O		O	O		O
	L. harak							O	O	
	L. olivaceous							O		
	L. sp.1	O								O
	L. sp.2	O								
Lutjanidae	*Lutjanus biguttatus*	O					O			O
	L. bohar	O								
	L. boutton	O								
	L. carponotatus				O			O		O
	L. decussatus	O		O	O	O		O	O	
	L. fulviflamma	O					O			O
	L. fulvus							O		
	L. gibbus	O								
	L. kasmira	O								
	L. semicinctus								O	
	L. timorensis								O	
	L. sp.								O	
	Macolor macularis								O	
	M. niger				O	O				
	Symphorichthys nematophorus							O		
Monacanthidae	*Aluterus scriptus*	O								
	Amanses scopas								O	
	A. sp.					O				
Mugiloididae	*Propercis polyopthalma*				O					
Mullidae	*Parupeneus barberinoides*			O	O					
	P. barberinus			O	O					
	Parupeneus bifasciatus					O		O	O	
	P. cyclostomus					O				
Mullidae	*P. forskali*							O	O	O
	P. indicus			O	O			O		
	P. multifasciatus	O		O		O		O	O	O
	P. pleurostigma							O		
	P. sp.								O	
	Upeneus moluccensis		O		O					
	U. vittatus				O					
Muraenidae	*Gymnothorax javanicus*	O								
	G. sp.								O	
Nemipteridae	*Monotaxis grandoculis*	O						O		
	Pentapodus caninus							O	O	
	P. macrurus				O					
	P. sp.	O						O	O	
	Scolopsis bilineatus	O		O	O	O	O	O	O	
	S. bimaculatus								O	
	S. ciliatus	O								
	S. frenatus								O	
	S. ghanam								O	
	S. lineatus			O		O		O		
	S. margaritifer	O		O	O		O	O	O	O
	S. monogramma						O	O	O	
	S. trilineatus							O		
Ostraciidae	*Ostracion cubicus*				O					
	O. meleagris							O		
	O. sp.								O	
	Rynchostracion rhinorhynchus				O					
Parapercidae	*Parapercis hexophthalma*								O	
	P. polyophthalma	O								
Platicephalidae	*Platicephalus indicus*									O

Table 3-6 cont.

(O present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Plotosidae	*Plotosus lineatus*							O		
Pempherididae	*Pempheris sp.*	O		O						
Pomacanthidae	*Centropyge multispinnis*	O								
	C. tibicen	O								
	C. vroliki	O			O				O	
	Chaetodontoplus mesoleucus	O	O		O		O			O
	Pygoplites diacanthus								O	
Pomacentridae	*Abudefduf curacao*								O	
	A. lorentzi				O			O		
	A. octofasciatus				O					
	A. saxatilis			O				O	O	
	A. septemfasciatus		O		O					
	A. sexfasciatus	O	O		O	O		O		
	A. vaigiensis	O	O		O					
	Acanthochromis polyacanthus			O		O	O	O		O
	Amblyglyphidodon aureus								O	
	A. curacao			O	O	O	O	O	O	O
	A. flavilatis	O								
	A. leucogaster	O			O		O	O		
	A. ternatensis		O		O			O		
	Amphiprion akindynos	O								
	A. chrysopterus	O								
	A. clarkii						O			
	A. frenatus	O		O			O			
	A. ocellaris	O		O	O		O	O		
	A. perideraion			O						
	A. sandaracinos	O	O		O			O		
	Cheiloprion labiatus							O		
	Chromis analis				O					O
	C. caeruleus	O								
	C. flavomaculatus								O	
	C. nitida								O	
	C. notata								O	
	C. ovalis								O	
	C. pembae			O			O			
	C. ternatensis	O		O	O		O		O	O
	C. viridis	O	O	O	O		O	O	O	
	C. weberi	O		O						
	C. xanthura							O	O	
	C. sp.1				O		O	O		O
	Chrysiptera oxycephalus							O		
	Chrysiptera parasema		O		O		O	O	O	O
	C. springeri								O	O
Pomacentridae	*C. talboti*					O				
	Dascyllus aruanus	O							O	
	D. corneus								O	
	D. melanurus							O		
	D. reticulatus	O		O			O	O	O	
	D. trimaculatus	O					O			
	D. sp.								O	
	Dischistodus melanotus							O	O	
	D. perspicillatus	O			O		O	O		O
	D. prosopotaenia	O							O	
	D. pseudochrysopoecilus							O		
	Glyphidodontops parasema				O					
	G. rolandi				O					
	Hemiglyphidodon plagiometopon	O							O	O
	Neoglyphidodon melas	O		O	O	O	O	O	O	O
	N. nigroris	O		O	O	O	O	O	O	
	Neoglyphidodon polyacanthus								O	
	N. sp.	O								
	Paraglyphidodon oxyodon							O		

Table 3-6 cont.

(O present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Pomacentridae	*Parma sp.1*							O		
	Plectroglyphidodon dickii			O		O		O	O	
	P. johnstonianus	O						O		
	P. lacrymatus	O		O		O		O	O	
	Pomacentrus agassizi	O							O	
	P. albicaudatus							O		
	P. alexanderae		O		O					
	P. amboinensis	O					O	O		
	P. aquilus					O		O		
	P. bankanensis					O		O		
	P. brachialis			O						
	P. burroughi						O			O
	P. chrysurus			O		O		O		
	P. coelestis	O		O		O		O		
	P. grammorhynchus	O						O		
	P. lepidogenys			O		O		O	O	O
	P. moluccensis	O	O	O			O	O	O	
	P. nigromanus			O			O	O		O
	P. nigromarginatus	O								
	P. philippinus	O		O				O	O	
	P. semicirculatus	O		O						
	P. smithii									O
	P. stigma	O		O				O	O	
	P. trilineatus								O	
	P. vaiuli				O				O	
	P. sp.1							O		O
	P. sp.2							O		
	Premnas biaculeatus	O		O						O
	Stegastes insularis	O							O	
	S. obreptus							O	O	
Pseudochromidae	*Dampieria sp.*	O								
	Labracinus cyclopthalmus				O					
	Ogilbyina queenslandiae			O			O	O		
	O. velifera									O
Scaridae	*Cetoscarus bicolor*	O			O	O			O	
	Scarus barid				O					
	S. bleekeri						O	O		
	S. dimidiatus			O			O			O
	S. fasciatus				O					
	S. flavipectoralis	O			O	O	O	O		O
	S. fosteri								O	
	S. frenatus	O				O		O		
	S. ghobban				O					
	S. gibbus	O								
	S. globiceps				O					
	S. hyselopterus						O	O		
	S. niger								O	
	S. oviceps								O	
	S. prasiognathus			O					O	
	S. rubroviolaceous	O		O						
	S. sordidus	O		O	O		O	O	O	O
	S. spinus							O		
	Scarus sp.	O				O		O	O	
Scorpaenidae	*Pterois volitans*	O							O	
Scombridae	*Rastrelliger kanagurta*	O								
Serranidae	*Cephalopholis argus*	O					O			O
	C. boenack					O	O	O		O
	C. cyanostigma	O			O				O	O
	C. hemistiktos								O	
	C. leopardus				O					
	C. miniata	O		O						
	C. pachycentron	O								

Source: Marine Survey, Study Team

Table 3-6 cont.

(O present)

Family	Taxonomy	Bacuit Bay	Green Is.Bay	St.Paul Bay	Taytay Bay	Western Busuanga	Coron Island	Western Culion	Dimakya Island	Tangat Island
Serranidae	*Cephalopholis urodela*	O							O	
	C. sp.								O	
	Cromileptes altiveles	O								
	Diploprion bifasciatus	O		O					O	O
	Epinephelus argus	O								
	E. cyanostigma	O								
	E. fasciatus	O		O					O	
	E. fuscoguttatus							O		
	E. hexagonotus	O								
	E. merra	O		O	O	O		O		
	E. microdon				O				O	
	E. summana				O					
	E. sp.								O	
	Plectropomus leopardus	O			O			O	O	
	P. oligacanthus									O
	Pseudanthias hucktii	O								
Siganidae	*Siganus argenteus*				O				O	
	S. corallinus								O	
	S. guttatus	O								
	S. lineatus							O		
	S. puellus							O	O	
	S. spinus			O		O		O		
	S. stellatus						O			O
	S. virgatus	O	O	O	O	O		O	O	O
	S. vulpinus	O	O		O		O	O	O	O
	S. sp.				O				O	
Sphyraenidae	*Sphyraena flavicauda*	O		O				O		
	S. picuda	O								
Teraponidae	*Terapon jarbua*				O					
Tetraodontidae	*Arothron nigropunctatus*	O		O	O		O	O	O	O
	Arothron stellatus								O	
	Canthigaster compressa								O	
	C. solandri							O	O	
	C. valentini	O								
Zanclidae	*Zanclus cornutus*	O	O	O		O	O	O	O	O

Source: Study Team

Table 3-7 Fish / shellfish species caught in Northern Palawan waters.

Fish, Shellfish	Bus.	Coron	Lin.	El Nido	Taytay	Araceli	Dum.	San Vicente	Roxas	P.P City
Anchovy	O	O	O	O	O	O	O	O	O	O
Bangus fry	O									
Baritos				O						
Barracuda	O				O					
Blue-eyed squid		O								O
Bonito										O
Caesio		O	O	O	O			O	O	O
Catfish										O
Cavella					O					O
Chub mackerel									O	
Crab	O	O		O					O	O
Crevalle		O		O		O	O			O
Coaker										O
Cuttle fish					O					
Eel										O
Garfish										O
Goat fish										O
Grant										O
Grouper	O	O	O		O	O	O	O		O
Hairtail		O								O
Hardtail										O
Half beak	O			O	O					O
Herring	O	O	O	O	O					O
Jelly fish			O		O					O

Table 3-7 cont.

Kanuping							O			
Kepis shells					O					
Lizard fish				O	O					
Lobster	O		O		O			O		O
Mackerel	O	O	O	O	O		O	O	O	O
Mullet	O			O	O			O		O
Nemipterid	O	O	O		O	O				O
Octopus		O								
Ornamental shells					O				O	
Parrot fish				O	O					
Porgy										O
Prawn					O					
Ray	O									
Round Scad	O	O	O	O	O	O	O			O
Sardines	O	O	O	O	O	O		O	O	O
Sea cucumber	O	O			O		O		O	O
Sea urchin	O									O
Seaweed	O								O	O
Shark	O									O
Shells			O	O			O	O		O
Shell pearl	O									
Shrimps	O	O				O			O	O
Siganid	O	O	O	O					O	O
Slipmouth	O	O	O	O	O			O	O	O
Snapper	O	O	O	O	O	O		O	O	O
Sole fish	O				O					
Spanish Mackerel						O				
Squid	O	O	O		O		O	O	O	O
Theraponid										O
Trepang		O						O		
Tropical Fish		O			O				O	O
Tuna	O				O	O	O	O	O	O

Source : "Municipal Data" PCSD, 1994

3) Type of fishing gear used

The following fishing gears are used in Northern Palawan waters: gill net (midwater and bottom), hook and line, beach seine, purse seine, bag net, ring net, fish pot, fish trap, fish corral, spear gun and baby trawl.

Table 3-8 shows the number of fishing gear used by fishermen as of 1988. Hook and line fishing is most abundant in Puerto Princesa City, Roxas and Coron municipalities. Gill net which is usually set at intermediate layer or on the sea bottom is common in PPC and El Nido. Some of those fishing gears are illustrated in Figure 3-7

Table 3-8 Fishing gear used by municipal fishermen

(Unit : Person)

Municipality	Hook & Line	Gill Net	Bag Net	Purse Seine	Trawl	Fish Corral	Fish Trap
Busuanga	430						
Coron	1,028	185			192	7	
Linapacan	176	92					
El Nido	350	420		3		180	64
Taytay	375	246			105	146	
Araceli	189	135	76				
Dumaran	253	239					
San Vicente	30	75	442	24	159		30
Roxas	1,200	80	459	120	11	53	
P P City	1,384	505	203	144		238	

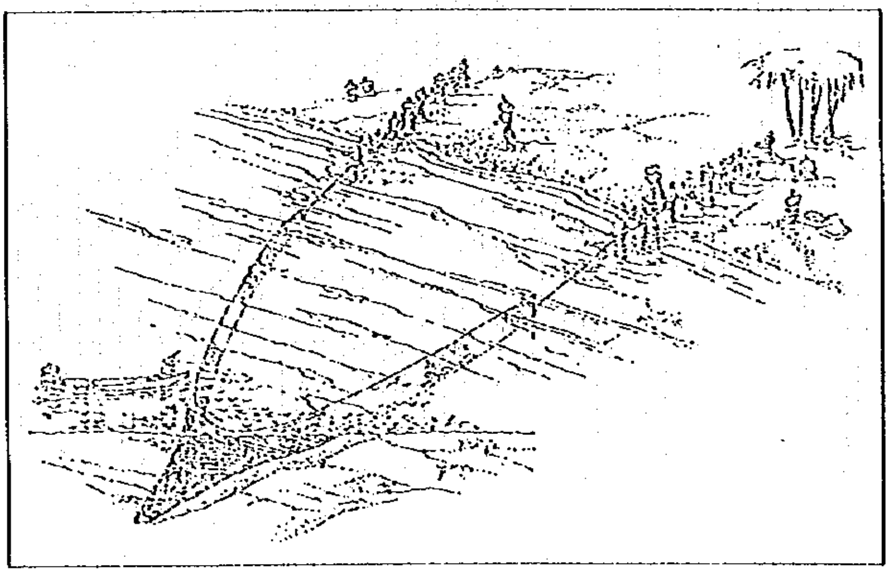
Source: "Municipal Data" PCSD, 1994

Table 3-9 Fishing gear used by commercial fishermen

Municipality	Bag Net	Hook & Line	Purse Seine	Fish Carrier
Coron	42			
Linapacan				1
Taytay	51			
Dumaran	2			
San Vicente	2		2	
Roxas	3	2		
Puerto Princesa	1		4	

Source : "Municipal Data" PCSD, 1994

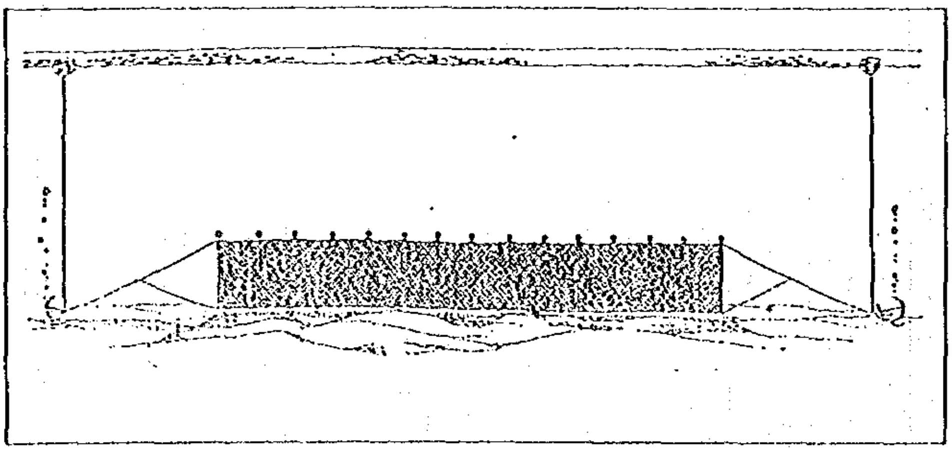
Figure 3-7 Fishing Gears Used in Palawan Waters



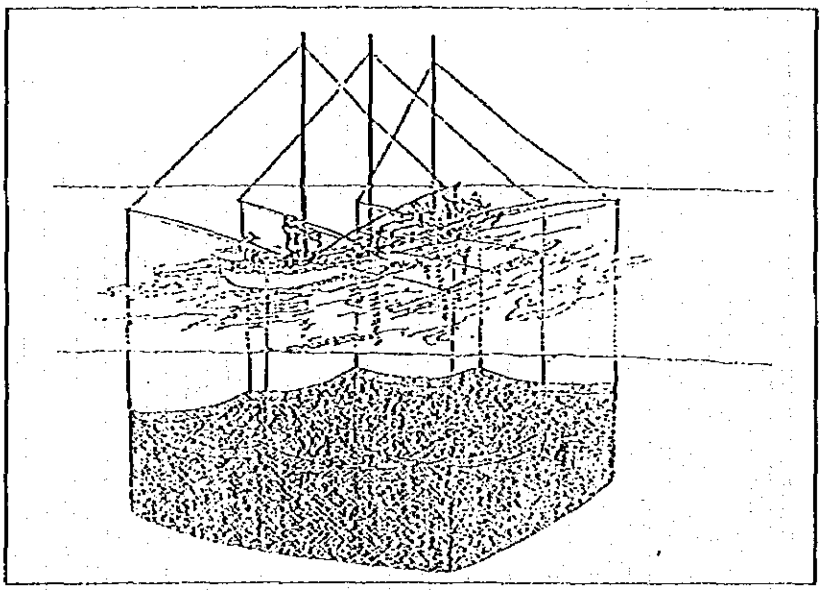
Beach seine

Figure 3-7 cont.

Gill net
(Bottom-set type)



Bag net



Purse seine

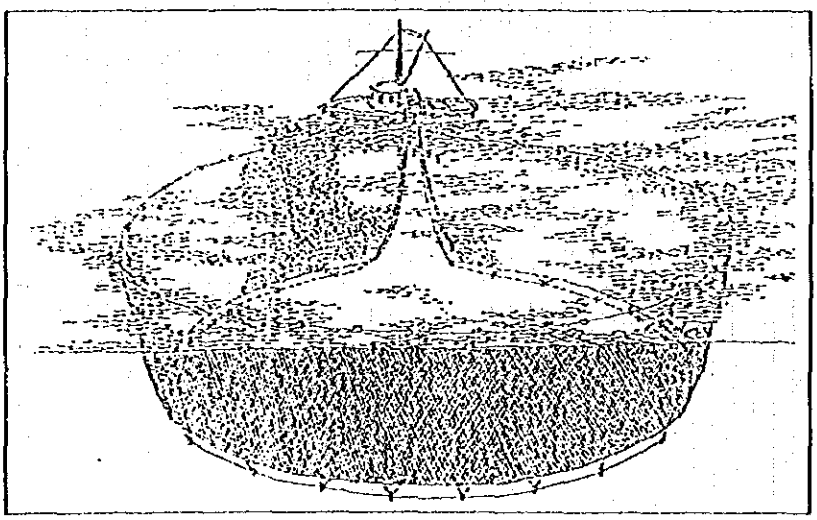
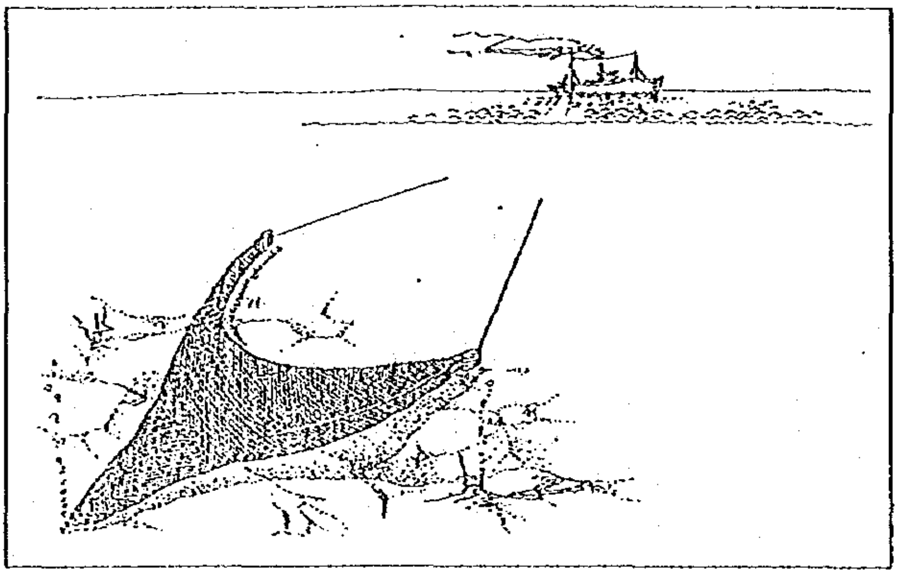
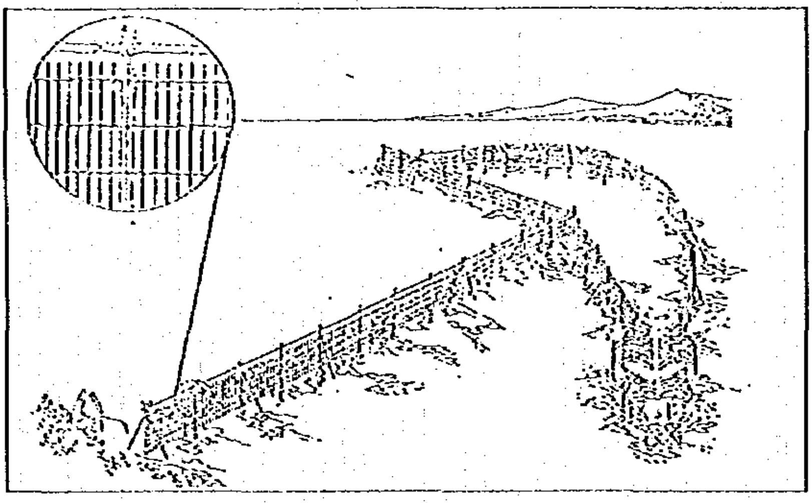


Figure 3-7 cont.

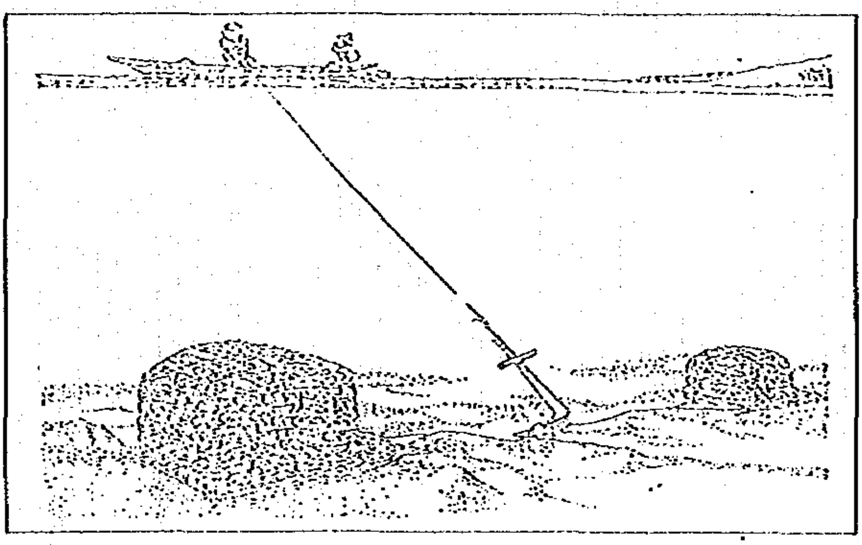
Trawl





Typical fish corral

Fish pot



4) Fishing ground

Municipal fishing is operated mainly in Coron Bay, Honda Bay, West Sulu Sea Imuruan Bay, Malampaya Sound, West Palawan Waters, Dumaran Channel and Taytay Bay, while commercial fishing is conducted outside of 7kms offshore. Major fishing grounds of commercial fisheries are in the outer parts of Bacuit Bay, Imuruan Bay, Malampaya Sound, Coron Bay, Dumaran Channel, Taytay Bay and Honda Bay, Linapacan Strait and West Sulu Sea (Figure 3-8). As a whole the most significant fishing grounds in Northern Palawan are Malampaya Sound, Ulugan Bay and Bacuit Bay.

Bag net gear is used intensively in near-shore areas of Roxas and San Vicente municipalities. Hook and line fishing is operated throughout the province and offshore for a duration of up to two weeks. Purse seine is employed beyond 7 km from the coastline of Ulugan Bay, Taytay Bay, Bacuit Bay, etc. Trolling is also permitted in areas beyond 7 km of the coastline, and its major grounds are off Roxas and Dumaran municipalities and off the Bays of Honda and Puerto Princesa. Gill net is used provincial wide. Fast trap fishing is often found on the coastal areas of El Nido, San Vicente, Araceli and Dumaran municipalities and Malampaya Sound in Taytay municipality. Aquaculture grounds exist in the strait between Busuanga Island and Culion Island.

5) Illegal Fishing Activities

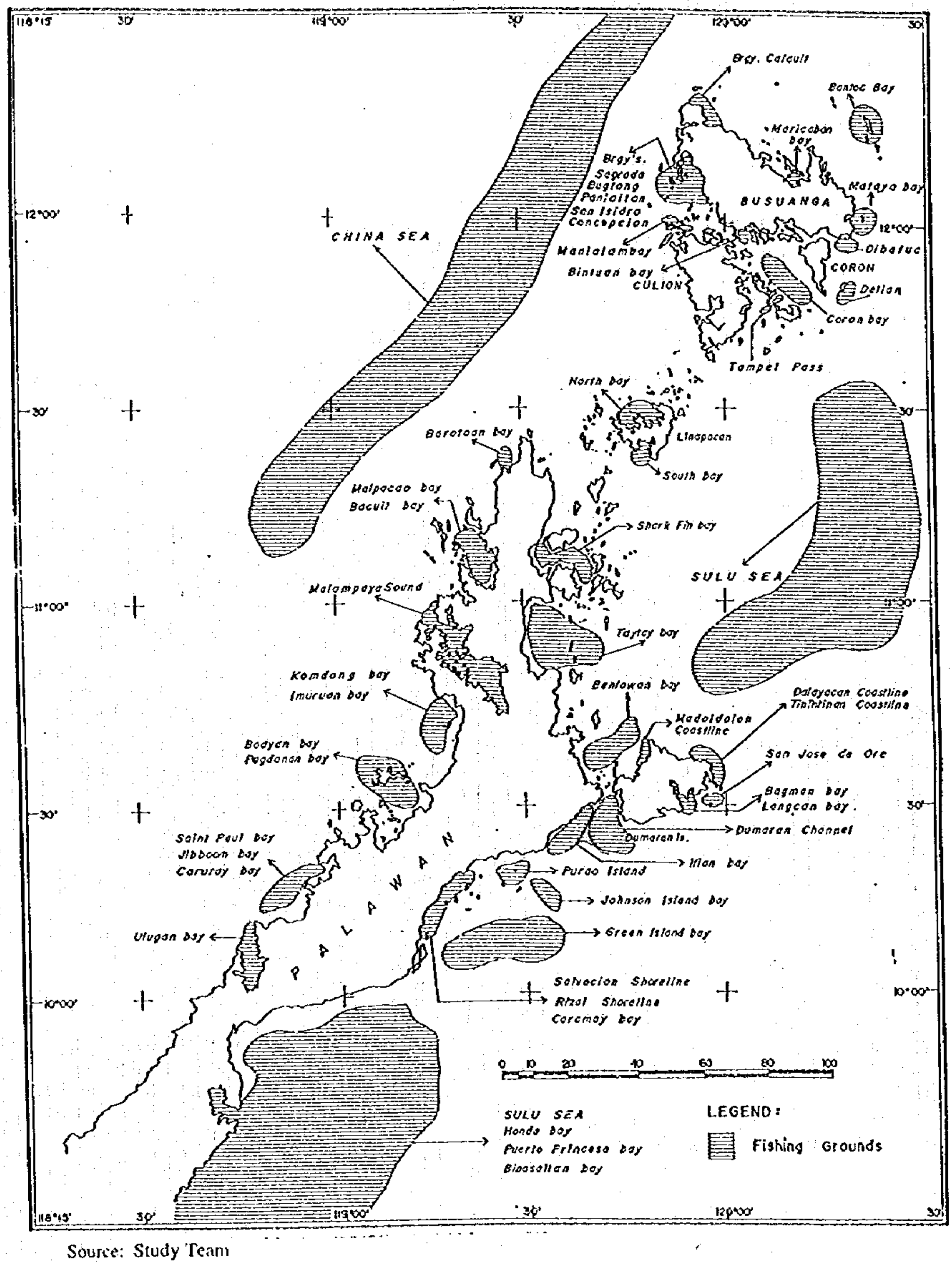
Dynamite or blast fishing, fishing with poisons, such as sodium cyanide, or with depletive gear, such as muro - ami and kayakas, and the illegal collection of aquarium fish and invertebrates are particularly damaging to coral reef habitat.

Explosives have been used for fish gathering in the Philippines since World War II. Although blast fishing was banned in 1972, the practice is still widespread today. In addition to endangering the safety of the user and causing structural damage to coral reef areas, blast fishing tends to indiscriminately kill aquatic organisms essential to marine productivity.

Sodium cyanide, which affects enzyme systems involved in oxygen metabolism, is used for fish gathering both by fishermen and aquarium fish collectors. In addition to fish mortality, many of the coral polyps and other plants and invertebrates that form the basis of the coral reef ecosystem are either killed or severely stressed by cyanide.

Muro - ami and kayakas fishing are two very effective methods of harvesting fish in coral reef areas. Reef damage occurs when weighted scare lines are dropped onto coral by swimmers as they move towards the net. Finally, the unregulated collection of aquarium fish and invertebrates for local use and export can severely affect both freshwater and coral reef productivity.

Figure 3-8 Fishing Grounds of the Study Area



Source: Study Team

The Bantay Palawan Program was established in 1993 by the provincial government to combat rampant illegal fishing and illegal logging, in cooperation with the Philippine National Police (PNP), Maritime Command and Military. The Bantay Palawan Program activities cover the entire province except for Puerto Princesa where "Bantay Palawan" has operated with similar purpose since mid 1992 (refer to Table 3-10). Its powers and functions are to:

a) Enforce and implement the laws, ordinance, rules and regulations against illegal logging, illegal fishing, illegal kaingin and similar illegal activities affecting the environment and natural resources in its area of jurisdiction;

b) Monitor and apprehend violators of the laws involving environmental protection and conservation and;

c) Protect and safeguard the terrestrial and marine environment and natural resources.

4. Assessment of Current Environment in Northern Palawan

4.1. Marine Ecosystem

From a macroscopic point of view, the following physical and chemical environmental characteristics were noticed in the study area.

1) Physical aspect

The flow patterns of the currents are regulated by wind direction during monsoons. Therefore, distinct current direction is observed in both near-shore and offshore areas during the monsoon season. Logging road formation which generates turbid water with a high concentration of soil particles every time it rains has brought huge amounts of land soil into the coastal sea area.

2) Chemical aspect

Seawater temperature is very stable at around 29°C throughout the year, which ensures rapid coral growth. There is no severe water pollution at present in the northern Palawan coastal areas, except in Honda Bay where mercury contamination due to mining tailings reclaimed into the sea is observed.

3) Biological aspect

Coral reef has degraded in most parts of the study area. Dead coral and sargasso covering shallow reef areas make it very difficult to restore healthy coral communities even when countermeasures against soil discharge are undertaken immediately. The northeastern part of the study area still has healthy coral reef, though the threat of dynamite fishing remains. Reef associated communities seem to be degrading due to deterioration of coral reefs and the increase of fishing pressure.

Table 4-1 Apprehended Illegal Fishing in Northern Palawan

	No. of Apprehensions				No. of Persons Involved / Apprehended				Amount of Fish Confiscated (kg)				Estimated Market Value (Peso)			
	1993	1994	1995	TOTAL	1993	1994	1995	TOTAL	1993	1994	1995	TOTAL	1993	1994	1995	TOTAL
BUSUANGA	2	-	2	4	4	-	12	16	-	-	-	-	-	-	-	-
CORON	5	2	18	25	34	-	35	69	1,900	800	5,130	7,830	28,500	20,000	178,700	227,200
CULION	-	1	4	5	-	9	24	33	-	100	1,100	1,200	-	102,500	30,000	132,500
LINAPACAN	1	-	-	1	-	-	-	-	100	-	-	100	ND*2	-	-	-
EL NIDO	3	1	2	6	32	2	3	37	1,500 +600 pcs	50	180	1,730 +600 pcs	89,250	1,500	5,100	95,850
TAYTAY	3	3	4	10	18	13	3	34	210	40,000 +201 pcs	441	40,651 +201 pcs	3,100	6,280,150	42,670	6,325,920
SAN VICENTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROXAS	4	5	6	15	45	17	59	121	1,025	-	3,420	4,445	15,375	385,600	102,600	503,575
DUMARAN	-	1	-	1	-	-	-	-	-	-	-	-	-	100,000	-	100,000
APACELI	-	1	1	2	-	2	-	2	-	-	500	500	-	500,000	15,000	515,000
PUETRO PRINCESA*1				ND*2				133				17,500				ND*2
TOTAL	18	14	37	9				445				73,956 +801 pcs				7,900,045

*1: Accomplishment of Bantay Puerto, July 1992 - December 1995

*2: No Data

4.2. Regional Assessment of Selected Marine Ecosystems

1) Busuanga Island

Though Busuanga Island has little forest coverage, coral reef on the north and west coasts are well protected from turbid water discharge due to the small catchment areas bounded by shore along the mountain ridges. South coast facing Busuanga Strait receives much more influence instead, from the river water discharge and the pearl farming activity.

2) Coron Island

Coron Island has outstanding natural features characterized by limestone forest and cliff. The National Museum is spearheading a campaign to declare Coron Island a protected area. It should be promoted because the coral community of Coron Island shows signs of damage due to dynamite fishing, though it is still relatively healthy. Tangat Island has similar natural conditions to Coron Island, and is also threatened by dynamite explosions.

3) Culion Island

Beaches in the western side of Culion and smaller islands are often uninhabited. However, small clusters of settlements have been observed in some small islands. Use of beaches in the western side of the small islands and Culion Island area is limited to visits from fishermen who wait for nightfall on the island. These visits are evidenced by the presence of fire pits. Tar was found on all beaches (SEASTEMS, 1995). However, its occurrence is not pervasive. Tar was commonly observed above the high tide level and in the rocky portions of the beaches. The coral reef community is well preserved except for the north coast facing Busuanga strait.

4) Linapacan Island

Owing to a small amount of turbid water discharge and remote location from intensive human activity, the natural condition of marine ecosystem seem to be in good condition.

5) Bacuit Bay

The mainland and islands in and around Bacuit Bay are made up of limestone formations, where small natural catchment areas impose little damage on the marine natural ecosystem. A natural process that may constitute an environmental hazard to human activities is coastal erosion and deposition. It has been reported that shore erosion in one of the islands has been accelerated by mining of beach sand.

As for a human - originated problem, oil pollution in the Bacuit Bay area can be attributed to the fishing and recreational boats in the area. The offshore area of northwestern Palawan is the site of numerous oil wells while oil exploitation remains a source of oil pollution.

Coral reef in Bacuit Bay was extensively infested with the crown-of-thorns starfish (*Acanthaster planci)* sometime in 1987 - 88.

Illegal fishing have been known to occur inside the El Nido Marine Reserve and the Reserve has past and pending cases filed against illegal fishers (MTF, 1995).

Negative impacts on coral reef in outer Bacuit Bay from recreational activities have also been observed in the past from anchorage, diving, and small boat damage, as well as reef walking. There is no significant coral reef in inner Bacuit Bay, i.e. the coast of the mainland.

6) Taytay Bay

Taytay Bay has extensive reef flats which are dominated by brown algae (*Sargassum* spp.) and seagrass beds. Seagrass beds serve as a food source for the sea cow and green turtle populations in the Bay. Observation through diving surveys imply that the coral community in this area was destroyed several years ago through a huge amount of turbid water discharge, and was replaced by the brown algae.

7) Malampaya Sound

Malampaya Sound is the most intensive fishing ground and is regarded as the most significant nursery ground for marine resources. The main threat to the area is the rapid increase in population which is expected to impose pressure on the relatively undisturbed mangrove areas. Over exploitation of the mangroves or clearing for brackish water aquaculture ponds is expected to affect coastal fishery production in and around Malampaya Sound.

8) Green Island Bay

Being remote from the mainland, small islands in Green Island Bay still have a few living coral communities. The proximity of Malad River to the built - up areas of Roxas may pose a major threat to the bay in terms of runoffs resulting from construction, development and pesticide discharge from agricultural areas. Attention should also be given to illegal fishing (dynamite and cyanide) which has been reported in the area near Green Island and Cocoloco Resort (PCP, 1995). Cyanide is used in the collection of live aquarium fishes in the area.

9) St. Paul Bay

The bay consists of several coves characterized by white sand beaches, limestone, and rock formations. Fringing reef is restricted to some parts of the coastline, while extensive beds of sargasso and other seaweed have been noted.

10) Ulugan Bay

Ulugan Bay is a major shallow bay with coastal mangrove forest associated with tidal flats, seaweed beds, small islands and smaller bays. There is still threat from oil pollution from a naval station in the bay which has already killed some strands of mangrove trees, *Rhizophora* and *Bruguiera*, in the area.

Blast and cyanide fishing were rampant in the recent past. Over-fishing with traditional methods coupled with the above activities has resulted in the marginal economic productivity of the Bay (Walters, 1995). Pa-aling, a highly technical fishing gear, is still being used for fishing in coral reefs.

11) Honda Bay

The bay embraces twelve islands together with fringing reefs, patch reefs and shoals. The coral community has been degraded already on the coast of the mainland, while small-scale living coral can be seen in offshore areas.

As mentioned previously, mercury contamination of a significant level is known in this area. Dealing with the contamination is very difficult. Special measures to protect and improve the ecosystem of Honda Bay are required.

12) Puerto Princesa Bay

The coral community of this shallow bay with estuaries, mangrove islands, intertidal mudflats, sandflats, mangrove forest and aquaculture ponds is almost dead. The mangroves of Puerto Princesa Bay are threatened by pollution from Puerto Princesa City. Timber cutting and the operation of fish ponds contributes to the reduction of the mangrove forest area.

The Puerto Princesa Bay is a nature and wildlife reserve. Being so, the mangrove ecosystem in the bay is thus protected against unsustainable uses that threaten the mangrove biodiversity and mangrove resources therein.

4.3. Environmental issues to be cared

1) Soil discharge into the sea

Palawan Island has many steep mountains. This topographic character often results in land slides particularly when trees are cut or logging roads are constructed. Every time it rains, turbid water rushes down into the sea, because the slope is steep due to the elongated land shape and high mountains. Severe soil discharge to the sea can be seen on the coast of Roxas, Dumaran and San Vicente, the east coast of Taytay and Malampaya Sound.

Siltation inhibits not only the survival of coral, but also seaweed from attaching to substrates. Once the coral reef is damaged by siltation, there is no feasible way to restore it.

2) Dynamite fishing

Dynamite fishing is still being operated countrywide, though it is illegal. In Northern Palawan, the west Sulu Sea area is a likely major fishing ground. Bantay Palawan Program in cooperation with PNP and the Coast Guard is enhancing law enforcement by apprehending dynamite fishermen. Shortage of personnel, equipment and funds, however, does not make their effort so effective at present.

Dynamite blasting brings about the collapse of the coral reef which is irretrievable. This results in the deterioration of reef-associated communities. Signs of this phenomenon were observed through the diving survey.

3) Cyanide fishing

Cyanide fishing is also illegal and is still operated countrywide. The Bantay Palawan Program is conducting inspection of the cyanide content of fish at fishery ports and fish markets to enforce the law. Cyanide fishing, as well as dynamite fishing, is regarded as attributable to the deterioration of the coral reef community. Though fishing grounds cover all northern Palawan waters, they tend to concentrate on the good coral reef areas.

4) Mercury pollution

Mercury pollution in Honda Bay, as mentioned before, shows a severe level of bottom sediment contamination with the maximum concentration of 570ppm. Contaminated bottom sediment has already been diffused by wave action along the shore.

In Minamata Bay, Japan, Minamata Disease caused by mercury pollution of the marine environment was reported in 1956. Mercury contamination of surface sludge revealed more than 600ppm within the most polluted areas of about 1km^2, according to the survey of 1974. Though in Palawan the polluted area is limited to Honda Bay, the maximum concentration is at the same level as that of Minamata Bay.

In the case of Minamata Bay, the Japanese Quality Criteria for Removing Polluted Seabottom Sediment was applied, and sludge with mercury concentration of 25ppm or higher was dredged and reclaimed in carefully designed containers. Similar careful environmental measures should be conducted for Honda Bay.

5) Oil pollution

Based on the oil spill model, Berger (1991) predicted that an oil spill of major proportions was likely to occur at some time in the vicinity of Palawan. The near-shore and intertidal zone (coral reefs, mangrove swamps, and sand beaches) would have the greatest risk.

The presence of tar in the beaches of the islands in El Nido has caused nuisance to tourists. This environmental risk should be contained province-wide, especially in the western coast of Palawan.

Oil film Whether intentional or accidental, oil film damages both marine resources and the scenic value of the Palawan marine coastal area.

5. Existing Environmental Status in the Case Study Areas

5.1. Introduction

As a basis for the environmentally sustainable tourism development plan, a detailed study was carried out on the marine environment in the selected case study areas. The existing condition of the marine environment was analyzed through primary and secondary data study. Prediction and evaluation on the impact of proposed developmental activities were done based on the obtained environmental data and the development plan.

5.2. Method

The existing environmental condition of the marine environment was analyzed with the following methods:

1) Aerial Photo-based Analysis

A series of aerial color photographs were taken and used with a scale of 1/10,000 covering the priority areas. Horizontal distribution of coral reef, seagrass beds and mangrove forests was mapped and evaluated.

2) Field Survey

Physical, chemical and biological aspects were surveyed using a hired boat. Field survey included the following:

(a) Current measurement: Current speed and direction were measured using current meters in El Nido and drogue in Busuanga.

(b) Water quality measurement: Surface water was sampled with a Vam Dorn water bottle. Water quality measurement was done in a laboratory on the parameters of suspended solids (SS), chemical oxygen demand (COD) nitrogen, phosphorus and E. coliform.

(c) Bottom sediment analysis: Surface sediments were sampled with a Smith - McIntire sediment sampler. A Quality test was carried out in a laboratory on the parameters of grain size and COD.

(d) Diving survey: Visual observation was done by divers supplemented by an underwater video and an underwater camera. Coral, seagrass/seaweed and reef-associated organisms were surveyed.