Assessment of Mangrove Management Areas in Four Coastal Barangays of Bolinao, Pangasinan, Philippines

Annie Melinda Paz-Alberto
Institute for Climate Change and Environmental Management
Central Luzon State University,
Muñoz, Nueva Ecija. Philippines

Annie Rose D. Teñoso
Pangasinan State University
Binmaley, Pangasinan, Philippines

This study aimed to assess the diversity of mangroves, fish, and other economically important aquatic species and to determine the physical, chemical and biological characteristics in the mangrove management areas at Balingasay, Arnedo, Victory and Binabalian, Bolinao, Pangasinan in order to evaluate the present condition of these mangrove areas.

Based on the assessment made, the municipality of Bolinao has established several projects and programs on the management of the mangrove ecosystems. In the mangrove management areas, 24 mangrove tree species were found with *Rhizophora mucronata* as the most dominant and densest among the species in each area except in Balingasay where *Nypa fruticans* was the densest and most dominant. Only 18 fish and invertebrate species were identified from the four mangrove management areas. *Polinces aurontius, Trachycardium orbita,* and *Terebralia polustris* had the highest importance value index for the fish and invertebrate species. Diversity index values of mangrove and other marine species in the mangrove management areas are very low.

The physical, chemical and biological characteristics of the mangrove ecosystems of Bolinao were found to be of good water quality being within the optimum level set by the DENR for marine species to thrive and replenish. However, all the mangrove ecosystems obtained high total coliform and Barangay Balingasay got also high fecal coliform which are attributed to domestic wastes.

The mangrove management areas still have low diversity of

mangroves and other marine species and high total and fecal coliform due to human activities. Hence, for the attainment of sustainability of the mangrove management areas, it is imperative that there should be a strong cooperation, coordination and involvement among the key stakeholders such as local and national government and the local community to address the issues and problems present in the mangrove areas.

KEYWORDS: Mangrove management areas, total coliform, fecal coliform, species diversity, mangroves, fish and invertebrates

INTRODUCTION

The Philippines has rich coastal resources. With its numerous islands, the Philippines has a total coastline of about 36,289 km or 22,549 mi (BFAR, 1996). However, management of these resources by national level has failed to curtail the degradation and overexploitation of these coastal resources that became widespread in the Philippines (White & Cruz-Trinidad, 1998) indicating a high level of degradation primarily from fishing practices, overexploitation, siltation, pollution, and habitat loss.

In order to optimally utilize and reap the benefits without hampering the fragile balance, adoption of integrated coastal management strategies must be done. Based on solid scientific foundation, this will allow multiple uses of the resources without causing serious damage to the environment. Unlike land resources, marine resources are not easy to fence-off and moreover, are often considered as "common property" and available to all. Protection and management of these resources are extremely difficult without the support and cooperation of the stakeholder community.

In Lingayen Gulf, several studies were made by concerned agencies. McManus and Chua (1990) compiled reports on the coastal environmental profile of Lingayen Gulf which was the basis for management interventions. The earlier study undertaken by Mines (1986) in the Lingayen Gulf disclosed the dismaying status of the gulf of which the exploitation rate has reached its critical point. This report triggered concerned agencies to save the gulf. Silvestre et al. (1991) outlined several measures to save Lingayen Gulf. Coastal Resource Management (CRM) is one of the

Figure 1. **Geographic location of the four coastal barangays in Bolinao, Pangasinan.**

key management strategies.

Bolinao, one of the coastal municipalities of Pangasinan, has experienced the challenges of degrading resources in its coastal areas. With its 23 coastal barangays, most of the residents depend on coastal resources for living. To maintain these valuable resources, the local people in Bolinao have taken the initiative to conserve their resources through the coastal resource management programs like the establishment of marine fish sanctuary and mangrove management areas. This kind of intervention started in 1998 and has been adopted by some of the coastal barangays of the municipality. Through the years, they have managed to slowly deal with the problems on the degradation of their coastal resources hoping to revive and save these resources and their biodiversity. This study was aimed to assess the diversity of mangroves, fish and other economically important aquatic species and to determine the physical, chemical, and biological characteristics of the mangrove management areas in Arnedo, Balingasay, Victory and Binabailan, Bolinao, Pangasinan in order to evaluate the conditions of these mangrove areas.

.

METHODOLOGY

Data Gathering

This study was conducted in the four coastal barangays of Bolinao Pangasinan from November to December 2009: Arnedo, Balingasay,

Binabalian and Victory (Figure 1)—areas identified to have active coastal resource management programs. In these areas, mangrove ecosystems were managed by the local communities and other stakeholders. The data on mangrove management programs and activities in the four coastal barangays were gathered by means of an interview with the Municipal Agricultural Officer of Bolinao, Pangasinan.

Mangrove Fisheries

Three sampling stations were established in the mangrove area with a total area of 1500 m2 per barangay. A random sampling of different species of mangrove, fish and other economically important species in each station was done using the quadrat method. Ten quadrats were laid in each station measuring 10m by 5 m. Mangrove species were identified and counted for every quadrat. Fish and invertebrates present in the mangrove area were assessed using two kinds of gear: a gill net and cover pot. The gill net with a panel length of 10 m and depth of 1 m were set along the mangrove fringe within the quadrats for two hours on a falling tide in such a way that the flowing water did not escape outside the limit of the net. The nets were hauled after two hours. Likewise, the cover pots were used as supplemental gear to catch those fishes and invertebrates trapped in the mangroves. The cover pots were used during low tide to facilitate the catch. For gill net, entangled fishes and invertebrates were disentangled and their pictures were taken for identification. Species were identified based on the works of Munro (1967), Conlu (1986), Fishbase (2010) and Matsuda and Kaneda (1984). The number of individuals per species was recorded.

Mangrove Community Structure

The mangrove community structure was determined in the four coastal barangays of Bolinao such as Arnedo, Balingasay, Binabalian and Victory. For each species, the following parameters were determined (Smith & Smith, 1998 as cited by Paz-Alberto, 2005): [1] Number of individual species in each quadrat; [2] Frequency (F); [3] Relative frequency (RF); [4] Density (D); [5] Relative Density (RD); [6] Dominance (Do); and [7] Relative Dominance (RDo). Importance Value Index (IVI) was also measured and computed for each mangrove ecosystem in four barangays and the formula used is: Relative

Frequency (RF) + Relative Density(RD) + Relative Dominance(RDo). The species diversity of the mangroves and fish and invertebrates was determined and computed using the Shannon Diversity Index formula (Smith & Smith, 1998):

$$H` = -\sum_{i=1}^{S} pí \ln (pí)$$

where H`= Shannon Index of Diversity
pí = Proportion of species from the total species
ln = Naperian logarithm or natural logarithm
S = Total number of species

Water Sampling and Analysis

Two sampling stations from each of the four coastal barangays in Bolinao were selected. Two stations from the mangrove management areas were identified. The physical, chemical, and bacteriological characteristics of the coastal water within the sampling sites were determined.

Physical Parameters

In situ analysis of physical parameters was done. Temperature was analyzed using a portable laboratory mercury thermometer. This was submerged immediately below the water surface for 5 minutes. Reading was done while the thermometer was in the water to avoid inaccuracy during temperature reading. This was done three times per station at varying depths within the coastal area.

Light penetration was determined by using a graduated secchi disk. This secchi disk was lowered into the water until the black and white colors of the disk were not clearly noticeable. The water mark on the string was noted and recorded for the depth. The process was repeated and the average of the two readings was computed to get the measure of sunlight pevetration.

The pH of the water samples from every sampling station was taken by using a digital pen-type pH meter. In measuring the salinity, a drop of water sample was taken in the sampling site and placed into the glass mount of the refracto-salinometer.

Chemical Analysis

The pH and salinity were analyzed in situ. The pH of the water samples from every sampling station was taken by using a digital pen-type pH meter. A sample was taken and placed in a beaker then the pH meter was dipped until the probe mark. When the readings appeared on the pH meter screen, and it was stabilized, this reading was recorded as pH measurement.

In measuring the salinity, a drop of water sample was taken in the sampling site and placed into the glass mount of the refracto-salinometer. The salinity reading was based on the blue level mark of the screen of the said device and expressed in parts per thousand (ppt). The glass mount was cleaned with distilled water for every sampling made.

The water sample was collected from each sampling station for the analysis of ammonia, nitrite, phosphate, and total suspended soil solids (TSS) including the bacteriological analysis for the total fecal colifrom. Water samples for laboratory analysis were collected at 4 to 5 feet depth from the four sampling stations during daytime. Sterilized bottles were dipped 6 inches below the surface of the water. The bottles were held by the hand near the base and plunged, neck downward from the middle of the surface water then turned them until the neck pointed slightly upward against the water flow. These bottles were labeled according to the station where these were collected. These were put into a cooler with ice to maintain the temperature of 4°C while being transported to the laboratory. The samples were examined within 24-hours period after they were taken from the site.

Two hundred milliliters of water sample was collected for each sampling station between 9:00 AM to 10:00AM for the analysis of ammonia, nitrite, phosphate and total suspended solids (TSS) including the bacteriological analysis for total and fecal coliform. Laboratory analysis for composite water samples was done in the BFAR-NIFTDC Limnological Laboratory in Dagupan City.

Gathered data on water quality were tabulated and analyzed using their mean/average. These were compared to the standards set by the Department of Environment and Natural Resources (DENR) and Association of Southeast Asian Nation (ASEAN) for marine water.

RESULTS AND DISCUSSION

Mangrove Management Programs

The municipality of Bolinao has established several programs and projects in order to manage its coastal resources. Some of these can be found in Barangay Arnedo, Balingasay, Binabalian and Victory where marine areas are protected and mangroves are managed by the LGU and NGO's or people's organizations (Table 1).

Table 1.

Mangrove Management Programs in Arnedo, Balingasay, Binabalian and Victory Bolinao, Pangasinan

Programs	Activities	In-charge in Management
Mangrove Planting and Management	- Mangrove planting	LGU
	- Coastal clean-up	KAISAKA Federation
	- Nursery development and management	SAPA
	- Replenishment and planting	SAMMABAL
	- Monitoring and evaluation	SAMMABI
	- Patrolling and protection	SMMV

Community-based mangrove conservation projects were observed in all four barangays. Mangrove management area in Arnedo is 8.65 hectares which started in 2004 whereas the management of 8.8 hectares in Binabalian commenced in 2004. The widest of the four is the 15 has. in Victory which started in 1999. Meanwhile, conservation of the mangrove area is naturally occurring along Balingasay (Figure 2.)

Marine protected areas and mangrove management areas in these barangays were part of the coastal resource management programs implemented by the Local Government Units (LGUs). These were established to bring back the integrity of the coastal resources which were degraded since the Lingayen Gulf was declared to be an environmentally critical area. The marine protected areas were established to be a "no take" zone where fishing and other activities are prohibited to ensure the freedom of the species to replenish in the area.

Figure 2. **Marine protected areas and mangrove management areas in Bolinao, Pangasinan.**

Regular consultations with the community and information campaigns were being done to ensure the progress of the program. Guarding and patrolling had been included in the activities in the areas in the form of deputizing "bantay dagat."

In the mangrove management areas, different activities were also done to implement the program including nursery development, replenishment and planting of mangroves, coastal clean-up, monitoring and evaluation as well as patrolling and protection. These activities had been supported by the Local Government Units through the leadership of the municipal mayor and his staff in-charge in cooperation with the people's organization. The allotted budget for all the coastal resource management programs for the whole coastal area of Bolinao is PhP 1,105,000 in 2009 and PhP 500,000 in 2010.

All of these programs were launched and managed by the local government units (LGU) in partnership with the People's Organization (PO), the Kaisahan ng mga Samahan Alay sa Kalikasan, Inc. (KAISAKA) federation. Management of these projects is specifically given to the member organizations of the KAISAKA in every barangay. The members are the "Samahang Pangakalikasa ng Arnedo" (SAPA) in Barangay Arnedo, "Samahan ng mga Mangingisda at Mamamayan ng Balingasay" (SAMMABAL) in Barangay Balingasay, "Samahan ng Mangingisda at Mamamayan ng Binabalian" (SAMMABI) in Barangay Binabalian and "Samahan ng Maliliit na Mangingisda ng Victory" (SMMV) in Barangay Victory.

ASSESSMENT OF THE DIVERSITY OF MANGROVE, FISH AND OTHER ECONOMICALLY IMPORTANT AQUATIC SPECIES

Mangrove Identification.

Table 2 shows that 23 species belonging to 14 families can be found in the selected mangrove areas. These are *Rhizophora mucronata, Rhizophora apiculata, Rhizophora stylosa, Bruguiera gymnorhiza, Bruguiera cylindrical,* and *Ceriops tagal* under family Rhizophoraceae, *Avicennia lanata, Sonneratia casoelaris,* and *Avicennia officialis* for family Avicenniaceae, *Nypa fruticans* under Palmae, *Aegiceras floridum* of Myrsinaceae, *Acanthus embractitus* for family Acanthaceae, *Acrostichum aureum* of Pteridaceae, *Sonneratia caseolari* and *Sonneratia alba* of Sonneratiaceae, *Excoecaria agallocha* under Euphorbiaceae, *Barringtonia asiatica* for family Barringtoniaceae, *Heritiera littoralis* of Malvaceae, *Terminalia catappa* for family Combretaceae, *Xylucarpus granatu* and *Xylucarpus molluccensis* under Meliaceae, *Dolichandrone spathaceae* for Bignoniaceae, *Pongamia pinna* and *Derris trifoliata* for Fabacceae. Seven mangrove species were observed in Arnedo, 21 magrove species were seen in Balingasay, eight mangrove species were found in Binabalian, and only three mangrove species were observed in Victory.

Fish and Invertebrates Within the Mangrove Management Areas

There were four species of fish and 14 invertebrates belonging to 16 families identified from the four selected mangrove management areas (Table 3). These are *Trachycardium orbita* (Carditidae), *Terebralia polustris* (Potamidae), *Periglypta reticulata* (Veniridae),*Tectarus pagodas* (Litiorinidae), *Murex aduncuspinosus* (Muricidae), *Strombus labiatus* (Strombidae), *Pinctada radiata* (Pteroidae), *Atlantahelicimoides* (Atlantidae), *Placuna placenta* (Anomiidae), *Liza argentea* (Mugilidae), *Periopthalmus barbarous* (Oxudercinae), *Siganus canaliculatus*, *Siganus javus* (Siganidae), *Alpheus* spp., *Nenalpheus* spp. (Alpheidae), *Percnon plannissimum* (Grapsidae), *Polinces aurontius* (Naticidae), and *Cypraea maculifera* (Cepraeidae). Fourteen of these species were found in Arnedo, 17 in Balingasay, nine in Binabalian, and 11 in Victory. With the increase or improvement of habitat, different species could have found their way to find shelter. With existence of these mangrove areas, different species were also observed to be thriving. The species now found in the mangrove management areas indicate the benefits gained from the management of marine habitats.

Table 2.

Mangrove species identified at the mangrove management areas of four coastal areas of Bolinao, Pangasinan

Family	Scientific Name	Common Name	Arnedo	Balingasay	Binabalian	Victory
Rhizophoraceae	*Rhizophora mucronata* Lam	Bakawan babae	X	X	X	X
	Rhizophora apiculata Blume	Bakawan lalaki	X	X	X	X
	Rhizophora stylosa Griff	Bakawan bato		X	X	
	Bruguiera gymnorhiza	Busain		X		
	Ceriops tagal (Perr.) C.B. Rob	Tangal		X		
	Bruguiera cylindrical (L.) Blume	Pototan	X			X
Avicenniaceae	*Avicennia lanata*	Bungalon	X	X	X	X
	Avicennia officinalis L.	Api-api		X		
Palmae	*Nypa fruticans* Wurmb	Nipa	X	X	X	
Myrsinaceae	*Aegiceras floridum* Roem. and Schult.	Saging saging	X		X	
Acanthacaeae	*Acanthus embractitus*	Diliuatiao		X		
Pteridaceae	*Acrostichum aureum* L.i	Lagolo		X		
Sonneratiaceae	*Sonneratia caseolaris*	Pagatpat	X	X	X	
	Sonneratia alba	Pedada		X		
Euphorbiaceae	*Excoecaria agallocha*	Buta buta		X		
Barringtoniaceae	*Barringtonia asiatica*	Botong		X		
Malvaceae	*Heritiera littoralis*	Dungon-late		X		
Combretaceae	*Terminalia catappa*	Talisay		X		
Meliaceae	*Xylucarpus granatum*	Tabigi		X		
	Xylucarpus molluccensis	Piagau		X		
Bignoniaceae	*Dolichandrone spathaceae*	Tui		X		
Fabacceae	*Pongamia pinnata*	Bani		X		
	Derris trifoliata	Tuble		X		

Table 3.

Fish and other invertebrates within the mangrove management areas of four coastal areas of Bolinao, Pangasinan

Family	Scientific Name	Common Name		Arnedo	Balingasay	Binabalian	Victory
		English Name	Local Name				
FISH							
Mugilidae	*Liza argentea* (Quoy and Gaimard, 1825)	Flattail mullet	Burasi	X	X	X	•
Gobiidae	*Periopthalmus barbarus* (Linnaeus, 1766)	Mud skipper	Bannasak	X	X	X	X
Siganidae	*Siganus canaliculatus* (Park, 1797)	Siganid/white-spotted spine foot	Baraangan		X		
	Siganus javus (Linnaeus, 1766)	Streak spine foot	Malaga		X		X
INVERTEBRATES							
Carditidae	*Trachycardium orbita*	Cardila clam	Giritan	X	X	X	X
Potamidae	*Terebralia polustris*	Mud creeper	Bangar	X	X	X	X
Veniridae	*Periglypta reticulata* (L., 1758)	Venus shell	Piwisan	X	X	X	X
Litiorinidae	*Tectarus pagodas*	Periwinkle	Trokos	X	X		X
Muricidae	*Murex aduncuspinosus*	Murex	Hermet shell	X	X		X
Strombidae	*Strombus labiatus* (Roding, 1798)	Plicate conch	Kumukusay	X	X	X	X
Pteroidae	*Pinctada radiate* (Leach, 1814)	Pearl oyster	Talaba	X	X	X	
Atlantidae	*Atlanta helicimoides*		Sobol	X	X		X
Anomiidae	*Placuna placenta* Linnaeus, 1758)	Window-pane oyster	Kampis	X	X	X	
Alpheidae	*Alpheus sp.*						
	Nenalpheus sp.	Shrimp	Hipon	X	X		
Grapsidae	*Percnon plannissimum*	Shore crab	Crab	X	X		
Naticidae	*Polinces aurontius*	Moon shell	Balabalatong	X	X	X	X
Cepraeidae	*Cypraea maculifera* Schilder, 1932	Shell			X		

X—species present

Table 4.

Importance Value Index of mangrove species in Balingasay, Bolinao, Pangasinan

Species	Importance Value Index			
	Arnedo	**Balingasay**	**Binabalian**	**Victory**
Rhizophora mucronata	41.34	26.42	47.34	84.13
Rhizophora apiculata	40.49	1.70	36.42	101.97
Rhizophora stylosa		2.89	18.30	
Bruguiera gymnorhiza		15.13		
Bruguiera cylindrica	25.40		28.73	
Ceriops tagal		3.29		
Avicenia lanata	35.19	4.86	23.50	14.90
Avicenia officialis		13.03		
Nypa fruticans	18.60	53.03	17.83	
Acanthus embractitus		5.36		
Acrostichum aureum		2.00		
Aegiceras floridum	18.10		9.87	
Sonneratia caseolaris	21.89	15.47	18.99	
Sonneratia alba		16.73		
Excoecaria agallocha		6.79		
Barringtonia asiatica		0.11		
Heritiera littiratis		3.12		
Terminalia catappa		3.83		
Xylucarpus granatum		6.62		
Xylucarpus molluccensis		9.31		
Dolichandrone spathaceae		8.28		
Pongamia pinnata		2.50		
Derris trifoliata		0.51		

Mangrove Management Areas

Seven species were found within the sampling area in Arnedo, Bolinao, Pangasinan (Table 4). The most dense, most frequent, most dominant, and most important mangrove species are Rhizophora species having importance value indices of 41.34% (*Rhizophora mucronata*) and 40.49% (*Rhizophora apiculata*). There were 21 species found in the mangrove area of Balingasay. Nypa fruticans has the highest importance value index of 53.03% followed by *Rhizophora mucronata* with 26.42%.

However, eight species were identified in Binabalian where the Rhizophora species dominated having the highest importance

Table 5.

Importance Value Index of fish and invertebrates in the mangrove areas of Arnedo, Bolinao, Pangasinan

Species	Arnedo	Balingasay	Binabalian	Victory
FISH				
Liza argentea	13.08	7.91	16.95	4.27
Periopthalmus barbarus	11.71	6.78		10.27
Siganus canaliculatus		7.91	14.63	
Siganus javus		6.85		10.42
INVERTEBRATES				
Terebralia polustris	50.98	36.05	70.77	45.88
Polinces aurontius	63.74	68.15	46.67	35.88
Trachycardium orbita	19.87	13.35	26.76	46.41
Periglypta reticulata	17.60	12.50	23.43	30.29
Murex aduncuspinosus	3.03	4.45		6.14
Atlanta helicimoides	0.88	3.18		1.38
Strombus labiatus	0.51	4.33	0.63	6.38
Placuna placenta	0.47	3.37	0.60	
Tectarus pagodus	0.43	4.47		3.69
Pinctada radiata	0.43	3.78	0.56	
Alpheus sp.	13.08			
Nenalpheus sp.		7.18		
Percnon plannissimum	5.19	6.59		
Cyprea maculifera		4.15		

value index of 47.34% for *Rhizophora mucronata*. This was followed by *Rhizophora apiculata* (36.42%). Table 4 also shows that in Victory, only three species were identified thriving in the area. *Rhizophora apiculata* showed the highest importance value index of 101.97%.

Fish and Invertebrates in the Mangrove Management Areas

Four species of fish and 14 species of invertebrates are present in the mangrove areas of Arnedo (Table 5). *Polinces aurontius* had the highest importance value index of 63.74%. This is followed by *Terebralia polustris* with an importance value index of 50.98%.

The mangrove areas of Balingasay, Bolinao, Pangasinan is dominated by *Polinces aurontius* also which got the highest importance value index (68.15%). This is followed by *Terebralia polustris* (36.05%) and *Trachycardium orbita* (13.35%).

Also reflected is that the mangrove areas of Binabalian, Bolinao,

Pangasinan is dominated by *Terebralia polustris* and *Polinces aurontius* (Table 5). These have importance value indices of 70.77% and 46.67%, respectively. These species covered almost every area of the mangroves that is why even in the presence of seven other species, diversity was only 0.030. Their importance value indices were 46.41%, 45.88 and 35.88%, respectively. Meanwhile, in Victory, *Trachycardium orbita*, *Terebralia polustris,* and *Polinces aurontius* are the most abundant species (Table 5).

Diversity in the Mangrove Management Areas

The diversity index values of mangroves, fish, and other invertebrates observed in the four coastal barangays (Table 6) were very low. This is because only a few species dominated the areas and the rest of the species had few numbers of individuals.

THE PHYSICO-CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF THE COASTAL WATERS

Physical Parameters

In the mangrove management areas, the temperature values ranged from 27.5°C (Balingasay) to 29.9°C (Victory) (Table 7). In terms of turbidity, the values were lower ranging from 0.5 m (Victory) to 0.8 m (Arnedo). Likewise, the water depth ranged from 0.5 m (Victory) to 1.0 m (Balingasay). The temperature values in the mangrove areas were within the standard value set by the DENR (Table 2). In terms of turbidity and water depth, although the values were surprisingly lower, these are still allowable since the sampled areas are mangroves thriving in shallow portions of the water.

In the mangrove areas, the chemical characteristics were monitored showing surprising identical salinity values in the four stations at 35 ppt (Table 8). The DO concentrations ranged from 6.51 mg/l (Arnedo) to 8.32 mg/l (Victory). The pH values varied from 7.8 (Balingasay) to 8.44 (Binabalian) while the TSS differed from 4.19 mg/l (Balingasay) to 69.88 mg/l (Binabalian). The phosphate values taken fluctuated from 0.010 ppm (Balingasay) to 0.043 ppm (Binabalian). The nitrogen components; ammonia and nitrite, ranged from 0.015 ppm (Balingasay) to 0.031 ppm (Victory) and 0.031 ppm (Binabalian) to 0.048 ppm (Arnedo), respectively. The values of each chemical

Table 6.

Diversity Index Values of mangrove, fish, and other invertebrate species in four coastal barangays in Bolinao, Pangasinan

Barangay	Number of Individuals in 1500 m^2		Number of Species		Diversity Index Values	
	Mangrove	Fish and Invertebrates	Mangrove	Fish and Invertebrates	Mangrove	Fish and Invertebrates
Arnedo	3,704	132,125	7	14	1.74	1.08
Balingasay	3,795	111,228	21	17	2.09	1.09
Binabalian	3,100	87,933	8	9	1.77	1.13
Victory	2,108	41,423	3	11	0.71	1.43

Table 7.

Physical characteristics in four Mangrove Management Areas (MMA) of Bolinao, Pangasinan.

Station	Temperature (°C)		Turbidity (M)		Average Depth	
	Mean	SD	Mean	SD	Mean	SD
Arnedo	28.00	0.50	0.80	0.10	0.80	0.10
Balingasay	27.50	0.20	1.00	0.20	1.00	0.20
Binabalian	27.90	0.10	0.70	0.05	0.70	0.05
Victory	28.9	0.40	0.50	0.10	0.50	0.14
Mean	**28.07**	**0.59**	**0.75**	**0.20**	**0.77**	**0.17**
DENR Standard (SA)	**26-30**		**>100**		**> 3**	

Table 8.

Chemical characteristics in four Mangrove Management Areas of Bolinao, Pangasinan

	Salinity	**D.O.** (Mg/L)	**pH**	**Tss** (PPM)	**Phosphate** (PPM)	**Ammonia** (PPM)	**Nitrite** (PPM)
Arnedo	35	6.51	8.34	52.42	0.011	0.023	0.048
Balingasay	35	7.28	7.80	4.19	0.010	0.015	0.034
Binabalian	35	7.95	8.44	69.88	0.043	0.029	0.031
Victory	35	8.32	8.40	30.45	0.025	0.031	0.039
Mean	35	7.52	8.24	39.24	0.022	0.024	0.038
SD	0	0.79	0.30	28.39	0.015	0.007	0.007
DENR Standard (SC)		5	6.5-8.5	80	0.5	< 1	1.00
ASEAN criteria		5	6-8.5	50	0.48	0.5	0.395

Table 9.

Bacteriological characteristics in four Mangrove Management Areas (MMA) of Bolinao, Pangasinan

	Total Coliform (MPN/100 ML)	**Fecal Coliform** (MPN/100 ML)
Arnedo	> 1,100	53
Balingasay	> 1,100	290
Binabalian	> 1,100	23
Victory	> 1,100	0
DENR Standard (SA)	1,000	200
ASEAN Criteria	1,000	200

parameter taken from the four stations were within the criteria values set by DENR and ASEAN (Table 3).

Bacteriological Characteristics

The bacteriological characteristics in all the mangrove areas (Table 4) indicate that the total coliform concentration was similar in all four stations at ≥ 1,100 MPN. With regard to fecal coliform, the highest concentration was obtained in Barangay Balingasay at 290 MPN. Only Barangay Victory had no fecal coliform. Unfortunately, no mangrove area met the standard set by DENR and ASEAN for total coliform (Table 9). In terms of fecal coliform, three stations passed the criteria set by DENR and ASEAN. Barangay Balingasay failed to meet the criteria.

DISCUSSION

The Philippines is an example of a tropical country where significant mangrove forest areas have been lost and degraded. Forested mangroves have been reduced from about 450,000 ha in 1920 to only about 120,000 ha. in the late 1990s. The most common reason for the reduction of mangrove areas in the Philippines has been the conversion of these coastal mangrove areas to fishponds for aquaculture purposes. This situation has prompted the Philippine government to attempt mangrove reforestation of abandoned fishponds and other previously occupied mangroves with the assistance of development projects and new policies .The municipality of Bolinao has a total mangrove forest stand of 93.4 hectares, out of which 70.63 is natural and 22.77 hectares are established plantations.

Rhizophora species were found to have the highest in importance value index because these species survive in the characteristics of the environment in Arnedo. Diversity of mangroves in Arnedo is quite low, although this is the area where the mangrove nursery of the Office of the Provincial Agriculturist is situated because almost all the newly planted mangroves were washed out during the Typhoon "EMONG" in May, 2009.

Balingasay is the area where majority of the mangroves are naturally occurring and are preserved. Only a small part is planted, that is why there were many species found during the survey. These were dominated by *Nypa fruticans* and *Rhizophora mucronata* which

were observed to be suited and easy to grow and they reproduce and survive in the area. Among the four study areas, Barangay Balingasay has the most diverse species. Twenty-one species were identified to thrive in the area. However, in Binabalian and Victory the management areas were mostly affected by typhoon 'Emong", that is why only a few species were found to survive in the mangrove areas. Most of the species found were planted and are only a few years old.

Overall, *Rhizophora mucronata* is the most dominant and densest species in each area. However, Balingasay had *Nypa fruticans* as the densest and most dominant among the species. In terms of diversity, Balingasay had the most diverse species of mangroves compared to the other areas. This can be attributed to the area having naturally occurring species and having mangrove trees which are already old and sturdy. Thus, the effect of environmental disturbances is minimal in the survival of the species.

According to the people's organization, the natural regeneration potential of mangrove areas in Bolinao is high with two seedlings per square meter. This is attributed to the muddy substrate and sheltered areas where natural mangrove stands of the municipality are mostly growing. However, a large track of degraded mangrove areas remains open and needs rehabilitation to improve the condition of the mangrove resources in the municipality. Planted mangroves need total management and surveillance to ensure their survival. To date, many of the mangroves planted were destroyed during the typhoon "Emong." Few survived after the typhoon particularly in Arnedo and Victory where the mangroves planted are still in their recovery stage; many were washed out. This was why during the survey, the densities of the species in the area were quite low, and despite the many planting activities undertaken. Balingasay and Binabalian were also affected by the typhoon although this was minimal. Also, majority of their mangroves are naturally occurring and are on their adult stage and planted areas are only a small portion. A positive feature for mangrove ecosystem management is that mangrove forests are relatively easy to restore through natural regeneration, or via artificial restoration using planted seedlings. That is why Rhizophora species are the major species planted in the area because it can survive easily and grow faster in the areas. Duke (1983) reported that this is the only Malayan mangrove which can survive daily inundation. On the other hand, *Nypa fruticans* was found to dominate in Balingasay because of its muddy characteristics. Little (1983) described this species as the one most likely to be found in deep soft mud.

Overall, 18 species of fish and invertebrates were found within the mangrove areas of Arnedo, Balingasay, Binabalian and Victory. Of these species, three were found to be of relative abundance in the areas. These are *Polinces aurontius, Trachycardium orbita,* and *Terebralia polustris* and were found to be of great number in the area. *Polinces aurontius* were documented in thousands being scattered around and can be seen clinging within the small mangroves. However, it cannot be eaten although it is used as a material for different accessories. *Trachycardium orbita* and *Terebralia polustris* also appearing in great number are the two species which can be eaten. Even with the dominance of these three species, the diversity of the species in the area is still very low. The other species exist only in small number, because a crucial aspect of biodiversity for mangrove management is that many species use the mangrove forest ecosystem only part of the time (e.g. fish, birds, crustaceans, shellfish). Moreover, diversity of species in the mangrove management areas is very low due to the conversion of mangrove ecosystems to fishponds and the strong typhoons which affected the coastal areas. The continuous illegal fishing within the municipal waters of Bolinao, Pangasinan has resulted in the rapid depletion of fish stocks and the destruction of the coastal and marine resources. These could also be the reasons for the low diversity of organisms in the mangrove management areas as well as the low catch and poverty in the area. This was also the problem of the whole Lingayen Gulf as stated by White and Cruz-Trinidad (2000).

The temperature readings taken from the mangrove management areas of the four barangays of Bolinao, Pangasinan were within the optimum level for tropical fishes from 27.5-28.9^{o}C (DENR, 1997, 2001). The turbidity of the water may be influenced by the water depth. The shallower the water is, the more likely the water would be turbid because the bottom friction is higher than the deeper water (Reid, 1983). Also, the variation of water depth in the study areas can be attributed to location or sampling station. In the mangrove areas, the little variation on the temperature readings in the four stations maybe linked to water depth of the sampling stations. Mangroves are found along the coastal margins and river banks where water is shallow (Reid, 1983). The identical values of turbidity and water depth could have been caused by the physical structure of the mangroves. Mangroves are regarded as buffer zone receiving more wave impact from the ocean and runoff from the inland causing more agitation and resulting in higher turbidity (Reid, 1983).

The higher salinity values in the mangrove areas might be attributed to the location of the mangroves. The mangroves are situated along the coastal margins of Bolinao, Pangasinan and exposed to the sea. The shallow characteristics of the mangrove contribute to fast evaporation thereby increasing salinity (Reid, 1983).

Mangroves exposure to the sea might have caused the water pH slightly alkaline. Likewise, the constant agitation could have increased the TSS concentrations of the mangroves. Since mangroves are productive ecosystems (Nybakken, 1992), the TSS levels may increase due to presence of diverse organisms.

However, the phosphate, ammonia and nitrite concentrations were within the desirable range set by the standards of DENR and ASEAN on marine waters. Results indicated that there was a great improvement in the water quality of Bolinao as compared to the previous studies conducted by Azanza et al. (2006) which revealed that the nutrient concentration in Bolinao waters had been increasing which had been attributed to the increase in fish pens and fish cages. However, significant decrease in nitrate and nitrite had been observed between 2002 and 2003 which was parallel to the decrease in fish pens and fish cages due to a massive milkfish kill. On the other hand, ammonia, a more reduced form of nitrogen was higher in 2003 which implicates a low oxygenated environment that favors its formation that can be contributed to continued build up of decomposing products (fish feeds) and other organic materials. In addition Azanza et al. (2005) also reported that the death of milkfish was clearly the result of lack of oxygen mostly from the collapse of the algal bloom. The optimal level of dissolved oxygen is about 5 mg/l for milkfish growth in tropical waters. The observed dissolved oxygen during the fish kill was 2.1 mg/l in 2002 (Azanza et al. 2005).

According to Fortez and Paningit (2009), the uncontrolled milkfish culture such as the high feeding input and the proliferation of fish cages and pens have contributed to the deterioration of the water quality of Bolinao coastal areas. The number of fish pen and cage structures in the area increased from 242 in 1995 to 1170 in 2001, contributing to the nutrient enrichment in the area. The nutrient enrichment leads to the excessive growth of algae at the water surface and the onset of hypoxic and anoxic conditions in the bottom water. As a consequence of the depletion of dissolved oxygen, a massive milkfish kill took place, incurring a loss of approximately P500 million in 2002. Another fish kill incident happened again in the area in June 2007. This study corroborates the study conducted by McGlone et al.

(2008) which reported that the most significant effect of the major fish kill event in 2002 coincided with the first reported Philippine bloom of a dinoflagellate *Prorocentrum minimum*. Days before the bloom, dissolved oxygen was < 2.0 mg/l in the waters that were stratified. These conditions may be linked to the uncontrolled proliferation of fish pens and cages to more than double the allowable limit of 544 units for Bolinao waters. Mariculture activities release organic matter from unconsumed feed and fecal material that accumulate in the water and sediments. In over 10 years, water quality conditions have become eutrophic with ammonia increasing by 56%, nitrite by 35%, nitrate by 90%, and phosphate by 67%. The addition of more fish pens and cages placed additional stress to this poorly flushed, shallow area that affected water quality due to changes in the water residence time.

However, results of the analysis of chemical characteristics of water particularly the DO concentrations, phosphate, ammonia and nitrite in Bolinao waters in this study revealed an enhanced water quality, passing the limit set by DENR and ASEAN for marine water. The constant wave impact and phytoplankton/algae abundance might have contributed to the high DO levels. The improved water quality may be attributed to the coastal resource management programs being implemented in the four coastal barangays such as coastal cleanup, mangrove planting, protection, monitoring and evaluation of the coastal resources by the local government agencies, NGOs, and people's organizations.

The higher total coliform concentrations in all the mangrove areas can be attributed to its proximity to land being on the coastal margins. Its proximity is tantamount to receiving first the domestic wastes. This scenario might have aggravated the situation in barangay Balingasay having exceeded the fecal coliform count set by DENR and ASEAN. The extreme value may have been caused by human population in the area. The lack of sanitary toilets may have influenced people in the area to use the mangroves as their "toilets." Likewise, the lower fecal coliform counts in the three mangrove areas could be attributed to the management interventions of people's organizations.

CONCLUSION

Barangays Arnedo, Balingasay, Binabalian, and Victory in Bolinao, Pangasinan had established mangrove management areas and other conservation activities such as mangrove planting, coastal clean-up

and patrolling and protection activities in order to manage its coastal resources. Based on the assessment made, 23 species of mangroves, four species of fish and 14 invertebrates were identified in the selected mangrove areas. The diversity of species in the mangrove areas in the four coastal barangays are still very low. This is attributed to the conversion of mangrove ecosystems to fishponds and strong typhoons which affected the coastal areas. The physico-chemical characteristics of the mangrove management areas are within the desirable range set by the standards of the DENR and ASEAN on marine water which is extremely better and enhanced the water quality compared with the water quality three-five years ago (Azanza et al.,2005; Azanza, 2006; Fortez & Paningit, 2009; McGlone et al., 2008) due to the management activities conducted in the areas. However, all the mangrove ecosystems obtained high total coliform and Barangay Balingasay got also high fecal coliform which are attributed to domestic wastes present in the four coastal barangays.

RECOMMENDATIONS

1. Regular biodiversity assessment and monitoring should be done in the mangrove ecosystems in order to determine the success of the management initiatives in the mangrove areas.
2. Information, communication, and education on the management of mangrove areas should be strengthened by the local government particularly by the ICRM department, and the people's organization should also heighten public awareness and encourage community involvement and participation in the management of mangrove areas.
3. A long-term participatory research should be conducted by the local government units and cooperating research institutions particularly in the academe and other national research institutions such as DENR and BFAR should strengthen, improve, and develop further mangrove management programs and activities.
4. Water quality monitoring should be done not only in the mangrove management areas but also in the nearby milkfish cage culture areas in order to further improve the quality of marine water in the coastal ecosysytems.

REFERENCES

Azanza, M. P.V., Azanza R. V., Vargas, V. M. D., & Hedreyda, C. T. (2006). Bacterial endosymbiotics of Pyrodinium bahamense var compressum. *Microbial Ecology, 52* (4), 756-764.

Azanza, R. V., Fukuyo Y., Yap, L. G., & Takayama, H. (2005). Prorocentum minimum blooms and its possible link to a marine fish kill in Bolinao, Pangasinan, Northern Philippines. *Harmful Algae, 4*(3), 519-524.

Bureau of Fisheries and Aquatic Resources (BFAR). (1996). *Philippine Profile*. Manila, Philippines: Department of Agriculture-Bureau of Fisheries and Aquatic Resources.

Conlu, P.V. (1986). Guide to flora and fauna. Fishes. Vol. IX NRMC. Quezon City: Ministry of Natural Resources and UP Diliman.

DENR, DA-BFAR, DILG, CRMP (Department of Environment and Natural Resources, Department of Agriculture—Bureau of Fisheries and Aquatic Resources, Department of Interior and Local Government and Costal Resource Management Project) (1997). *Legal jurisdiction guidebook for coastal resource management in the Philippines*. Coastal Resource Management Project, Cebu City, Philippines.

DENR, DA-BFAR, DILG, CRMP (Department of Environment and Natural Resources, Department of agriculture—Bureau of Fisheries and Aquatic Resources, Department of Interior and Local Government and Costal Resource Management Project)(2001). Coastal Management Orientation and Overview. *Guidebook for Philippine coastal management*. Coastal Resource Management Project, Cebu City, Philippines.

Duke, J. A. 1983. *Handbook of energy crops*. Retrieved from www.host.purdue.edu/newcrop/duke_ energy /Rhizophora_mucronata.html

Fortes, M. & Paningit, E. C. (2009). Integrating support system for managing environmental change and human impacts on tropical ecosystems in East Asia and the Pacific (Final Report for APN Project: ARC 2007-03CMY). Marine Science Institute, University of the Philippines, Tokyo Institute of Technology, Japan, Research Institute of Subtropics, University of the South Pacific, Fuji Islands, Water Resources Division, Samoa and College of Marshall Islands, Marshall Islands.

Froese, R. & Pauly, D. (Eds.). FISHBASE 2010. Retrieved from www.fishbase.org

Little, E.L. Jr. (1983). *Common fuelwood crops: A handbook for the identification*. Parsons, WV: McClain Printing.

Matsuda, Y. & Kaneda, Y. (1984). The seven greatest fisheries incidents in Japan. In K. Ruddle & T. Akimichi (Eds.)., *Maritime Institutions in the Western Pacific* (pp. 159-182). Osaka: National Museum of Ethnology.

McGlone, M.L.S., Azanza, R., Villanoy, C. L., & Jacinto, G.(2008). Eutrophic waters, algal bloom and fish kill in fish farming areas in Bolinao, Pangasinan, Philipiines. *Marine Pollution Bulletin, 57* (6-12), 295-301.

McManus, L.T. & Chua, T.E. (Eds.). (1990). The coastal environmental profile of Lingayen Gulf, Philippines. *ICLARM Tech.Rep., (22)*, 69.

Mines, A. (1986). An assessment of the fisheries of Lingayen Gulf. PCARRD/NSTA Project, 26 p. College of Fisheries, University of the Philippines, Marine Science Institute, Diliman, Quezon City.

Munro, J.L. & Bell, J. D. (1997). Enhancement for Marine Fisheries Resources. *Rev. Fish. Sci., 5*(2), 185-222.

Nybakken, J.W. (1992). *Marine biology: An ecological approach*. New York: Harper and Row.

Paz-Alberto, A.M.P. (2005). *Biodiversity*. Science City of Munoz, Nueva Ecija: Environmental Management Institute, Central Luzon State University.

Reid, G.D. (1983). *Ecology of inland waters and estuaries.* New York: D. Vand Nostrand.

Silvestre, G., Armanda, N., & Cinco, E. (1991). Assessment of the capture fisheries of Lingayen Gulf, Philippines. *ICLARM Conf. Proc., (22),* 25-36.

Smith, R.L. & Smith, T.M. (2000). *Elements of ecology.* CA: Addison Wesley Longman, Benjamin/Cummings.

White, A.T. & Cruz-Trinidad, A. (2000). *The values of Philippine coastal resources: Why protection and management are critical*. Coastal Resource Management Project, Cebu City, Philippines.

White, A.T. & Cruz-Trinidad A. (1998). *The values of Philippine coastal resources: Why protection and management are critical*. Coastal Resource Management Project, Cebu City, Philippines.