Assessment of Marine Protected Areas in Four Coastal Barangays of Bolinao, Pangasinan

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This study aimed to assess the diversity of fish and macrophytes present in the marine protected areas (MPAs) in Barangays Balingasay, Arnedo, Victory and Binabalian in Bolinao, Pangasinan, and to determine the physical, chemical and biological characteristics in order to evaluate the present condition in these marine protected areas. The physical and chemical characteristics of the selected coastal areas in Bolinao were found to be of good water quality being within the optimum level set by DENR for marine species to thrive and replenish. The total coliform was high due to the presence of milkfish pens nearby and domestic wastes from residential areas.

Twenty marine fish species were identified from the four marine protected areas: 14 were found in Arnedo, 16 in Balingasay, 5 in Binabalian, and 5 in Victory. Overall four species, namely *Chromis dimidiata, Acanthurus olivaceus, Halichoeres hortulanus,* and *Chlororus microrhinos* registered a high importance value index. The diversity of the marine fish species in the said areas was very low. Only 9 macrophytes were identified—7 seagrasses and 2 seaweeds. Eight macrophytes were found in Barangay Arnedo, 5 in Balingasay, 4 in Binabalian, and 5 in Victory. *Thalassia hemprichii* and *Caulerpa racemosa* had the highest percent cover in almost all of the study areas for macrophytes. The marine protected areas in Bolinao, Pangasinan have low diversity of fish and macrophytes and high total coliform due to anthropogenic activities. The marine protected areas have only recently made a modest start on their way towards the rehabilitation of the coastal resources. Hence, a no take zone is imperative to bring back the integrity of the coastal resources. This would constitute a step towards the attainment of sustainability.

KEYWORDS: Marine protected areas, species diversity, fish, macrophytes, total coliform

INTRODUCTION

The coastal zone—the transition between the land and the sea—is one of the most fragile, complex, and productive ecosystems. It is bestowed with enormous resources, both living and non-living, and constitutes a potential area for the creation and harnessing of non-conventional energy resources (wave and wind energy). This is the zone of dynamic activity, constantly forming itself to maintain equilibrium, under the varying intensity of the natural processes operating in it. It is a region of diverse activities, both complementary and conflicting to each other. However, accelerated and unscientific developmental activities performed in it have induced catastrophic consequences.

Over the past 20 years, coastal areas in the Philippines have come under increasingly severe threat due to human activities. The coastal situation in the Philippines mirrors global trends where unsustainable use of natural resources, pollution and habitat destruction are resulting in a significant if not irreversible loss of the coastal life support system.

Coastal areas in the Philippines are experiencing rapid population growth due, in part, to migration to coastal areas. About 60 percent of the Philippine population lives within the 832 coastal municipalities and 25 coastal cities (DENR et al., 1997). There is also widespread poverty along the coastal areas where fishers are among the poorest of the poor and where declining fisheries productivity due to overharvesting and loss of habitats occurs (Courtney et al., 1999). According to the DENR et al. (1997), environmental damage in the coastal resources is also increasing at an alarming rate due to overfishing, the use of destructive fishing practices, and habitat conversion. Moreover, the increase in population goes hand in hand with land-based activities, industrial and urban development, deforestation and agriculture, which all contribute to the declining productivity in the marine environment. As such, water quality is diminished implying an even greater impact from global climate change on coral reef ecosystems and on the fisheries they support, thereby affecting the status of the coastal resources (DENR et al., 2001).

The Lingayen Gulf is a major area for capture and coastal aquaculture in Northwestern Luzon. Its marine waters are biologically diverse, providing 1.5 percent of the Philippine Fish supply. But like most of the country's coastal waters, Lingayen Gulf is beleaguered by various concerns affecting its resources. Luna (1992) and Luna and Quitos (1992) stated that the ability of Lingayen Gulf to support multiple uses of its coastal resources was critical because of several problems and issues related to resource-use in the gulf's coastal area. Moreover, Silvestre et al. (1991) revealed that the Lingayen Gulf has suffered from excessive fishing pressure since the late 1970s due to biological and economic overfishing. This unwanted scenario was earlier reported by Silvestre (1990), Calud et al. (1996), and Ochavillo et al. (1991) stating that the Lingayen Gulf has been dramatically degraded in terms of its resources.

Several studies were also made by concerned agencies. McManus and Chua (1990) compiled the reports on the coastal environmental profile of the Lingayen Gulf which constituted 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. In response to the threats to the environment and natural resources, the former president of the Philippines Fidel V. Ramos declared the Lingayen Gulf as an environmentally critical area by virtue of Proclamation no. 156 (LGCAMC, 1996).

Bolinao, one of the coastal municipalities in Lingayen Gulf, Pangasinan has experienced the challenges of degrading resources in its coastal areas. The local government unit of Bolinao is continuously working out to fulfill its vision through its coastal resources management programs and projects. These include fisheries registration and licensing (FRC), mangrove planting and management's support to rehabilitation and protection of other habitats and high value species, support to livelihood projects, revitalization of M/BFARMC, mariculture water quality management, and establishment of marine protected areas and management (DENR et al., 2001). Thus, the main aim of this study was to assess the

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

diversity of aquatic species particularly fish and macrophytes present in Barangays Balingasay, Arnedo, Victory and Binabalian in Bolinao, Pangasinan, and to determine the physical, chemical and biological characteristics in order to evaluate the present condition of these marine protected areas.

METHODOLOGY

Data Gathering

This study was conducted in the four coastal barangays of Bolinao, Pangasinan, namely Arnedo, Balingasay, Binabalian and Victory (Figure 1) from November to December 2009. These areas were identified to have an active coastal resource management program centered in Bolinao, Pangasinan, for the past few years. In this location, marine protected areas were established and mangrove ecosystems were managed. The data on marine protected areas management programs and activities in the four coastal barangays were gathered by means of an interview with the Municipal Agricultural Officer of Bolinao, Pangasinan.

Species Diversity

Three sampling stations were established in each of the coastal barangays of Bolinao, Pangasinan. These three sampling stations were established at the coralline areas of the marine protected areas.

The locations of the sampling sites were determined using a GPS (Global Positioning System) device. The economically important aquatic flora and fauna were assessed particularly in terms of the diversity of macrophytes such as sea grasses and seaweeds as well as the diversity of fish in the selected marine protected areas.

Fish, sea grass and seaweeds were sampled using a nondestructive method— snorkeling visual census. A random sampling of different species of fish and other economically important species in each station was done using the quadrat method. Ten quadrats were laid out in each station measuring 10m by 5m. After the quadrat was fully deployed, the divers waited for a minute in order for the fishes that were disturbed by the deployment process to resume normal activity patterns. The divers recorded and counted all fishes which were seen within the quadrat. Fishes that were seen were recorded using underwater writing slates or data sheets. Pictures using an underwater camera were also taken for verification in the identification of the species. Faster swimmers were recorded earlier than slow movers. The species of fish were identified using different references from the local government unit, the fishbase, and the local residents.

Seaweeds and sea grasses were assessed using a transect line and quadrat method. The method described by Saito and Atobe (1970) for the transect-quadrat method was adopted in this study. A transect line measuring 50 meters with a graduation of 1 meter was laid perpendicular to the shore. A quadrat measuring 50 cm x 50 cm which had subdivisions of 25 (5 cm x 5 cm) was used. After the quadrat was placed on the bottom, organisms or substrate type located under each intersection were recorded. The percent cover of the plants was estimated using the 25 cm grid of a quadrat. Each species was scored in the grid according to the method of Saito and Atobe (1970). The depth and the substrate at each interval were recorded to support the analysis of the study. Species were identified based on the works of Munro (1967), Conlu (1986), Fishbase (2010) and Matsuda et al. (1984). The number of individuals per species was recorded.

Macrophyte and Fish Community Structure

The macrophyte and fish community structure were determined in the four coastal barangays of Bolinao such as Arnedo, Balingasay, Binabalian and Victory. Using the quadrat method, data gathered were the following:

1. **Frequency (%)**

$$F = qn/25 \times 100 = qn \times 4$$

where qn is the number of small squares within the quadrat in which an algal and other plant organisms species occurred/appeared.

2. **Percent cover**

The percent cover observer was estimated as the percentage of quadrat area filled by each taxon or substrate type. Quadrats were partitioned into smaller subunits with percent cover being independently estimated for each subunit for accuracy. In general, the smaller the sub-unit, the easier it was to estimate percent cover of included organisms. For convenience, the index numbers 5, 4, 3, 2, and 1 were used for recording data in the field.

Table 1.

Indices and Multiplier Used to Determine the Cover Value.

Indices	Degree of Algal Cover	Multiplier (CN)
5	Covering $^1/_2$ to $^1/_1$ of substratum surface	3.0
4	Covering $^1/_4$ to $^1/_2$	1.5
3	Covering $^1/_8$ to $^1/_4$	0.75
2	Covering $^1/_{16}$ to $^1/_8$	0.375
1	Covering < $^1/_{16}$ of substratum	0.1875

To compute for area in the substrate occupied by the species, percent cover was computed as follows:

$$\text{Percent cover} = (qn5 \times C5) + (qn4 \times C4) + (qn3 \times C3) + (qn2 \times C2) + (qn1 \times C1)$$
$$= (qn5 \times 3) + (qn4 \times 1.5) + \ldots (qn1 \times 0.1875)$$

where qn is the number of small squares in which a species occurred to have corresponding coverage area described in the above table.

3. **Dominance**

The dominance for each macrophyte was computed using this formula:

D = Percent cover of individual species/ total percent cover of all species

Dominant species are those species whose cover values constitute 5 percent or more fraction of the total algal cover while SD (sub-dominant) are those organisms whose cover values, when added to those of dominant, equals 75 percent or more of the total algal cover.

For each species, the following parameters were also determined (Smith & Smith, 1998 as cited by Paz-Alberto, 2005): [1] Number of individual species in each quadrat; [2] Frequency distribution (F); [3] Relative frequency (RF); [4] Density (D); [5] Relative Density (RD); [6] Dominance (Do); [7] Relative Dominance (RDo); [8] Importance Value Index (IVI) = RF + RD +RDo; and [9] Species Diversity. The species diversity of the macrophytes and fish were determined and computed using the Shannon Diversity Index formula (Smith & Smith, 1998):

$$H` = -\sum_{i=1}^{S} p\acute{\iota} \ln (p\acute{\iota})$$

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. These two stations were located in the coralline areas where the marine protected areas were established. 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 are 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 penetration.

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 water reached 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 coliform. 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 the bottles were turned 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 a 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

Coastal Resource 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 NGOs or people's organizations (Table 2).

Barangay Balingasay has 14.77 hectares of marine protected area which was launched in 1998; Victory has 4.8 hectares established in 2002, while Arnedo has 19.47 hectares established in 2004. The newest of the four study areas is the 10.8 hectares in Binabalian which started in 2006 (Figure 2).

Table 2.

Coastal Resource Management Programs in Barangays Arnedo, Balingasay, Binabalian and Victory in Bolinao, Pangasinan.

Programs	Activities	In-Charge For Management
Marine Protected Areas	Planning workshops and consultations Guarding and patrolling in cooperation with the community Deputized "bantay dagat" Regular monitoring	LGU KAISAKA Federation SAPA SAMMABAL SAMMABI SMMV

Marine protected areas in these barangays are part of the coastal resource management programs implemented by the local government units. 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

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

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.

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

All of these programs were launched and managed by the local government unit (LGU) in partnership with the people's organization (PO), the Kaisahan ng mga Samahan Alay sa Kalikasan, Inc. (KAISAKA) Federation. Management of these projects was specifically given to the member organizations of the KAISAKA in every barangay. These members are the "Samahang Pangkalikasang 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 Mangingisdang Victory" (SMMV) in barangay Victory.

Table 2.

Macrophytes Identified inside the Four MPA of Bolinao, Pangasinan.

Species	Location			
	Arnedo	Balingasay	Binabalian	Victory
Sea Grasses				
Halophila ovalis (R.Br.) Hook.f.	✓			
Enhalus acoroides (R.Br.) Hook.f.	✓	✓	✓	✓
Thalassia hemprichii (Ehrenberg) Ascherson	✓	✓	✓	✓
Halodule uninervis (Forsskal) Ascherson	✓			
Halodule pinifolia (Miki den Hartog				✓
Cymodocea rotundata Ehrenberg et Hemprich	✓	✓		
Syringodium isoetifolium Kutz	✓			
Seaweeds				
Caulerpa racemosa (Forsskål) J.Agardh	✓	✓	✓	✓
Acantophora spicifera	✓	✓	✓	✓

* ✓ = species present

ASSESSMENT OF THE DIVERSITY OF MACROPHYTES AND FISH

Macrophyte Identification

Macrophytes identified in the 4 marine protected areas include sea grasses and seaweeds. These macrophytes were identified from the 4 selected marine protected areas in Bolinao (Table 2). Eight of these species were found in Barangay Arnedo, 5 in Balingasay, 4 in Binabalian and 5 in Victory. The 9 identified macrophytes within the selected marine protected areas in Bolinao, consisted of 7 sea grasses and 2 seaweeds. The identified sea grasses were *Halophila ovalis, Enhalus acoroides, Thalassia hemprichii, Halodule uninervis, Halodule pinifolia, Cymodocea rotundata,* and *Syringodium isoetifolium*, meanwhile the identified seaweeds were *Caulerpa racemosa* and *Acantophora spicifera*.

Table 3.

Observed and Identified Fish Species within the MPA of Four Coastal Areas of Bolinao, Pangasinan.

Family	Scientific Name	Common Name		Occurrence			
		English Name	Local Name	Arnedo	Balingasay	Binabalian	Victory
Pomacentridae	*Chromis dimidiata* (Klunzinger, 1871)	Damselfish	Palata	✓	✓	✓	✓
Labridae	*Halichoeres hortulanus* (Lacepede,1801)	Checkboard wrasse	Galis-galis	✓	✓	✓	✓
	Cheilinus trilobatus (Lacepede,1801)	Trippletail wrasse	Epes	✓	✓		
	Cheilio inermis (Forsskal,1775)	Cigar wrasse	Sangitan	✓			
Scaridae	*Chlorurus microrhinos* (Bleeker, 1874)	Heavybeak parrotfish	Molmol, Loro	✓	✓	✓	✓
Acanthuridae	*Acanthurus olivaceus* (Bloch and Scheneider, 1871)	Surgeon fish	Baliwak-wak	✓	✓	✓	✓
Serranidae	*Cephalopholis leopardus* (Lacepede,1801)	Coral Grouper	Lapu Lapu	✓	✓	✓	
Plotosidae	*Plotosus lineatus* Thunberg, 1787	Eel-tailed catfish	Hito	✓			
Tetraodontidae	*Arothron hispidus* (Linnaeus, 1758)	Pufferfish	Butete		✓		
Nempteridae	*Nemipterus japonicus* (Bloch, 1791)	Japanese threadfin	Labayan	✓			
	Scolopsis ghanam (Forsskal,1775)	Arabian monocle	Silay		✓		
Caesionidae	*Caesio cuning* (Bloch, 1791)	Fusilies, solid	*Dalagang Bukid*	✓	✓		
Balistidae	*Balistapus undulatus* (Park, 1797)	Triggerfish	Papakol	✓	✓		
Lethrinidae	*Lethrinus harak* (Forsskal,1775)	Thumbprint emperor	Rugso	✓			
Siganidae	*Siganus canaliculatus* (Park, 1797)	Siganid	Baraa-ngan	✓	✓		✓
Mullidae	*Parupeneus insularis* (Rhandall and Myers, 2002)	Goatfish	*Gumyan*	✓	✓		
Ephepidae	*Heniochus acuminatus* (Linnaeus, 1758)	Longfin bannerfish	Bayang-bayang		✓		
Chaetodontidae	*Chaetodon kleinii* (Bloch, 1790)	Butterfly fish	Alibang-bang		✓		
Zanclidae	*Zanclus cornutus* (Linnaeus, 1758)	Morish idol	Sangu-wanding		✓		
Centriscidae	*Macroramphosus scolophax* (Linnaeus, 1758)	Longspine snipefish	Trumpeta		✓		

* ✓ - species present

Fish Species Identification

Table 3 shows the 20 fish species observed and identified within the four marine protected areas of Bolinao, Pangasinan belonging to 17 families, namely; *Chromis dimidiata* for family Pomacentridae, *Halichoeres hortulanus, Cheilinus tribatus,* and *Cheilio inermis* of Labridae, *Chlororus microrhinos* under Scaridae, *Acanthurus olivaceus* under family Acanthuridae, *Cephalopholis leopardus* of Serranidae, *Plotosus lineatus* from Plotosidae family, *Arothron hispidus* of Tetraodontidae, *Nemipterus japonicus* and *Scolopsis ghanam* from family Nempteridae, *Caesio cuning* of Caesionidae, *Balistapus undulatus* of Balistidae, *Lethrinus harak* of Lethrinidae, *Siganus canaliculatus* of Siganidae, *Parupeneus insularis* from the family of Mullidae, *Heniochus acuminatus* of Ephepidae, *Chaetodon kleinii* of Chaetodontidae, *Zanlus cornutus* of Zanclidae, and *Macroramphosus scolophax* from the Centriscidae.

Of these species, 14 of them were found in Arnedo from 12 families, Balingasay had 16 species belonging to 15 families, and Binabalian and Victory had 5 species identified belonging to five families.

Macrophytes

Table 4 shows that *Thalassia hemprichii* (31.07%) is the most abundant in Arnedo. This is followed by *Cymodocea rotundata* (10.37%) and *Syringodium isoetifolium* (9.20 %). In Balingasay, *Caulerpa racemosa*

Table 4.

Percent Cover of Macrophytes inside the Marine Protected Areas of the Four Coastal Barangays in Bolinao, Pangasinan.

Species	Percent Cover (%)			
	Arnedo	Balingasay	Binabalian	Victory
Seagrass				
Halophila ovalis	1.87	0.00	0.00	0.00
Enhalus acoroides	1.17	5.13	2.93	2.93
Thalassia hemprichii	31.07	21.77	39.33	1.83
Halodule uninervis	2.83	0.00	0.00	0.00
Halodule pinifolia	0.00	0.00	0.00	13.6
Cymodocea rotundata	10.37	23.53	0.00	0.00
Syringodium isoetifolium	9.20	0.00	0.00	0.00
Seaweeds				
Caulerpa racemosa	3.90	2.53	11.17	14.6
Acantophora spicifera	6.27	9.63	7.23	7.23

(23.53%) had the highest percent cover. Next to it is the *Thalassia hemprichii* (21.77%) and *Acantophora spicifera* (9.63%). In Binabalian, *Thalassia hemprichii* (39.33%) also has the most cover. This is followed by *Caulerpa racemosa* (11.17%) and *Acantophora spicifera* (7.23%). Meanwhile, in Victory, *Cymodocea rotundata* (33.33%) had the highest percent cover which is followed by *Caulerpa racemosa* (14.67%) and *Halodule pinifolia* (13.67%).

Importance Value Index and Diversity of Fish in the Four Marine Protected Areas in Bolinao, Pangasinan

Results revealed that in Arnedo, *Chlororus microrhinos* had the highest importance value index of 47.75 percent (Table 5) which indicates that this species is the most dense, frequent and dominant in the area. This was followed by *Chromis dimidiata* (30.12%) and *Acanthurus olivaceus*

Table 5.

Importance Value Index of Fish in the Marine Protected Area of Four Coastal Barangays in Bolinao, Pangasinan.

Species	Importance Value Index (IVI)			
	Arnedo	Balingasay	Binabalian	Victory
Chromis dimidiata	30.12	59.00	86.45	66.38
Halichoeres hortulanus	9.76	1.31	47.84	34.98
Chlororus microrhinos	47.75	36.15	21.89	51.54
Acanthurus olivaceus	26.47	58.72	33.80	22.62
Cheilinus tribatus	6.71	1.95		
Balistapus undulatus	7.08	3.30		
Plotosus lineatus	15.66			
Cephalopholis leopardus	9.82	8.45	11.01	
Parupeneus insularis	1.64	4.18		
Nemipterus japonicus	1.41			
Cheilio inermis	6.37			
Caesio cuning	1.39	3.91		
Lethrinus harak	4.10			
Siganus canaliculatus	32.72	2.96		25.47
Arothon hispidus		2.04		
Heniochus acuminatus		13.44		
Chaetodon kleinii		1.86		
Zanclus cornutus		3.72		
Scolopsis ghanam		4.67		
Macroramphosus scolophax		1.95		

(26.7%). Meanwhile, the most dense, frequent and dominant species in Barangay Balingasay was *Chromis dimidiate* which obtained the highest importance value index of 59% followed by *Acatharus olivaceus* (58.72%) and *Chlororus microrhinos* (36.15%).

Moreover, Binabalian had only five species observed and identified. These were dominated again by *Chromis dimidiata* which obtained the highest importance value index (86.45%). The second highest IVI was obtained by *Halicoeres hortulanus* which got an importance value index of 47.84 % followed by *Acanthurus olivaceus* (33.80%).

Meantime, results in Table 5 show that only five species were identified in Victory, Bolinao where *Chromis dimidiata* obtained again the highest importance value index (66.38%). This was followed by the *Chlororus microrhinos* (51.54%) and *Halichoeres hortulanus* (34.98%).

Species Diversity of Fish

Table 6 shows the diversity index values of the different fish species present in the marine protected areas in the four coastal barangays of Bolinao, Pangasinan. Results revealed that the diversity index values of marine fishes in the marine protected areas of the four coastal barangays are very low.

Although the MPA in Arnedo was established only in 2004, the diversity of fish species in this marine protected area was very low which was almost the same as Balingasay MPA. The abundance of these species is due to their characteristics which are well adapted to the area. These species are tropical fishes which inhabit lagoons and seaward reefs and are abundant in large aggregations of reef tops, bare rocks or mixed rubble and sand (Meyers, 1991).

Table 6.

Diversity Index Values of Fish Present in the Marine Protected Areas of the Four Coastal Barangays in Bolinao, Pangasinan.

Barangay	No. of Species	No. of Individual	Diversity Index Values
Arnedo	14	861	1.99
Balingasay	16	1,129	1.90
Binabalian	5	544	1.14
Victory	5	1,797	1.46

Binabalian got a diversity value index of only 1.14 which was also very low. Binabalian was the youngest MPA established among the four study areas. This explains why there are a few species observed and why it has low diversity. The area is still starting to recover from overfishing and environmental degradation after it was declared as a marine protected area in 2006. Despite this, results indicated that even if there were only a few species found, the number of individuals was observed to be high in every sampling area. They appeared to have reproduced and increased in the said environment where they were not disturbed allowing them to grow until they spill over. Diversity of species in the MPA in Victory had 1.46 which is also very low due to environmental disturbances which occurred in the area.

THE PHYSICO-CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF THE COASTAL WATERS

Physical parameters

Assessment of the physical characteristics of the study areas (Table 7) showed that the temperature values ranged from 27.5^{o}C to 28.4^{o}C in the marine protected areas. These temperature values taken from the waters of these barangays are within the criteria or standard value of DENR (Table 2). In terms of turbidity, Barangay Binabalian had the lowest turbidity value of 1.2 m among the four stations. This indicates lower transparency in the waters of the said barangay. Despite this, however, the turbidity values are within the allowable limits set by the DENR. The water depth varied from each station, where Barangay Balingasay had the highest water depth of 10 m while Barangay Binabalian is the shallowest with 3.2 m. Still, the water depths in all stations fell within the standard value given by DENR.

Chemical Characteristics

The basic and important chemical parameters in the marine protected areas as shown in Table 8 show the salinity values from 34 ppt (Arnedo) to 36 ppt (Binabalian). However, the dissolved oxygen (DO) concentrations varied across stations where Barangay Victory had the highest value (8.44 mg/l) while Barangay Arnedo had the lowest (6.53 mg/l). The DO concentrations were within the criteria value set

Table 7.

Physical Characteristics in Four Marine Protected Areas (MPA) of Bolinao, Pangasinan.

	Temperature (^oC)		Turbidity (M)		Average Station Depth	
	MEAN	SD	MEAN	SD	MEAN	SD
Arnedo	28.0	0.28	7.2	0.57	7.2	0.57
Balingasay	27.5	0.71	9.0	0.71	10.0	0.00
Binabalian	28.3	0.42	1.2	0.28	3.2	0.14
Victory	28.4	0.14	4.0	0.35	6.0	1.41
Mean	28.05	0.40	5.4	3.45	6.6	2.79
DENR Standard (SA)	26-30		> 100		> 3	

by DENR and ASEAN except for Barangay Arnedo (Table 8). The hydrogen ion concentrations differed from station to station. Barangay Victory had the highest pH value of 8.33 while Barangay Arnedo got the lowest with 8.0. The pH values were within the allowable range given by DENR and ASEAN. The highest total suspended solids (TSS) value was recorded in Barangay Binabalian with 49.92 mg/l. In contrast, Barangay Arnedo obtained the lowest TSS value of 16.04 mg/l. However, TSS values of the four stations were within the criteria value set by ASEAN but two stations failed under the DENR standard for Class SA. These are Barangays Binabalian and Victory.

The phosphate concentrations fluctuated from 0.014 ppm (Arnedo) to 0.243 ppm (Balingasay). All these phosphate values fell within the allowable concentrations set by DENR and ASEAN, except that of Barangay Balingasay. In terms of ammonia, the concentrations ranged

Table 8.

Chemical Characteristics in Four Marine Protected Areas of Bolinao, Pangasinan.

	Salinity	D.O. (MG/L)	pH	TSS (PPM)	Phosphate (PPM)	Ammonia (PPM)	Nitrate (PPM)
Arnedo	34	6.53	8.0	16.04	0.014	0.030	0.144
Balingasay	35	7	8.24	16.26	0.243	0.039	0.132
Binabalian	36	8.38	8.31	49.92	0.021	0.053	0.031
Victory	35	8.44	8.33	30.45	0.049	0.030	0.043
Mean	35	7.59	8.22	28.17	0.082	0.038	0.088
SD	0.82	1.28	0.15	15.47	0.182	0.207	0.371
DENR Standard (SA)		7	7-8.5	25	0.1	< 1	1.0
ASEAN criteria		5	6-8.5	50	0.48	0.5	0.395

from 0.030 ppm (Arnedo and Victory) to 0.053 ppm (Binabalian). These ammonia values taken were within the standard value set by DENR and ASEAN. Likewise, the nitrite concentrations varied from 0.031 ppm (Binabalian) to 0.144 ppm (Arnedo) which was within the accepted value given by DENR and ASEAN.

Bacteriological Characteristics

The bacteriological characteristics in all the marine protected areas and mangrove management areas (Table 9) were identical in the total coliform values at > 1,100 MPN/100 ml. In terms of fecal coliform, the values ranged from 0 MPN (Victory and Balingasay) to 7.3 MPN/100 ml (Binabalian). The total coliform in all stations obtained high values and did not meet the criteria set by DENR and ASEAN for MPA (Table 5). However, the four stations passed the criteria set by DENR and ASEAN for fecal coliform.

Table 9.

Bacteriological Characteristics in Four Marine Protected Areas (MPA) and Mangrove Management Areas (MMA) of Bolinao, Pangasinan.

	Total Coliform (MPN/100 ML)	Fecal Coliform (MPN/100 ML)
Arnedo	> 1,100	3.6
Balingasay	> 1,100	0
Binabalian	> 1,100	7.3
Victory	> 1,100	0
DENR Standard (SA)	1,000	200
ASEAN Criteria	1,000	200

DISCUSSION

Results indicated that the species observed and identified were very few as compared to the over 100 species of fish documented and found in Bolinao by the UP-MSI in the 1950s. This can be attributed to the Bolinao experience of degrading coastal resources, and the loss of its species due to dynamite fishing. Also, the rise in milkfish grow-out pens and massive fish kills and bleaching during the 1998 El Niño and 1999 La Niña (Uychiaoco et al., 2000) could have caused the depletion of these marine species. This data of decreasing species was further supported by the data gathered over a 4-year period (1988–91) by McManus et al. (1992). This revealed evidence of overharvesting of reef fish that decreased the adult-fish density and species diversity, as well as the size of reproductively mature fish.

Overharvesting of coral fish resulted in decreased adult fish density and in species diversity as well as in the size of reproductively mature fishes. McManus et al. (1992) documented these trends for adult fish communities along the slope of the Bolinao reefs from 1988 to 1991. For siganid fishes, the smallest recorded size of reproducing females was down to 3 cm. This showed that intense fishing pressure has selected small and fast reproducing individuals. With the massive exploitation of the Lingayen Gulf by commercial fisheries, artisan fishers and peasants who depend on the Gulf to provide food for them and their family are struggling to compete for marine resources, resorting to Malthusian overfishing (Dayton et al., 1995). Malthusian overfishing illustrates the imbalance of sustainability in the Lingayen Gulf. Fisherman are forced to use any means possible to obtain fish such as blasting, cyanide, etc., in order to obtain fish. Such cutthroat tactics are resorted to because commercial trawling has drastically reduced the numbers of several fish species available to common fishers (Ochavillo et al., 1989).

A significant portion of the coastal habitats (like sea grass beds) is at high risk of being lost in the next decade. About half have either been lost or severely degraded during the past 56 years (Chou, 1994; Fortes, 1994), and the rate of degradation is increasing.

These studies led to recommendations for the creation of protected areas, the development of alternative or supplemental livelihoods, and the promotion of public education. These can provide the needed social sanctions against economically efficient but illegal fishing methods (McManus et al., 1992).

The overall goal of an integrated coastal management, like the establishment of the Marine protected areas in Bolinao, is to improve the quality of life of human communities who depend on coastal resources while maintaining biological diversity and productivity of coastal ecosystems. Adoption of the coastal area management philosophy (and its corresponding planning and management framework) is essential to long term sustainable use and conservation of sea grass resources of the country (DENR et al., 2001).

The marine protected areas in Arnedo, Balingasay, Binabalian and Victory were established to be a "no take zone" to bring back the species lost in the coastal area. An MPA was established in Balingasay in 1998, in Victory in 2002, in Arnedo in 2004 and in Binabalian in 2006. The Bolinao experience shows that establishing "no take areas" is important to bring back the diversity of species in the area.

Binabalian and Victory are both on the coast of Santiago Island that is why they share almost the same characteristics. In Victory, only five species were also identified but these appeared to be with high number of individuals in every sampling station similar to Binabalian. This shows that even though Victory was established several years earlier (2002) than Binabalian, the same numbers of species were observed in the area but with lower diversity value. This may be due to its small area as it has only 4.8 hectares, as compared to Binabalian with an area of 10.8 hectares. Still the area had a high number of individuals per species indicating that the species thriving were also given a chance to find a permanent spawning area which is undisturbed and that they were able to increase in number. This effect was also shown in the review of 31 studies made on MPAs and their effect by Dugan and Davis (1993). They found out that of the 31 studies they conducted 24 studies showed increased density of species within the boundaries of MPA core zones.

The data showed that whichever had the highest species density would have the highest dominance index, relative dominance and species importance value. Overall four species, namely; *Chromis dimidiata, Acanthurus olivaceus, Halichoeres hortulanus,* and *Chlororus microrhinos* registered a high importance value index in the four marine protected areas. Abundance of food and shelter for these species within the marine protected areas contributes to the increase in their number, particularly their reproduction. The marine protected area has been declared a "no take zone," so this allowed them to reproduce freely and grow until they are ready to spill over. *Chromis dimidiata* feed mostly on plankton and usually seen in solitary reefs, staying close to the substrates of about 10 m (Kuiter & Tonozuka, 2001).

Meanwhile, according to Meyer (1991), *Chlororus microrhinos* are tropical marine fish which are reef associated and usually found in schools together whereas *Acanthurus olivaceus* inhabits waters nine to at least 46 m in depth. It feeds on the surface film of detritus, diatoms and fine filamentous algae covering sand and bare rocks. While *Halichoeres hortulanus*, on the other hand, feeds mainly on hard-shelled organisms including mollusks, crustacean and sea urchins.

The Philippines, with its 18,000 km of coastline, has sizeable sea grass areas spread discontinuously along the shallow portions of the coastline. According to Fortes (2004), 16 species of sea grasses were identified in the Philippines. However, this study found only 8 species of sea grasses thriving in the MPAs of Bolinao. Seaweeds also have been observed to be naturally occurring in the marine protected areas. This is an indicator of a good quality of water since seaweeds are sensitive to pollutants. The presence and growth of seaweeds in the MPAs can enhance the ecological system.

Presence of sea grass and seaweed cover in the MPAs is an indication that the area is now recovering from degradation particularly in terms of water quality since sea grasses are sensitive to pollution (Fortes, 2004). Although the percent cover is still thin, the habitat is an important factor to help in the regeneration of species in the area. Sea grass beds are an ecologically significant marine habitat, and serve as a nursery area for juvenile marine animals while providing food and shelter. Sea grass beds colonize and grow in areas of shallow water especially in the presence of unstable mud, silt and sand substrates. Some sea grasses grow at greater depths, but will vary according to the amount of sunlight they can receive through the water column. These areas are important in maintaining biodiversity and are vulnerable to environmental pressures (Fortes, 2004). Sea grasses found in the MPAs of Bolinao are bound to be conserved to maintain the different species thriving in the area. According to the survey, percent cover of each species of seaweeds and sea grasses ranges only from 7% to 33%. This is an indication that macrophytes covering the area is still thin and still in the process of recovery. With the marine protected area, these species can be conserved and managed through the proper management of the quality of water and the environment.

The four marine protected areas observed showed very low diversity of species. Balingasay is the oldest MPA but still shows a very low diversity like the other three which are younger. Moreover, this shows that the programs for the establishment of the marine protected areas have not shown the best outputs through the years that they were established, particularly in Balingasay and Victory. These 2 MPAs have been there for more than 10 years. This can be attributed to poor management due to the manpower structure where there are only a few staff members from the local government unit who handle and manage the programs. Likewise, the first hand management was given to the People's Organizations for whom there are no evaluation and monitoring programs regarding their specific roles and duties guaranteeing the success of the CRM programs. Many environmental problems and issues contribute to the results obtained particularly the destruction of critical habitats due to overfishing, pollution and coastal erosion. Moreover, results can also be attributed to the reality that the establishment of the "no take zone" has not yet been effective for the past years as these areas showed very little improvement in the species diversity.

The higher salinity values are inherent to seas being salt water. The salinity values suggest that the marine sanctuaries are not affected by river runoff which is one of the criteria in setting up a sanctuary. The DO levels are acceptable except for Barangay Arnedo which was lower than the required 7 mg/L for marine protected areas. Although the DO in Barangay Arnedo value fell short of the required DO level, the obtained reading did not substantially affect the biota of the MPA. The higher DO concentrations in the three MPA might have been caused by constant agitation of the water by sea current and the abundance of phytoplankton and algae in the area considering that these areas are protected areas. The slight alkalinity of the marine sanctuaries is attributed to the chemical nature of the sea. The carbon dioxide-carbonic acid- bicarbonate system acts as buffer to keep the sea water slightly alkaline from 7.5 to 8.4 (Nybakken, 1992). The total suspended solids concentration is very critical to MPA. Higher TSS may limit the light penetration and hamper the photosynthetic activities of plants particularly those on the benthic portion. McGlone et al. (2004) reported higher TSS values in some areas of Lingayen Gulf where river runoffs are evident. The absence of river runoffs may have caused the lower values of phosphate, ammonia and nitrite in the MPAs. Domestic and agricultural wastes, through river runoff, contribute to the increase of phosphate, ammonia and nitrite (McGlone, et al., 2004).

Results of the present study indicated that there was a great improvement in the water quality of Bolinao as compared to the previous studies. The Lingayen Gulf suffered from pollution from point and non-point sources and runoff. Microbial contamination, fertilizers, pesticides, heavy metals, silt, and untreated sewage are the main pollutants of the Lingayen Gulf (Guarin, 1991). Pollution has caused a multitude of problems for the Lingayen Gulf, including eutrophication of coastal areas, deaths of marine life, sedimentation, and destruction of the physical habitat (Guarin, 1991). The study of Azanza et al. (2006) revealed that the nutrient concentration in Bolinao waters had been increasing which was been attributed to the increase in fish pens and fish cages. However, a 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 implies a low oxygenated environment that favors its formation that can be attributed to continued build up of decomposing products (fish feeds) and other organic materials. In addition, Azanza (2005) also reported 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).

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 that largely surpassed the limit set by DENR and ASEAN for marine water. The improved water quality may be attributed to the coastal resource management programs being implemented in the four coastal barangays such as coastal cleanup, no take zone policy, monitoring and evaluation of the coastal resources by the local government agencies, NGOs and people's organizations.

However, the total coliform in all study areas had high values which did not meet the criteria set by DENR and ASEAN for marine waters. The higher values for total coliform in all the MPAs of the four stations could have been caused by the nearby milkfish pens (Azanza et al. 2006) which can create excess bacteria and light-blocking algae as well as domestic and agricultural wastes from the land. McGlone et al. (2004) hinted that an increase of total coliform is triggered by the domestic and agricultural wastes carried through the river. According to Fortez and Paningit (2007), the uncontrolled milkfish culture characterized by high feeding inputs and the proliferation of fish cages and pens have contributed to the deterioration of the water quality of Bolinao coastal areas. However, the fecal coliform count in all the MPAs is still manageable as it passed the ASEAN criteria and DENR standard. Marine protected areas are deemed ideal ecosystem that meet all the appropriate physico-chemical standards.

The Bolinao experience of deteriorating marine resources shows that establishing no-take areas is important to bring back the integrity of their coastal areas. According to Uychaco et al., (2003), for a complex multi-species fishery sustaining diverse user groups, multi-pronged approaches are necessary to make any headway and in order to generate good results. Therefore, the initiatives in Bolinao—particularly the establishment of marine protected areas as no take zones in these barangays—are indicators of good practices for coastal resource management programs in order to bring back the integrity of the coastal resources which were degraded since the Lingayen Gulf was declared to be an environmentally critical area. Even though the diversity of species is still low but in time if the marine protected areas will continue to be "no take" zone areas where fishing and other activities are prohibited to ensure the freedom of the species to replenish in the area and if other management measures are pursued in the context of integrated coastal management, perhaps in the future, it will make a difference.

CONCLUSION

Marine protected areas (MPAs) were established in Barangays Arnedo, Balingasay, Binabalian and Victory and several programs and projects were initiated to manage these coastal resources. Nine (9) macrophytes such as 7 sea grasses and 2 seaweeds and 20 fish species were observed and identified in the selected MPAs in Bolinao. The diversity of species in the MPAs is still very low because the MPAs are still starting to recover from overfishing (McManus et al., 1992; Dayton et al., 1995), and environmental degradation (Chou, 1994; Fortes, 1994) after they were declared as marine protected areas in 2006. The physico-chemical characteristics of the marine protected areas in the four barangays of Bolinao, Pangasinan are within the desirable range set by the standards of the DENR and ASEAN. However, the total coliform in all the MPAs in the four barangays exceeded the optimum level set by DENR and ASEAN due to the presence of fish cages (Azanza et al., 2006; Fortez & Paningit,2007) nearby and from domestic wastes (Guarin, 1991; McGlone et al., 2004) from the residential areas. The fecal coliform were below the standard value given by the DENR and hence, passed the DENR and ASEAN criteria. Overall, the physico-chemical characteristics of the MPAs have improved considerably and the water quality has likewise greatly improved compared to the water quality three to five years ago (Azanza, 2006; Fortez & Paningit,2007; McGlone et al., 2008) due to the management activities conducted in the areas . A no take zone in the MPA is very imperative to bring back the integrity of the coastal resources. The MPAs in Bolinao, Pangasinan have only just made a first start on their way towards the rehabilitation of their coastal resources.

RECOMMENDATIONS

1. Regular biodiversity assessment and monitoring should be done in the marine protected areas of Bolinao in order to determine the success of the management initiatives in the MPAs and to examine the diversity of fish and macroflora.
2. Regular water quality monitoring should be done not only in the MPA but also in the nearby milkfish cage culture areas.
3. Information, communication and education on the management of marine protected areas should be strengthened by the local government units and the people's organizations to intensify public awareness and obtain community involvement and participation in the management of MPAs.
4. The Solid Waste Management Act and Clean Water Act should be strictly implemented in Bolinao to lessen pollution and continue the restoration and rehabilitation of coastal resources.

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