PAG-ASA ISLAND AND ADJACENT REEF RESOURCE ASSESSMENT, KALAYAAN ISLAND GROUP, KALAYAAN, PALAWAN

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1 author:

Benjamin J. Gonzales
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COLLEGE OF FISHERIES AND MARITIME TECHNOLOGY
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Editor: Benjamin J. Gonzales

Authors: Joel G. Becira
Honorio B. Pagliawan
Marcial V. Bolin
Edwin F. Rodriguez
Benjamin J. Gonzales
Noli D. Dieron
Ria S. Sariego
Johanne G. Gonzales
Bernaldo S. Montaño
Joseph P. Gallo

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EXECUTIVE SUMMARY

Palawan is one of the provinces of the Republic of the Philippines endowed with rich and diverse natural resources, most especially its marine ecosystem. In the west of Palawan, with its declared jurisdiction covering approximately 64,976 square miles, the Municipality of Kalayaan has further extended the marine resources of the country to the far west.

In spite of the significant potential of the large marine ecosystem in Kalayaan Island Group, very few scientific studies were conducted in this vast area, and the data and information gathered from these studies are not sufficient for the Municipality of Kalayaan to base their decisions regarding eco-friendly planning and development.

Since it is the vision of the Government of Kalayaan, spearheaded by the current Mayor Rosendo Mantes that by the year 2010 Kalayaan will be developed into a highly productive local government unit with a stable territory where its constituency enjoys peace, security and satisfaction, and sustainable use of its natural resources, the municipality is undertaking their own initiatives to move towards the attainment of its goals. And one of the prerequisites to attain such goals is the conduct of a thorough resource assessment of the island.

Thus, the Western Philippines University was commissioned to provide baseline information on the resources of the island. The specific objectives of which are: 1) to provide detailed baseline information of the present state of the identified resources in Pag-asa Island, 2) to give recommendations for their sustainable use, and 3) to recommend eco-tourism activities for the island.

The survey trip lasted for 23 days from April 28 to May 21, 2008, while the actual sea survey was seven days from May 2- 8, 2008. The team also conducted surveys on land crab and got involved in sea turtle release. The selection of survey stations in the sea were based mainly from information gathered from island residents, boat crew, fishermen, and previous studies.

Survey results showed that the reef fronts surrounding the Pag-asa Island were characterized by grooves cut into the hard limestone surface most likely formed by the repeated pounding of surf and continuous movement of rubbles. This manifests the existence of consistent ocean swells and strong wave action influencing the shape of the physical profile of the reefs surrounding the island. These grooves serve as shelter to dwelling and visiting marine organism, including fish.

More than 50% of the benthic cover in most of the stations was composed of dead corals. One station, however, has good coral cover (50.5%). Four stations have fair coral cover, while the rest of the stations have poor (less than 25%) cover. The average condition of coral reefs in Pag-asa Island is found to be fair.

The average mean of live benthic cover in Pag-asa Island (27.48%) is little bit higher than that of St. Paul Bay (21.73%) located west of Puerto Princesa City, but lower compared to Honda Bay (50.93%), Bugsok Island (47.73%), Pandan Island (57.48%), and Sabang Reef (Binduyan) (51.31%).

The low coral cover in Pag-asa Island might be the result of the destructive fishing methods used in the vicinity. Coral rubbles in circular forms were observed during our dives in some stations, which may indicate the use of explosions, and according to some local fishermen and island residents, foreign fishermen use explosives for catching fish in KIG.

The occurrence of grey color intact, but dead standing coral structures in most stations implies the effect of the use of chemicals while fishing. Presence of crown of thorns in the reefs of Pag-asa Island further aggravates the poor situation of the corals. Additionally, there was also report on gathering of coral boulders by foreign fishing boats from the reefs of KIG.

The relatively high live coral cover in stations 4, 5, and 7 may be partly attributed to their locations. Station 7 is the site where the future pier will be constructed, hence it is recommended that proper precaution should be taken to minimize impact of its construction to the island coastal habitats and resources. The inputs of developments and the preservation of the integrity of the island's marine resources should be balanced.

As for the fishes of Pag-asa Island, the total number of species observed in ten stations was 251 species distributed to 36 families. Out of this, 241 were identified to species level. The families with high number of species were Labridae (ipes-padi/wrasse, 56), Pomacentridae (palata, 55), Acanthuriddae (labahita, 22) Chaetodontidae (tiol- tiol, 20) Scaridae (mulmul/parrot fish15), Holocentridae (buslit, 9) and Balistidae (pakol, 6). The total number of commercially valuable species is 104 species, comprising 41.8% of the total number of species observed.

The abundance of fish was estimated at 1.1 individuals/m^2, with the average density of 1,068.2 individuals/1000 m^2 is categorized as moderate density. The high category ranged from 2,268 to 7,592 indv./1000 m^2 density. The average fish biomass (96.00mt/km^2) of Pag-asa Island is categorized as very high. This result is far higher than that of 1998 survey in Pag-asa Island, with an average biomass of 23.3 mt/km^2 only.

Fish census results indicate that fishes are concentrated at the drop-off areas around the Pag-asa Reefs, though some species of small groupers (lapu-lapu) and siganids (padas/danggit) were observed to be relatively abundant inside the Pag-asa " barrier" reef. There were 52 species of reef fishes belonging to 19 families found around Pag-asa Island, which were not recorded in previous fish visual census conducted in the mainland Palawan waters.

It can be deduced from the results that the waters around Pag-asa Island remains a potential fishery ground, in terms of fishery resources, which is worthy of conservation in order to sustain the long term benefit that we are suppose to gain from it.

As for the invertebrates, there were eight distinct kinds of macro-invertebrates observed: giant clams (taklobo), sea cucumbers (balatan), topshells (samong), lobsters (banagan), sipunculids, crown of thorn (dap-ag/COT), sea urchin (tirik), and other starfishes.

Across stations, giant clams have the highest density, followed by starfishes not including COT. Station 2 has the highest number of giant clam species, having a density of 8 individuals/450 m^2. The giant clam density in Stations 1, 3, and 8, was one shell in every 150 m^2, while sea cucumber and topshell were noted only in station 3.

The average density of giant clams in Pag-asa Island (0.43 ind./100m^2) is far lower than other sites that we have surveyed: 6.81ind/100m^2 in Apulit Island, Taytay Bay; 0.7ind./100m^2 in Caramay, Green Island Bay, Roxas; 1.5ind/100m^2 in Green Island; 4.4ind/100m^2 in Tubbataha Reef and 5.99ind/m^2 in Malampaya Sound, Taytay, Palawan. However, the density of giant clams in station 2 (1.8 ind/100m^2) is higher than the average density in Green Island (1.5 ind/100m^2).

COT was found abundant in stations 4 to 6, with 61 individuals (highest) recorded in Station 5. This is expected since Station 5 has the highest live coral cover, composed mostly of regenerating corals. All stations were in COT outbreak condition during the survey except stations 7 and 8. Collection and proper disposal of COT should be conducted, since COT outbreak poses a major threat to the regeneration corals all over the reef communities of the Pag-asa Island.

The *Strombus canarium* shell (pasyak) was found to be very common in the inter-tidal zone. The Gracious Sea Urchin (*Tripneustes gratilla*), known as tirik in local dialect, also abounds the seagrass beds surrounding the island. This sea urchin is a candidate as a livelihood product for the island inhabitants and the municipality.

All of the above-mentioned invertebrates, except COT, are worth conserving and protected for food, livelihood, and eco-tourism purposes, thus proper management of these resources is strongly recommended.

A total of two species of seagrass and twenty eight seaweed species were recorded in Pag-asa island. The seagrass species consist of *Thallasia hemprichii* and *Halodule pinifolia. Thallasia hemprichii* dominates the macrophytes in the island having a percent frequency and cover of 80.166 and 87.380 respectively. It has a mean density of 882 shoots per m^2. They occur as monospecific beds in northeast and northwest part of the island with a rate of occurrence of 80.83% and 74.04%, and dominance of 54.79% and 46.24%, respectively.

The species diversity of seagrass in Pag-asa Island is very low, having only two species out of 16 species in the country and against 50 species of seagrass worldwide, while the seaweed species collected occur only as associates of the seagrass community. Of the twenty eight species of seaweeds observed in the island, 16 species were present in northeast part of the island, 19 species in northwest side, and southern portion of the island. These were composed of 16 chlorophytes, seven phaeophytes and five rhodophytes. The uses and level of utilization of some of the algal species found in Pag-asa Island are provided in this report.

The catch per unit effort (CPUE) of handline fishing in Pag-asa Island was estimated to be 4.2kg/person/hr compared to 1kg/person/hr in Honda Bay. It was observed that there were no facilities to store fresh fish and regular transportation available in the island. This situation makes marketing of fish products difficult. This has made the island residents to resort to drying their fish catch to lengthen its shelf life until transportation becomes available or use it for domestic consumption.

Although drying fish is popular in the island, it is not yet commercially known. Dried fish product in the island is unique in such a way that they are caught by hook and line (sometimes by spear gun), cut in fresh condition, and dried immediately after cleaning either on board the bangca or onshore. In addition, species being dried are high valued fishes.

It was observed that sea urchin was abundant in the island. It can produce a popular product called “sea urchin roe” that demands a high value in the markets of Asia and Europe. Thus, is a potential export commodity.

Nautilus shells also exist in the island as livelihood for some islanders. As such, studies on the conservation and development of nautilus livelihood would be necessary to improve the catch and at the same time conserve this economically valuable, but threatened species.

A community of trees (*Cerbera manghas*), called by the locals as *Alipata*, was found to thrive more or less central of the island. This tree community was observed to be a critical habitat for a relatively rare species of land crab (*Kuday*) scientifically named as *Gecarcoidea lalandii*. We named this land crab as the Pag-asa *Kuday* in this report.

Although the Pag-asa *Kuday* is distributed in Indo-West Pacific, this species could be the first record in Palawan or in the Philippines. Pag-asa Island could be the only area where this species occur. Thus, more survey of this land crab in the islands of KIG and other areas of the Philippines should be carried out to determine its distribution.

Since the particular *kuday* species in the island is rare, this species including its habitat should be protected from unregulated exploitation. The Pag-asa *Kuday* could be a tourist attraction and might become a livelihood commodity in the future. As such, it is encouraged that more studies and documentation on biology and ecology of Pag-asa *Kuday* should be conducted in the island.

A green turtle was found stranded in the southeast portion of Pag-asa Island in May 16, 2008 at 5:30 am. The turtle measured 106 cm in total length (TL) and 99 cm in width (W). The turtle was released at 6:25 am the same day, with tag number Ph 0760A. This was the second occurrence of sea turtle laying eggs in the beach during our stay in the island. Gathering of sea turtle eggs should be mitigated in order to maintain the number of population of returning sea turtles in the island.

Considering the benefits, which can be derived from the coastal resources mentioned above, protection and proper management of the resources, their respective habitats, and the users of these resources must be considered in the overall plan for livelihood and eco-tourism. Conduct of continuous environmental awareness and commitment activities will greatly help the resource users and stakeholders in protecting the Pag-asa Island.

I. GENERAL INTRODUCTION

Palawan is one of the provinces of the Republic of the Philippines known to be endowed with rich and diverse natural resources, most especially its marine ecosystem. This relatively bounty ecosystem carries an important role as source of livelihood for many marginalized coastal and island inhabitants. Likewise, the significance of its pristine and bountiful sea resources to fisheries and ecotourism sectors can not be undermined.

In western Palawan, where the China Sea is situated, is the Municipality of Kalayaan, which is also known as the Kalayaan Island Group (KIG). With Its declared jurisdiction covering approximately 64,976 square miles (Municipality of Kalayaan Features, VCD), Palawan's marine habitat is vastly extended to the far west.

Documents from the municipality says that in this vast ocean area of Kalayaan, our government holds of seven islands and two reefs with an aggregate land area of about 79 hectares. KIG is only a part of a much bigger archipelago of six hundred (600) scattered islands and islets which are internationally known as the Spratlys. These islands have been considered disputed due to overlapping claims of neighboring countries like China, Taiwan, Vietnam, Brunei, and Malaysia.

Kalayaan is said to be discovered by a Filipino named Tomas Cloma. He occupied 53 islets in the South China Sea which he named "Freedomland". On July 6, 1956, Mr. Cloma established a separate government for the archipelago which he declared to the whole world as "The Free Territory of Freedomland".

For almost two decades, events went on beyond his control until on December 4, 1974, he decided to irrevocably cede, transfer, and waive in favor of the Republic of the Philippines whatever and all rights he may have acquired under existing international and Philippine Laws over "The Free Territory of Freedomland."

Out of "The Free Territory of Freedomland", the Municipality of Kalayaan was created when former President Ferdinand E. Marcos signed and issued Presidential Decree 1596 on June 11, 1978. Pending the election of its first set of municipal officials, the decree set the administration of the islands and reefs under the custody of the Armed Forces of the Philippines.

The Municipality of Kalayaan comprises the seven islands and two reefs. The islands consist of: 1) Lawak Island, 2) Patag Island, 3) Likas Island, 4) Kota Island, 5) Panata Island, 6) Pag-asa Island, and 7) Parola Island. The reefs consists of: 1) Ayungin Reef, and 2) Rizal Reef

Among the islands in KIG, the Pag-asa Island is the largest with an approximate land area of 37 ha, though recent estimate is 32 ha. It is the only island in KIG that is self sustained water supply. It is considered as the seat of the local government of the Municipality of Kalayaan.

Presently, local government structures, facilities, and services are concentrated in Pag-asa Island, where the sole barangay (Barangay Pag-asa) of the municipality is situated.

Pag-asa Island is accessible by both sea and air transportation. The island of Pag-asa is located 280 nautical miles away from Puerto Princesa City and 579 miles from Metro Manila. It has an airstrip of 1.3 kilometers in length, named after the late General Rancudo, and caters virtually to military aircraft only. For twin engine Islander and Nomad aircrafts, Pag-asa is reached within 2 hours and 30 minutes from Puerto Princesa City Airport, but the C-130 Hercules Transport Plane takes only about an hour and twenty minutes.

For the municipal-owned motor launch, M/L Princess Seagull, Pag-asa Island is reached within 56 hours travel time via Balabac Strait. From Ulugan Bay on the west coast of Palawan, to the west of Puerto Princesa City, the course is shorter and travel time takes about 32 hours with calm and favorable weather condition.

In spite of the significant potential of the large marine ecosystem in KIG, very few scientific studies were conducted in this vast area. The UPMSI worked on the community structure and distribution patterns of fishes in some reefs in 1998 (Dantis, et al, 1998), while joint international researches by Vietnam, Philippines, etc, through the Joint Oceanographic and Marine Scientific Research Expedition (JOMSRE) in the South China Sea were conducted in different reef areas of KIG in1996, 2005, and 2007. The Western Philippines University (WPU) also conducted some fish census survey in the shallow reefs of the island in April 2006.

However, data and information gathered from the above-mentioned studies is not sufficient for the Municipality of Kalayaan to form their basis to decide on their eco-friendly planning and development.

Since it is the vision of the Government of Kalayaan, spearheaded by the current Mayor Rosendo Mantes that by the year 2010 Kalayaan will be developed into a highly productive local government unit with a stable territory where its constituency enjoys peace, security and satisfaction, and sustainable use of its natural resources, the municipality is undertaking their own initiatives to move towards the attainment of its goals. And one of the prerequisites to attain such goals is the conduct of a through resource assessment of the island.

The municipality launched the Kalayaan Discovery Tour in April of year 2002 to introduce Kalayaan to the general public and develop awareness about its strategic and economic importance to the country and the province as well. Since then, this event was celebrated annually. During the tour in 2004, a number of researches were conducted in the island (Becira et al, in press). By 2008, the municipality, decided to do a comprehensive survey of Pag-asa Island marine resources.

Thus, the Western Philippines University was commissioned by the Municipality of Kalayaan, generally to provide baseline information on the resources of the island. The specific objectives of this study are: 1) to provide detailed baseline information of the present state of the identified resources in Pag-asa Island, 2) to give recommendations for their sustainable use, and 3) to recommend eco-tourism activities for the island.

General Methodology

The survey trip lasted for 23 days from April 28 to May 21, 2008, while the actual sea survey was seven days from May 2- 8, 2008. The team was trapped in the island from May 10-20 due to series of typhoons. During this period, the team conducted surveys on land crab and got involved in sea turtle release.

The team left Puerto Princesa City to Bataraza, southern Municipality of Mainland Palawan, in the wee hour of the morning of April 28, 2008. At Buliluyan Port, Bataraza, the team first saw the municipality-owned pump boat "Otso-otso" that brought them to Pag-asa Island. On April 29, 2008, the Otso-otso departed Buliluyan Port and arrived at Rizal Reef Detachment (RRD), to drop some food and other supplies for soldiers manning the detachment in the morning of April 30, 2008. After then, Otso-otso passed by Ayungin Reef at 8:00 pm. The following day the boat reached the Bonifacio Reef, from where the captain of the boat directed our course to Pag-asa Island.

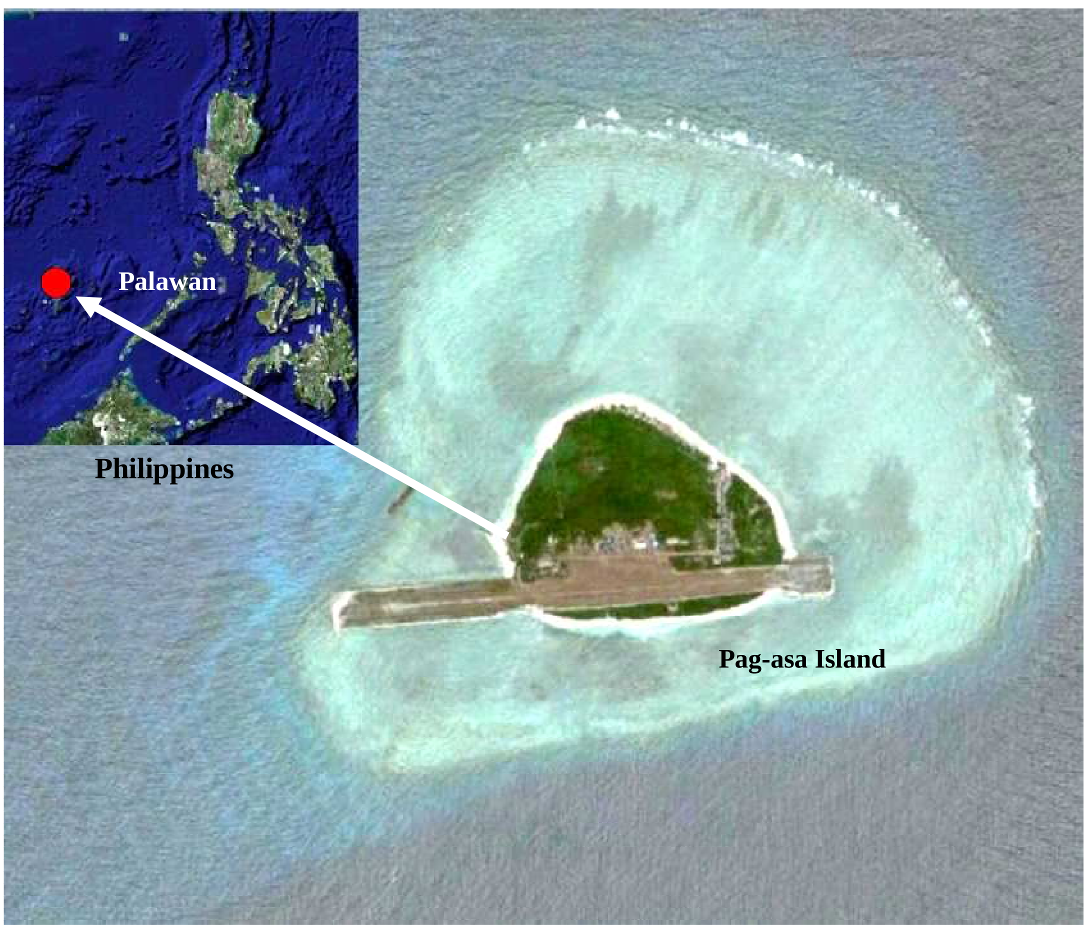

Figure 1. Google earth map of Pag-asa Island, KIG, showing its location with reference to Palawan and the Philippines (inset).

Upon arrival at Pag-asa Island Dr. Gonzales (Team Leader) and Mr. Bolen (Municipal Eco-tourism Officer) had a courtesy call with the Island Commander, his assistant and other officials. While mingling with the island residents, municipal and barangay officials, the survey team casually extracted information regarding the profile of the surrounding reefs and its resources.

The selection of locations for survey stations were based mainly from information gathered from island residents, boat crew, and fishermen. Locations of stations surveyed in previous studies were also considered in site selection.

II. LIVE COVER OF CORAL REEFS AROUND PAG-ASA ISLAND, MUNICIPALITY OF KALAYAAN, PALAWAN, PHILIPPINES

Joel G. Becira, Benjamin J. Gonzales, and Noli D. Dieron

Western Philippines University-Puerto Princesa Campus
Rafols Street, Puerto Princesa City, Philippines, 5300

Introduction

Coral reefs are essentially massive deposits of calcium carbonate that have been produced by coral polyps with addition from calcareous algae and other organisms that secrete calcium carbonate. They are the most dominant coastal ecosystem in the world, and the most diverse communities on earth.

Coral reefs support up to 3000 species of organisms including plants (phytoplankton, algae and seagrasses) and animals (sponges, jellyfish, soft corals, sea anemones, black corals, worms, crustaceans, mollusks, sea cucumber, and sea snakes). There are more than 2,000 species or 10% of the world's total number of species is found in coral reefs.

It inhabits millions of hectares of coastlines of tropical islands and continents. About 81,000 sq. km of coral reefs can be found in Indonesia and 27,000 sq. km in the Philippines. In Southeast Asia, only 25% of live coral cover is in good condition and only 5% of this are in excellent state. As much as 10% of the world's coral reefs have been degraded beyond recovery and another 30% is likely to decline within the next 20 years.

Average documented reef yield is 15.6 tons/sq. km/yr; if we destroy reefs, we destroy income for various beneficiaries in the order of US $50,000/sq.km/yr . Our country having 27,000 sq. km of coral reefs, if 50% of this is in a condition to support estimated revenues, coral reefs can contribute almost US $1 billion every year to the Philippine economy.

In order to mitigate the continuous decline of our reef communities, humans have developed several strategies, the most popular of which is the Marine Protected area (MPA). Marine Protected Areas were so established to serve as the generator and reservoir of diverse marine organisms directly or indirectly associated with the biological systems of the coral reef in particular and coastal habitats in general.

The Western Philippines University has been involved in coral reefs and fish assessments around islands and bays across Palawan and the Sulu Sea since 1987. The assessment were conducted either to form as basis for the establishment of a marine protected area, monitoring of coastal resources against the possible effects of development and other human actions, inventory of certain species, and to serve as basis for sustainable development planning for ecotourism.

Scientific studies already undertaken in Kalayaan Island Group were those conducted by UPMSI (Dantis et al 1999) and JOMSRE in 1997 and 2007. Dantis et al investigated distribution patterns and community structure of fishes, JOMSRE conducted biodiversity of fishes (Nañola et al 1997), and oceanographic and macrophyte biodiversity in 2007. Becira et al. of WPU, conducted reef fish assessment in Pag-asa Island in 2006.

However, until today, studies related to corals and coral reefs in KIG are nil and no concrete information on the conditions of coral reefs around Paga-asa Island is available. Thus, the main objective of this study is to determine the live coral cover of the coral reefs surrounding the Pag-asa Island and part of the adjacent Secret Reef.

Materials and Methods

Survey stations were selected through interview from boat crew, island residence, and some military officials in the Island. In connection with the eco-tourism agenda of the project, areas preferred for fishing and known to be abundant in benthic life forms were considered. In order to compare to previous studies, survey stations were also established in the west, east, south, and north of the island.

Figure 2. Map of Pag-asa Island and Secret Reef, showing the locations of coral and fish sampling stations.

Transects were laid between 6.7 to 20m (20 to 60 ft) water depths. Live benthic cover of Pag-asa Island was determined using the line intercept transect (LIT) method by English et al. (1997), which is a standard method popularly used in The Philippines and around the world (FRMP 2001; Becira 2004; Becira et al 2005, Gonzales et al, 2007). Ten stations were established, eight around the island of Pag-asa and two at the adjoining reef, locally called the Secret Reef (Fig. 2).

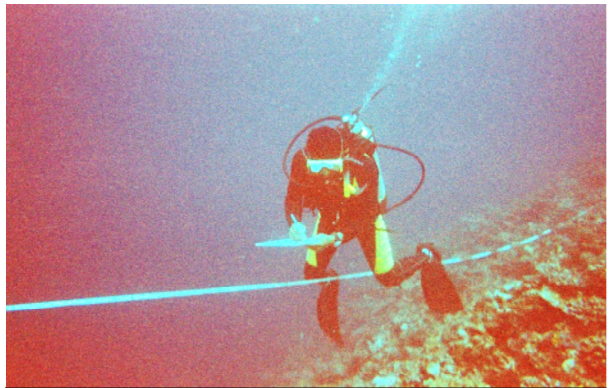

Figure 3. WPU research diver recording coral percentage at edge of drop-off in Station 1.

Three replicates of thirty meter transects were used in every station. Replicates were laid parallel to drop-off belts at around 8 m apart. All first replicates were laid along drop-off belts (Figs. 3 and 4) having depths between 10 and 20m (45 - 60ft) except in Station 7 (2m), while second and third transects were consequently laid towards upper slopes.

Markers made of empty plastic bottles were set in every station. Coordinates of stations were recorded, using Garmin II GPS. The graphical location of each station is found in Table 1.

Figure 4. WPU research diver, retrieving a transect line at a drop-off in Station 3.

Benthic cover was classified into hard corals (HC), soft coral (SC), others which include seafan, gorgonians, clams and crown of thorns (OT), dead corals which include recently dead corals, dead corals with algae (DC), coral rubbles (CR), sand (S), and rock (RCK).

Table 1. Geographical positions of coral and fish stations in this survey

Station	Latitude	Longitude
1	11° 2'46.32"N	114°16'48.54"E
2	11° 2'51.18"N	114°17'1.26"E
3	11° 2'55.80"N	114°17'21.60"E
4	11° 3'7.62"N	114°17'42.66"E
5	11° 3'40.62"N	114°17'11.40"E
6	11° 3'52.20"N	114°17'8.40"E
7	11° 3'11.52"N	114°16'52.50"E
8	11° 3'18.30"N	114°16'43.20"E
9	11° 4'56.58"N	114°15'29.04"E
10	11° 4'20.69"N	114°16'22.90"E

Percent benthic cover was determined by dividing the length of each of the benthic cover categories with the length of the transect line (30m) and was multiplied by 100. Mean of the three replicates represented the percent benthic cover of each station. The mean of 10 stations represented the average live cover of coral reefs in Pag-asa Island and part of Secret Reef.

Figure 5. Reef grooves, a common feature at reef fronts around Pag-asa Island; formed by continuous strong wave actions. Photo taken at Stations 5 (above), and 3 (below).

Results

The coral reefs surrounding the island are characterized by a flat reef extending seaward from the island, enclosed by a perimeter of relatively flat rocky and sandy substrate. At the edges of this flat corals are drop- offs with depth estimated to range between 20-33m (60-100 ft). The corals are dominantly grayish to white in color presenting dead corals, while some coral patches showed bright colors representing regenerating portions of coral communities.

The reef front of all coral reef stations, except 4, were characterized by grooves that were cut into the hard limestone surface most likely formed by the repeated pounding of surf and continuous movement of rubbles (Fig. 5). This manifests the existence of consistent ocean swells and strong wave action influencing the shape of the physical profile of the reefs surrounding the island. These grooves serve as shelter to dwelling and visiting marine organism, including fish.

Figure 6. Photograph of regenerating coral colony in Station 5, with 50.5% live cover.

Live coral cover in Pag-asa Island is presented in Table 2. Hard coral cover in the island ranged from 3.70 to 48.94% with an average mean of 24.38%. Station five had the highest hard coral cover with a mean value of 48.94%. It was followed by stations 7 and 4 with 41.50% and 40.10% hard coral cover, respectively. Below 10% hard coral cover was observed in stations 1 and 2 (Table 1).

Table 2. Mean percentage of benthic cover in Pag-asa Island, Kalayaan Island Group, May 2008

Benthic Category	**Station**										**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Live Benthic Cover	**5.40**	**12.92**	**21.88**	**41.75**	**50.97**	**28.60**	**45.82**	**13.21**	**31.49**	**22.76**	**27.48**
HC	3.70	6.06	21.88	40.10	48.94	27.44	41.50	11.55	29.61	12.99	24.38
SC	1.30	1.8	0.00	0.88	1.55	0.94	0.00	0.00	1.11	9.55	1.71
OT	0.40	5.06	0.00	0.77	0.48	0.22	4.32	1.66	0.77	0.22	1.39
Non-living components	**94.10**	**86.62**	**77.37**	**58.21**	**48.38**	**71.15**	**54.16**	**86.73**	**68.10**	**76.65**	**83.85**
DC	54.10	76.64	25.27	56.22	28.61	67.27	38.50	40.38	64.22	75.27	52.65
CR	32.40	9.43	0.00	0.44	0.00	0.00	10.33	36.99	0.00	0.00	17.92
S	7.60	0.55	5.55	0.00	2.33	0.00	4.33	6.99	0.00	0.00	5.47
RCK	0.00	0.00	46.55	1.55	17.44	3.88	1.00	2.37	3.88	1.38	7.81

Soft coral cover ranged from 0.00 to 9.55% and constituted 6.22% of the live benthic cover. Other organisms such clams, seafans, and gorgonians also composed the live benthic cover in the surrounding reefs of Pag-asa Island.

On the other hand, more than 50% of the benthic cover in most of the stations surveyed was dead corals with an average mean value of 52.65%. This figure includes recently dead corals and dead coral with algae. It was followed by coral rubble and rock categories respectively (Table 2).

Table 3. Reef condition in survey stations around Pag-asa Island, Kalayaan, Palawan, Philippines

Station	Hard Coral	Soft Coral	Total Coral Cover	Reef Condition
1	3.7	1.3	5	Poor
2	6.06	1.8	7.86	Poor
3	21.88	0	21.88	Poor
4	40.1	0.88	40.98	Fair
5	48.94	1.55	50.49	Good
6	27.44	0.94	28.38	Fair
7	41.5	0	41.5	Fair
8	11.55	0	11.55	Poor
9	29.61	1.11	30.72	Fair
10	12.99	9.55	22.54	Poor
Mean	**24.377**	**1.713**	**26.09**	**Fair**

Although one of the stations in Pag-asa Island belong to good coral cover category (Station 5, 50.49%) and four stations in fair coral cover category (Table 3), most of the stations are in poor category (less than 25% benthic cover) (Table 2). Generally, the health of corals in Pag-asa Island is in fair condition (Table 3).

Discussion

Average mean of live benthic cover in Pag-asa Island (27.48%) is little bit higher than that of St. Paul Bay (21.73%) located west of Puerto Princesa City, but lower compared to Honda Bay (50.93%), Bugsok Island (47.73%), Pandan Island (57.48%), and Sabang Reef (Binduyan) (51.31%) (Becira, in press).

The low coral cover in Pag-asa Island might be the result of the destructive fishing methods used in the vicinity. Coral rubbles in circular forms were observed during our dives in some stations, indicative of use of explosions. According to some local fishermen and island residents, foreign fishermen use explosives for catching fish in KIG.

On the other hand, in many areas we surveyed, the state of the coral reefs are: 1) coral's calcium carbonate structures remained intact and standing, but were devoid of live coral polyps, 2) whitish in color, and many are covered with algae indicate that these corals are dead.

Figure 7. Research divers preparing to ascend in Station 10 (Secret Reef); note dead coral community at background.

According to island residents, foreign fishermen use chemicals for catching and gathering fishes in this area. Additionally, the death of corals can not be attributed to coral bleaching, because these corals were observed in relatively deep (10-20m) waters, therefore not expose to extremely high temperature.

Other stations wherein massive occurrences of intact but dead standing coral structures like table corals may indicate the use of sodium cyanide fishing (Fig. 7). Presence of crown of thorns in the reefs of Pag-asa Island further aggravates the poor situation of the corals. The effect of the crown of thorns to the coral reefs is discussed further in the macro-invertebrate section of this report. Additionally, there was also report on gathering of coral boulders by foreign fishermen boats from the reefs of KIG.

The relatively high live coral cover in stations 4, 5, and 7 may be partly attributed to their locations. Station 4 is in the east end of the runway, where civilian residents and military personnel frequently fish, using hand lines, Station 5 is located in front of the Barangay Pag-asa, while Station 7 is situated in front of the military barracks.

Since, visibility of both island residents and military personnel might have deterred the destructive fishing activities of foreign fishermen in these areas, the possibility of using visibility as a strategy to deter foreign fishermen fishing around the island can be tried to further protect the other reefs in the island.

Among the stations, Stations 4, 5, and 7 are the candidate sites for fast recovery of corals. A popular and respected coral scientist Dr. Veron (Veron, 1986) noted that a coral reef devastated by crown of thorns can recover within a span of five to ten years. Thus, optimistically, if the coral reefs around the Island are properly protected, they could recover within five years, with preference to areas in Stations 4, 5, and 7.

However, Station 7 is the site where the future pier will be built, hence it is recommended that proper precaution should be taken to minimize impact of the pier structural elements to the island coastal habitats and resources. The inputs of developments and the preservation of the integrity of the island's marine resources should be balanced.

III. FISH ASSEMBLAGES IN CORAL REEFS AROUND PAG-ASA ISLAND PALAWAN, PHILIPPINES

Honorio B. Pagliawan, Edwin F. Rodriguez, and Benjamin J. Gonzales

Western Philippines University-Puerto Princesa Campus
Rafols Street, Puerto Princesa City, Philippines, 5300

Introduction

Fish is next to rice as the most important item in Filipino diet. The annual marine catch in the Philippines was 1.5 million MT in 1996, which is double the annual catch in 1970. The nearshore bottom fish stock has been reduced to only 30 % compared with 50 years ago. There are more than 400,000 fishing boats and 100,000 vessels operating in the Republic of the Philippine waters (Roldan, 2001). These combined circumstances leave almost all major bays in the country over fished.

On the other hand, reef-related fisheries yield an estimated 9-12 % of the world's total fishery of 70 million tons/year. Reef fishery contributes 8-20 % to the country's total catch. In small islands, this could reach 70%. The fishing industry in the country provides direct employment to roughly 1 million people, 68% from coastal areas (Roldan, 2001).

Fisheries is now not the sole or main source of livelihood by the coastal people, a big chunk of the income of some coastal communities comes from eco-tourism. As part of the initiatives to promote tourism and protect the Pag-asa Island resources, a resource assessment is necessary in the area. Resource assessment IS conducted to form as one of the bases for planning and development of the Island.

Several survey were already conducted in the island, however fish related survey was carried out a decade ago in 1998, and no recent comprehensive survey of fish and fisheries were conducted in the island. Thus in order to monitor and update the status of fish assemblages in the coral reefs around the island, a follow-up assessment should be conducted in the same area.

The main purpose of this survey is to assess the present status of reef fish communities around Pag-asa Island. Specific objective is to provide database on the fish diversity, abundance, and biomass that will serve as indicators of condition of the reefs. This will also serve as basis for detecting changes in fish stocks over time.

Materials and Methods

Ten stations were surveyed by visual census, using the Line Intercept Transect method (LIT) of English et al. (1994), around Pag-asa Island reefs between depths of 10 and 20m, (except in Station 7) from May 2 to 8, 2008. The length of transect used was 30m, employing three replicates per station. All first replicates were laid parallel to drop-off belts (Fig. 8), while second and third transects were subsequently laid towards upper slopes at around 8m apart. The researchers used mask and snorkel near the proposed pier site, station 7 (2m) and Self-Contained Underwater Breathing Apparatus (SCUBA) in the remaining nine stations.

All fishes encountered within 2.5m on either side, and 5m above the transect line were identified and recorded on an underwater slate board. Fish abundance was determined by actual counts. The total length of fish was estimated, and later used to estimate fish biomass. Parameters ***a*** and ***b*** were taken from Kulbicki et al. 1993 and a & b values developed by WPU.

For species with no available ***a*** and ***b*** constants, the known values of the closest relative with the most similar body size and shape were used. Global Positioning System (GPS) was used to record the coordinates of each station, so that it can be used as reference for future monitoring activity (Table1). References used for fish identification were; Gonzales (2005), Kuiter and Debelius (1993), Randall (1992), and Masuda et al (1984).

Figure 8. WPU researcher diver recording fishes along coral edge in Station 2.

Fishes were categorized as target (TGT), major families (MF), and as indicator (IND) (Table 2). Target species are those commonly utilized in fisheries with varying commercial values. Examples of target fishes are groupers (Serranids), snappers (Lutjanids), parrot fishes (Scarids), and rabbit fishes (Siganids). Major families are those group of fishes with less commercial value and less concern to fishermen. Indicator species are fish that are highly territorial such that their presence and abundance may indicate the condition of their habitat. Coordinates of sampling stations in Pag-asa Island is listed in Table 1.

Results and Discussion

The total number of species observed in ten stations was 248 (Appendix A), out of this 241 were identified to species level and distributed to 34 families (Table 3). However, three species were observed outside the transect lines: one grouper (Serranidae) *Gracila albimarginato* (30 cm), a bigeye (Prianchantidae) *Priacanthus hamrur,* and a soapfish (Grammistidae) *Grammistes sexlineatus* (10 cm). This added three more species to the above total of 248 to become 251 species (36 families) composing the reef fishes of the Pag-asa Island.

The families with high number of species were Labridae (ipes-padi/wrasse, 56), Pomacentridae (palata, 55), Acanthuriddae (labahita, 22) Chaetodontidae (tiol- tiol, 20) Scaridae (mulmul/parrot fish15), Holocentridae (buslit, 9) and Balistidae (pakol, 6).

The top five families represent 67.5.0% of the total fishes encountered during the survey. The total number of commercially valuable species shows a higher fisheries potential, having 104 species, comprising 41.8% of the total number of species observed along the transect lines.

In this report, commercially important species include fishes belonging to families of Serranidae (Groupers), Lutjanidae (Snappers), Labridae (Wrasses), Caesionidae (fusiliers/dalagang bukid), Acanthuridae (Surgionfishe/labahita), Nemipteridae (Breams/bisugo), and Scaridae (Parrotfishes). The result of the survey further shows that the target species (commercially important) represent 21.77%, major families 45.46 %, and indicator species 32.66% (Appendix A).

Table 4. Profile of associated reef fish species and some ecological indicators of reef fish conditions in ten sampling stations around Pag-asa Island, Palawan.

Station	Deep (ft)	Families	Diversity (species/1000m^2)	Density (individual/1000m^2)	Biomass (mt/km^2)	Remarks
1	25-60	17	*(47) 104	*(302) 671	89.3	very high
2	10-50	**21**	(51) 113	(307) 682	90.4	very high
3	10-23	14	(46) 102	(352) 607	35.9	high
4	21-45	16	(**81**) **187**	**(722) 1,589**	**228.7**	very high
5	21-25	15	(77) 176	(492) 1,535	214.0	very high
6	30-35	17	(63) 138	(504) 1,158	109.2	very high
7	4 - 6	16	(46) 102	(703) 1,562	28.5	high
8	10-23	19	(50) 118	(530) 982	90.4	very high
9	38-48	18	(74) 176	(463) 1,069	42.8	high
10	30-43	14	(63) 147	(370)826.67	30.7	high

***Actual count per station (450 m^2)

Total Fish Biomass = 959.9mt/km^2
Average Biomass = 96.0mt/km^2

The number of chaetodontids (Butterflyfishes) was considerably very low (2.7%). Butterflyfishes have been used as indicators for reef health since they are highly associated with coral reef, which corroborates with the poor condition of the reefs. Pomacentridae (Damselfishes) is known to be highly territorial reef fish. In this survey, this group had the highest individual count (1,647.00) with the relative abundance of (34.17%), followed by Acanthuridae, 574 (12.1%) and Labridae, 484 (10.2%).

The average fish biomass was estimated at 96.0mt/km^2. Station 4 has the highest fish biomass, 102,911.13 g/450m^2 (228.7mt/km^2), highest density (1,589 individual/1000m2), and most diverse (187 species/1000m^2), followed by station 5 with 96,314.61 g/450m^2 (214.0mt/km^2). The high biomass in the two sites maybe attributed to its location and the condition of corals in the area. Fishermen and local residents of Pag-asa Island claimed that the area is seldom visited for fishing.

Table 5. Fish family composition in the ten survey areas around Pag-asa Island

No.	**FAMILY**	**STATIONS**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Acanthuridae	3	3	6	12	8	5	1	5	7	11
2	Apogonidae	1	1	0	0	0	0	2	1	0	0
3	Aulostomidae	0	1	0	0	0	0	0	0		0
4	Balistidae	1	2	2	2	3	1	1	0	0	4
5	Blennidae	0	0	1	2	0	0	2	2	1	0
6	Caesionidae	0	0	0	0	0	0	0	0	2	1
7	Carangidae	1	1	1	0	0	0	0	1	0	0
8	Chaetodontidae	5	4	4	5	12	5	3	2	9	3
9	Cirrhitidae	0	0	1	2	2	1	0	1	1	1
10	Fistularidae	1	2	0	0	0	0	1	0	0	0
11	Gobiidae	0	0	0	0	0	0	0	0	1	0
12	Haemulidae	0	0	0	0	1	0	0	0	0	0
13	Holocentridae	2	1	0	6	0	1	0	0	1	0
14	Kyphosidae	0	0	0	0	0	1	0	0	0	0
15	Labridae	**10**	9	8	**23**	**21**	12	**17**	**13**	**25**	**21**
16	Lethrinidae	1	2	2	0	1	2	2	3	1	2
17	Lutjanidae	2	0	0	0	0	0	0	1	0	1
18	Microdesmidae	1	1	1	1	1	1	0	1	0	0
19	Monacanthidae	0	0	0	1	0	2	0	0	9	3
20	Mullidae	2	2	3	2	4	4	3	2	1	0
21	Muraenidae	0	0	0	0	1	0	0	0	0	0
22	Nemipteridae	0	0	0	0	0	0	2	0	0	0
23	Oplegnathidae	0	0	0	0	0	0	1	0	0	0
24	Ostraceidae	0	1	0	1	0	0	0	0	1	0
25	Penguipididae	1	0	0	1	0	0	1	1	1	0
26	Pomacanthidae	3	0	2	3	3	4	0	1	5	0
27	Pomacenthridae	8	**15**	**12**	15	13	**12**	8	11	7	12
28	Scaridae	2	1	0	4	4	7	2	0	6	2
29	Scorpionidae	0	1	0	0	0	0	0	0	0	0
30	Serranidae	2	2	3	2	2	2	0	1	2	1
31	Siganidae	0	0	0	0	0	0	1	1	0	0
32	Synodontidae	0	0	1	0	0	0	0	0	0	0
33	Tetraodentidae	0	0	0	0	0	0	0	0	0	1
34	Zanclidae	0	1	0	1	1	1	0	1	1	0

The abundance of fish was estimated at 1.1 individuals/m^2, with the average fish density of 1,068.2 individuals/1000 m^2 is categorized as moderate density. The high category ranged from 2,268 to 7,592 indv./1000 m^2 density (Hilomen et al., 2000).

Based on the category of Hilomen et al, (2000), the average fish biomass (96.00mt/km^2) of Pag-asa Island can be categorized as very high. This result is far higher than that of 1998 survey in Pag-asa Island, with an average biomass of 23.3 mt/km^2 only (Dantis, et al.), in four sites around Pag-asa Island. (North, South, East, West) (Table 7).

On the other hand, in the result of survey (using mask and snorkel only) conducted by Becira, et al, in the Island in April 2006, the total fish biomass for the five stations around Pag-asa Island was further lower with only 12.0 mt/km^2 (average, 2.0 mt/km^2). The fish biomass of surveys made in 1998 (four sites) and in 2006 (five sites) in Pag-asa Island were considered high and very low, respectively (Table 7). However, since the exact locations of the previous survey sites were not documented it is difficult to analyze the time series trend of fish biomass in the area.

Since the 2006 fish survey sites were located inside the "barrier" reefs (very low biomass), while our study was conducted in drop-off belts (very high biomass), it could be deduced that fishes are still concentrated at the drop-off areas around the Pag-asa Reefs, though some species of small groupers (lapu-lapu) and siganids (padas/danggit) were observed to be relatively abundant inside the Pag-asa " barrier" reef.

Considering that some areas surveyed in this study were categorized as having fair coral cover, this might have contributed to the high biomass reflected in the result and maybe due to the wide area surrounding the island and the favorable water movement brought by tidal currents influencing the diversity and productivity of the area.

Figure 9. *Acanthurus nigricans,* a surgeonfish species observed in Pag-asa Island , but not yet recorded in the waters around mainland Palawan.

With this premise, primary productivity of waters around the island would be an interesting topic to study. Thus, parameters to be investigated regarding the abundance of fishes in Pag-asa Island are: the relationship of fish abundance to the reef profile, primary productivity of the waters surrounding the island, and the relationships between fishes and the attached algae in dead coral reefs.

Although coral cover in Pag-asa are dominated by dead corals, the diverse physical profile of the island reefs: wide flat reef, drop-off, reef grooves, etc provides shelter to various kinds of fishes. In addition, algae covering wide surface area of coral rubbles and dead coral structures likewise serves as food to fishes, especially omnivores/herbivores (plant/algae feeding) species. This is why the fishes in Pag-asa is dominated by algae-eating species like: labrids (ipes-padi/wrasse), pomacentrids (palata/damsel), acanthurids (labahita/surgeon fish) chaetodontids (tiol-tiol/butterfly fish) scaridae (mulmul/parrot fish15), and balistidae (pako/triggerfish).

Figure 10. *Hemitaurichthys polylepis*, a butterflyfish species observed in Pag-asa Island , but not yet recorded in the waters around mainland Palawan.

The results of the survey also show that there were fifty two (52) species of reef fishes distributed to nineteen (19) families recorded around Pag-asa Island, which are not encountered in the previous fish visual census conducted in the six areas around mainland Palawan waters (Table 6).

Examples of this species are (1).*Acanthurus nigricans* (Acanthuridae) (Fig. 9). The caudal fin is slightly imarginate; black with white spot broader than eye; a narrow white band encircling mouth; a yellow band at base of dorsal and anal fins which broadens to nearly full height of these fins posteriorly; caudal fin whitish with a yellow bar on posterior third. This species is widely distributed around Pag-asa Island and nearby reefs up to a deep of 60 feet (18.3 m.)

Figure 11. *Gnathodentex aureolineatus*, Gold-lined Emperorfish, observed in Pag-asa Island, but not recorded yet in waters around mainland Palawan.

(2). *Hemitaurichthys polylepis* (Chaetodontidae) (Fig. 10). The body has white with triangular yellow area behind head (broader at top); dorsal fin and an area below soft portion of fin yellow (thus causing the broad white area of middle of body to be narrower at the top); caudal peduncle and anal fin white; anal fin yellow; head dark brown.

This species is encountered at station 2 (Fig. 2) at the depth of 50 ft., having an estimated length of 12 cm, swimming solitarily.

(3). *Gnathodentex aureolineatus* (Lethrinidae) (Fig. 11), several scale rows on check; inner base of pectoral fin scaleless; back finely striped with bluish silver and tellowish brown on side and below with 4-5 yellow or copper stripes; a large yellow blotch below rear end of dorsal fin; distal margins of median fins red.

This species is usually encountered in large aggregations anywhere around the island especially south of the island, juveniles were observed to shelter between reef grooves and also around the navy ship aground near shore in station 7.

A number of mature and big-bellied species of groupers (serranids/lapu-lapu), surgeons (acanthurids/labahita), and wrasses (labrids/mulmul) were observed in Stations 3 and 9. Further studies focused on potential for reef fish spawning aggregates in these areas is recommended.

Table 6. List of fish species and families observed around Pag-asa Island, but were not recorded yet in the mainland Palawan waters.

Family	Scientific Name
Acanthuridae	*Acanthurus nigricans*
	Acanturus glaucopareius
Ballistidae	*Sufflamen chrysoptera*
	Sufflamen frenatus
	xanthichthys auromarginatus
Blennidae	*Aspidontus taeniatus*
	Plagiotremus rhinorhyncus
Chaetodontidae	*Forcipiger longirostris*
	Forcipiger flavissimus
	Hemilaurichthys polylepis
	Chaetodon ornatissimus
	Chaetodon citrinellus
	Chaetodon unimaculatus
Cirrhitidae	*Paracirrhites arcatus*
	Paracirrhites forsteri
Fistularidae	*Fistularia commersonii*
Gobiidae	*Valenciennea strigata*
Holocentridae	
	Sargocentron ittodai
	Myripristis pralinea
Labridae	*Anampsis caeruleopunctatum*
	Cirrhilabrus scottorum
	Coris auirilineatus
	Coris gaimard
	Psuedocheilinus evanidum

	Psuedocheilinus octotaenia
	Labroides pectorales
	Labropsis xanthonota
	Halichoeres biocellatus
	Thalassoma trilobatum
	Thalassoma cupido
	Thalassoma quinquevittatum
	Thalassoma amblycephalum
	Thalassoma janseni
Kyphosidae	*Microcanthus striagatus*
Lethrinidae	*Gnathodentex aurilineatus*
Lutjanidae	*Aphareus furca*
Microdesmidae	*Nemateleotris magnifica*
Mullidae	*Parupenues bifasciatus*
Pinguipididae	*Parapercis hexopthalmus*
	Parapercis millepunctata
	Parapercis cylindrica
Pomacanthidae	*Cyntropyge flavissimus*
Pomacentridae	*Pomacentrus dickii*
	Pomacentrus wardi
	Chromis xanthurus
Scaridae	
	Scarus dimidiatus
	Scarus rubrioviolaceus
Serranidae	*Gracila albimarginata*
	Pseudoanthias sp.
	Pseudoanthias bicolor
	Liopropoma multilineatum
Siganidae	*Siganus argenteus*
19	**52**

Table 7. Trend of Reef fish abundance, diversity, and biomass of Palawan

Site	No. of Families	No. of species	Ave. Biomass (mt/km^2)
Apulit Is, Taytay Bay	20	110	61.94
Tabuyo Fish Sanctuary	16	51	22.94
Green Island Bay	33	210	36.87
St. Paul Bay	15	104	29.26
Pandan Island	29	178	84.00
Pag-asa Island (1999)	-	-	23.30
Pag-asa Island (2005)	14	32	2.04
Pag-asa Island (2008)	**34**	**257**	**96.00**
Honda Bay	-	-	27.11

The waters around Pag-asa Island remains a potential fishery ground, in terms of fishery resources, which is worthy of conservation in order to sustain the long term benefit that we are suppose to gain from it.

IV. MACRO-INVERTEBRATES IN CORAL REEFS OF PAGASA ISLAND, KALAYAAN ISLAND GROUP, PALAWAN, PHILIPPINES

[1]Benjamin J. Gonzales, Joel G. Becira, and Johanne G. Gonzales

[1]Western Philippines University-Puerto Princesa Campus
Puerto Princesa City

Introduction

Marine invertebrates are animals with no vertebrae or backbones. They represent more than 98% of the animal kingdom (Pechenik, 1996). Lately, the author conducted several invertebrate surveys and monitoring to get information on their commercial and eco-tourism potentials, however, invertebrates are studied to know the state of the marine environment and measure the degree of exploitation. For instance, the presence of tunicates indicates poor water quality, high nutrient content in water when zoanthids abound, and the number of filter feeders is related to water contamination due to high concentration of trace metals.

Additionally, invertebrates serve as major food of vertebrates and as pollinators of marine food plants (Barnes *et al*, 1993). Economically, large marine invertebrates provide income and food for fishermen. If properly managed, it can become an additional source of income for the fishermen and communities (Gonzales et al, 2005)

WPU has conducted several surveys on invertebrate along the coasts and islands of mainland Palawan: Pandan, Arraceffe, Snake Islands and reefs of Honda Bay, St. Paul Bay, and Tubbataha Reef. This is the second offshore island invertebrate survey of WPU, second to Tubbataha Reefs. UPMSI was known to have brought some giant clams to the island for stock enhancement sometime late 90's. However, this is the first time that macro-invertebrates were surveyed in the Pag-asa Island.

This study will focus on macro-invertebrate species of commercial, eco-tourism and ecological importance. Thus the main objective of this study is to determine the species composition, and abundance of large invertebrates, i.e., mollusks, echinoderms, etc. in the study area.

Figure 12. A researcher diver reading the transect line for macro-invertebrates in Station 5. Please note the COT in the foreground.

Materials and Methods

The authors went with fish and coral group to survey macro-invertebrates in

10 stations around the Pag-asa Island. The fish census, macro-invertebrate, and coral teams used the same transect lines for the assessment. Corals and invertebrate teams collected their data right after the first transect was laid, while the fish team descended from the dive boat right after the second transect was laid by the coral/macro-invertebrate team.

Stations were surveyed using line intercept method (English et al, 1994), between depths of 10 and 20m, (except in Station 7) from May 2 to 8, 2008. The length of transect used was 30m, employing three replicates per station. All first replicates were laid parallel to drop-off belts at around 8m apart, while second and third transects were subsequently laid towards upper slopes (Fig. 12).

Results and Discussion

There were eight distinct kinds of macro-invertebrates observed in ten sampling stations: giant clams (taklobo), sea cucumbers (balatan), topshells (samong), lobsters (banagan), sipunculids, crown of thorn (dap-ag/COT), sea urchin (tirik), and other starfishes.

Figure 13. Starfish (*Linckia laevigata*) Blue linckia in Station 9.

Starfishes were mainly composed of Ohidiasterids and Oreasterids, Blue Linckia (*Linckia spp.*) and Cushion Star (*Culcita spp.*), respectively. Dominant macro-invertebrate species were COT, tridacna, and starfishes. Number of macro-invertebrates and density/m^2 observed in every station in Pag-asa Island is presented in Table 8.

Across stations, among commercial macro-invertebrates around Pag-asa Reefs and portion of Secret Reef, giant clams have the highest density, followed by starfishes not including COT.

Station 2 (Fig. 8) has the highest number of giant clam species, having a density of 0.018 shells/m^2 (8 individuals/450 m^2). Or we can find one giant clam in every 56.25 m^2 of this area. The giant clam densities in Stations 1, 3, and 8 were 0.0067/m^2 or one shell can be found in every 150 m^2 (Fig. 14), while sea cucumber and topshell were noted only in station 3.

Figure 14. Giant clam (*Tridacna sp.*), imbedded in coral rock in Station 3.

These results have implications to commerce and eco-tourism. Although the clams in this station were relatively young with small sizes, divers who seek to see giant clams may visit station 2, Protection or regulation from further extraction of this marine resource will increase the size and number of giant clams in southern part of the Pagasa Island.

The average density of giant clams in Pag-asa Island (0.43 ind./100m^2) is far lower than other sites that we have surveyed: 6.81ind/100m^2 in Apulit Island, Taytay Bay; 0.7ind./100m^2 in Caramay, Green Island Bay, Roxas; 1.5ind/100m^2 in Green Island (Condesa 2005); 4.4ind/100m^2 in Tubbataha Reef (Dolorosa & Schoppe 2005) and 5.99ind/m^2 in Malampaya Sound, Taytay, Palawan (Sayson 2003). However, the density of giant clams in station 2 (1.8 ind/100m^2) is higher than the average density in Green Island (1.5 ind/100m^2).

Figure 15. Green Spiny Lobster (*Panulirus versicolor*), caught from drop-off.

It is worth to note that the above-mentioned survey areas with high densities of giant clams are protected areas (Apulit Island, Caramay, Tubbataha, and Malampaya Sound), while ones with low densities are not protected areas: Green Island and Pag-asa Island. Thus, it could be inferred that if the giant clam areas in Pag-asa Island are protected, it is most likely that the density of giant clams will increase just like the above-mentioned protected areas.

On the other hand, one spiny lobster per station was observed in stations 6 (Pag-asa Island) and 9 (secret reef). The presence of lobsters in these areas indicates that these areas are wild habitats of lobsters. Although only one lobster was observed per station during day time, there is greater chance that more number of lobsters could be present at night time. Since lobsters are nocturnal organisms, they generally go out from coral or rock ledges and crevices to search for food at night.

In addition, according to island residents, lobsters are still being sought and caught by Taiwanese, Vietnamese and local diver fishermen along the drop-offs of these reefs at night (Fig. 15). This shows that lobster resources might still be viable in this area, though thorough study should be conducted for this matter.

Figure 16. Crown of thorns (*Acanthaster planci*), preying on coral polyps.

If we want to ensure improvement of the condition of spiny lobster resources in the island, lobster areas should be properly managed, through protection. However, protecting resources in an open access body of water like in Pag-asa Island is complicated and requires long period of gestation along with various considerations.

A management scheme which will conserve lobster resources in areas where protection and regulation could readily be enforced by the Philippine and municipal governments could be a solution for sustainable use of the lobster resources of the island. Strategies on conservation and management of lobster in Palawan are discussed in Gonzales and Taniguchi (1995).

For example, transferring lobsters in areas inside the "barrier" reef surrounding the island. Lobsters could be transferred in this area for growing and later for breeding. Lobsters should be provided with habitat which would allow them to shelter, feed, and breed. This situation would likewise able the community and the military unit to enforce appropriate laws within the immediate vicinity of the island, and eventually benefit from the localized management effort.

COT is one of the most prominent enemies of coral reefs (Fig. 16). It was found abundant in stations 4 to 6, with 61 individuals (highest) recorded in Station 5 (Fig. 12). This is expected since Station 5 has the highest live coral cover, composed mostly of regenerating corals (Fig. 6). COT tends to accumulate in this portion of the reefs because of the available food (coral polyps) to eat. An area with a COT density of 150/ha or above is said to have an outbreak of COT (Schoppe, 2000), which is a great threat to its immediate coral community. Basing from the estimated densities in our stations, all stations were in COT outbreak condition during the survey except stations 7 and 8. Station 7 was situated in shallow water (2m) area dominated by seagrass, thus COT was not expected to be observed in this station.

Table 8. Number of invertebrates and (density/m^2) observed in every station in Pag-asa Island

Station/ Invert	**Tridacna**	**Starfish**	**Sea cucumber**	**Topshell**	**Lobster**	**Sipunculid**	**COT**	**Sea urchin**
1	3 (0.0067)	–	–	–	–	–	8 (0.018)	–
2	8 (0.018)	2 (0.004)	–	–	–	1 (0.002)	9 (0.020)	–
3	3 (0.0067)	1 (0.002)	1 (0.002)	3 (0.0067)	–	–	10 (0.022	–
4	–	–	–	–	–	–	36 (0.08)	–
5	2 (0.004)	1 (0.002)	–	–	–	–	61 (0.136)	–
6	4 (0.0089)	20 (0.04)	–	–	1 (0.002)	–	36 (0.08)	–
7	-	–	–	–	–	–	–	8 (0.018)
8	3 (.0067)	4 (0.0089)	–	–	–	–	5 (0.011)	–
9	1 (0.002)	7 (0.016)	–	–	1 (0.002)	–	29 (0.064)	–
10	_	1	_	_	_	_	_	_
Ave.	1.6 (0.0053)	3.6 (0.0075	.1 (0.0001)	.3 (0.0007)	.1 (0.0004)	.1 (.0001)	19.3 (0.0043)	.8 (0.0018)

On the other hand, coral reefs in Station 8 were noted to have a gloomy appearance brought about by traces of small oil patches on corals. This may be the reason why COT could not thrive in this area. According to island residents, the oil patches in station 8 could have came from the aground navy boat near the station.

Collection and proper disposal of COT should be considered, since COT outbreak poses a major threat to the regeneration corals all over the reef communities of the Pag-asa Island.

In terms of diversity, station 3 has the highest number of kinds of macro-invertebrates. This site could be a potential dive site for macro-invertebrate viewing. On the other hand, sea urchin was observed in station 7, this area was a relatively shallow seagrass bed with growing corals. The density of sea urchin in this station is 0.018/m2 (Table 8) or we can find one sea urchin in every 56.25 m^2 of this area.

The *Strombus canarium* shell (pasyak) was found to be very common in the inter-tidal zone, which we did not have survey station. This shell was not found in any of our station. This shell serves as food and could be a candidate as additional livelihood for island residents.

Similarly, the Gracious Sea Urchin (*Tripneustes gratilla*), known as tirik in local dialect (Fig. 22), also abounds the seagrass beds surrounding the island, particularly inside the "barrier" reef. This sea urchin is also a candidate as a livelihood product for the island inhabitants and the municipality. Livelihood opportunities are discussed in a separate section in this report.

All of the above-mentioned invertebrates, except COT, are worth conserving and protected for food, livelihood, and eco-tourism purposes, thus proper management of these resources is strongly recommended.

V. MACROPHYTE COMMUNITY STRUCTURE OF PAG-ASA ISLAND, WESTERN PALAWAN, PHILIPPINES

Ria S. Sariego, Bernaldo Montaño, and Joseph P. Gallo

Western Philippines University, Puerto Princesa Campus
Sta. Monica, Puerto Princesa City

Introduction

Macrophyte communities in the marine environment are composed of various species of seaweeds and seagrasses. These plants play an important ecological role in the marine ecosystem. They are the primary producers. They form the base of food chain and help oxygenate the water for animal life to thrive. Many large, fleshy algal species serves as human food and source of economically important phycocolloids. They also act as breeding, nursery and feeding areas for many vertebrates and invertebrates.

The tiny turf algae, crustose coralline red algae and calcareous green algae likewise play significant roles in the marine ecosystems. The turf algae are the first to colonize vacant substrate and cover essentially every vacant surface on the reef. These algae serve as important food source for herbivorous fish and invertebrates. The calcareous green algae contributes calcium deposit on the reef system, while the crustose coralline algae act as a glue that cements together loose components of the reef system and serves as a settling surface for larval invertebrates and other algae.

Seagrasses also play a significant role in the marine ecosystem. Like seaweeds, they serve as feeding, breeding, shelter and nursery areas for various marine organisms. They also produce food for various economically valuable fish and invertebrate species. The dugong and sea turtle depends on seagrasses as food source.

The seagrass ecosystem is connected on the landward side to mangroves and to coral reefs on the seaward side. The seagrass meadows contribute to the productivity of these two ecosystems through the transfer of nutrients and particulate matter. They also act as a hydrodynamic barrier, reducing the wave energy which could otherwise scour mangrove forests.

They act as a sediment stabilizer, preventing erosion and siltation that could smother the coral reefs. Due to this interconnectedness, the destruction and loss of seagrasses will not only result to the loss of biodiversity but also to the impairment of ecological stability of other ecological ecosystems.

In contrast to seaweeds or algae, seagrasses flower, develop fruit and produce seeds. There are 50 species of seagrasses worldwide, 16 of which are found in the Philippines.
The value to fisheries in seagrass bed was estimated in Puget Sound, Washington to be USD 412,324/.4 hectare of eel grass bed annually. However, no total inventory of this resources

have been made in the Philippines and there are only few available information on biology and ecology of seagrass and seaweeds in Southeast Asia.

Thus this assessment tends to contribute to the knowledge of seagrass and seaweeds in the region, focusing on the species composition and abundance of macrophytes particularly seagrasses and seaweeds present around the vicinity of Pag-asa Island, Kalayaan, Island Group, Palawan, Philippines.

Materials and Methods

Site Selection

An ocular inspection was conducted around the island before actual sampling was conducted. Two sampling stations were identified (Figure 17). These stations were located in the southern (Station 1) and southwestern (Station 2) part of the island. These stations are described below:

Station 1. This site is located in the southern portion of Apulit Island. It is moderately exposed to wave action during the northeast and southwest monsoon. It has sandy and coralline and dead coral substrates. The algal bed is dominated by *Sargassum* spp. and *Polysiphonia* sp.

Station 2. This site is situated in the southwest portion of the Island. It is protected from the effect of northeast monsoon but heavily exposed to wave action during the southwest monsoon. It has sandy and coralline substrate with inhabited by a dense colony of tridacnids. Its algal bed extends 10 to 100 meters from the shore dominated by *Sargassum* spp.

Only patches of seagrasses composed on *Halophila ovalis* and *Cymodocea rotundata* occur in the two stations.

Description of Sampling Sites

Three sampling stations were established around Pag-asa Island. These were located in the northeastern (11°03.05'N and 114°17.01'E), Station 1; northwestern (11°03.21'N and 114°17.22'E), Station 2 and southern (11°03.22'N and 114°16.93'E) Station 3, sides of the island, (Figure 1). Station 1 is characterized by sandy to corally substrate with an extensive seagrass bed running to ~500 m from the shore. This site is inhabited by a large population of rabbitfishes, sea urchins, groupers and gastropods.

The site is heavily exposed to wave and wind action during northeast monsoon but free from the blow of southwest wind. Station 2 is characterized by sandy to coral rubble substratum. The seagrass bed runs to only 200 meters from the shore but with unusually high density of *T. hemprichii* seedlings. The outer edge of seagrass bed is littered with dead corals. About

200 meters offshore of the station lies the shipwrecked military vessel which serve as a wind and wave breaker in the area.

Shoreline deformation caused by drowned military structures was evident in the station. This site is exposed to the effects of both northeast and southwest monsoons. Station 3 has the same substrate characteristics as Station 2. However, this site inhabited by patchy vegetation of seagrasses associated with seaweeds of the group rhodophyceae and chlorophyceae. The transect ends at 200 m where substrate shifts to coral rubble and rocks with no vegetation. The shoreline serves as nesting area for green turtles. This site is heavily exposed during southwest monsoon.

Figure 17. Map of Pag-asa Island showing the location of sampling stations.

Sampling

Systematic sampling was employed using the line transect/quadrant method. The transect line was laid perpendicular to the shore from 0 meter initial point up to 500 meters seaward depending on the stretch of seagrass bed. A 0.25 m^2 metal quadrant frame subdivided into 10 cm x 10 cm areas where laid down at regular interval on both sides of the transect line starting from the inner edge of seagrass bed. All seagrass and seaweed species found within the quadrant were identified *in situ*. The frequency and cover of all marine macrophytes intercepted were estimated using the method described by Saito and Atobe (1970). Other marine macrophytes species encountered were likewise identified and recorded.

Ecological Indices and Data Analysis

The cover occupied by a particular species in each quadrat was computed using the formula:

$$C = \frac{C_1}{25} + \frac{C_2}{25} + \ldots + \frac{C_{qn}}{25}$$

where qn: number of 10 x 10 cm areas in which the species appeared, and C/25 represents the indices 1 to 5 as described by Saito and Atobe (1970). The relative cover of each species was determined to show the proportion of the species' cover to the total cover of all species using the formula: RC = C/TC x 100, where C is the cover of each species and TC is the total cover of all species.

The species frequency was calculated using the formula:

$$F = \frac{qn}{25} \times 100$$

The relative frequency of each species was also determined to show its proportion relative to the occurrence of all macrophyte species using the formula RF = F/TF x 100, where F is the frequency of each macrophyte species and TF is the total frequency.

The mean cover values of seagrass and seaweed species were used for the computation of species ecological indices such as Simpsons's Dominance Index, Shannon's Diversity Index and Pielou's Evenness Index (Odum 1977). The Simpson's Dominance Index (*c*) was computed as:

$$c = \sum (n_i/N)^2$$

where: n_i = percentage cover of each species
N = total cover value of all species

Using similar n_i and N variables, the Shannon's diversity indices (H) of macrophyte communities were computed as:

$$H = -\sum [(n_i/N) \log (n_i/N)]$$

Pielou's Evenness Index (*e*) uses the Shannon's diversity index and computed as

$e = H/\log S$ where: S = total number of species

Results and Discussion

Species Composition and Community Structure

A total of two species of seagrass and twenty eight seaweed species were recorded in Pag-asa island (Table 9). The seagrass species consist of *Thallasia hemprichii* and *Halodule pinifolia*. *Thallasia hemprichii* dominates the macrophytes in the island having a percent frequency and cover of 80.166 and 87.380 respectively (Table 10; Fig. 18). It has a mean density of 882 shoots per m^2. They occur as monospecific beds in northeast and northwest part of the island with a rate of occurrence of 80.83% and 74.04%, and dominance of 54.79% and 46.24%, respectively.

A mixed seagrass community composed of the two aforementioned species was observed in south Pag-asa, *T. hemprichii* are mainly present nearshore to about 150 meters seaward, dominating the community from this point onwards are the *Halodule pinifolia*. Of the two species, *T. hemprichii* dominates with a rate occurrence of 53.75% and dominance of 37.12% as compared to *H. pinifolia* with only 5.30% and 3.98%, respectively.

Figure 18. Exposed more than 80% *Thallasia hemprichii* dominated seagrass bed at low tide, north beach of the island (Station 1).

Halodule pinifolia population likewise is small compared to that of *T. hemprichii* having a mean shoot density of only 60 shoots per m^2. Though their population is small, *H. pinifolia* played an important role in the establishment of seagrass community in the island. This species are fast-growing and known to first colonize areas not inhabited by other species of seagrasses. They stabilize loose sediments and promotes the establishment and colonization of the slower-growing seagrass species.

In the case of south Pag-asa, the portion that is currently inhabited by *H. pinifolia* would later be colonized by *T. hemprichii* and possibly other seagrass species. The *Thallasia hemprichii* is classified as a climax seagrass species indicating that the seagrass community in the island is stable.

The stability of seagrass community in the Pag-asa Island is further supported by high density of *Thallasia hemprichii* seeds germinating and seedlings growing around the island (Fig. 19). *T. hemprichii* is a perennial seagrass species and the seagrass meadows it has formed can be deduced to support the population of sea turtles that breeds on the island. This seagrass community likewise supports the population of rabbitfishes, surgeonfishes and other herbivitory fish species that thrives in the coastal waters and the wading bird population in the island.

Figure 19. Exposed seagrass bed of mostly *Thallasia hemprichii* at low tide, west beach of the island (Station 2).

The species diversity of seagrass in Pag-asa Island is very low, having only two species out of 16 species in the country and against 50 species of seagrass worldwide.

The seaweed species collected occur only as associates of the seagrass community. Of the twenty eight species of seaweeds observed in the island, 16 species were present in northeast part of the island, 19 species in northwest side, and southern portion of the island. These were composed of 16 chlorophytes, seven phaeophytes and five rhodophytes (Table 9).

The seaweed species contributes only 10.12 percent to the total macrophyte cover (Table 10). Of the seaweed species, *Dictyota* sp. and *Halimeda cylindraceal* dominate with relative cover of 39.64% and 12.97%, respectively. *Dictyota* sp. is also the most abundant species with the relative frequency of 24.11%. The least abundant and dominant among the seaweed species is the *Valonia aegagrophila* with relative frequency and cover of only 0.07% and 0.01%, respectively.

Based on their cover, the seaweed community in the island can be classified as Phaeophytan dominated, a typical seaweed community in a reef ecosystem. The Pag-asa Island can be said to have the least diversity of seaweeds and seagrasses in Palawan which can be explained by its location and the nature of its substratum.

Table 9. Classification and Distribution of Seaweed Species Collected in Pag-asa Island, Kalayaan, Palawan.

Species	Location		
	NorthWest Pag-asa	NorthEast Pag-asa	South Pag-asa
D: CHLOROPHYTA			
O: Cladophorales			
F: Anadyomenaceae			
Microdictyon okamurae		X	
O: Siphonocladales			
F: Siphonocladaceae			
Boergesenia forbesii	x		
Boodlea composita	x	X	
F: Valoniaceae			
Dictyosphaeria cavernosa	x	X	
Dictyosphaeria verluysii	x	X	x
Valonia aegagrophila	x	X	
O: Bryopsidales			
F: Bryopsidaceae			
***Bryopsis* sp.**			
F: Caulepaceae			
Caulerpa serrulata		X	x
F: Codiaceae			
Codium arabicum		X	
F: Halimedaceae			
Halimeda cylindracea	x	X	x
Halimeda discoidea	x	X	x
Halimeda incrassata		X	x
Halimeda opuntia	x	X	x
F: Udoteaceae			
Udotea argentea		X	x
O: Dasycladales			
F: Dasycladaceae			
Bornetella nitida			x
Neomeris annulata	x		x
Neomeris vanbossae		X	
D: PHAEOPHYTA			
C: Phaeophyceae			
O: Dictyotales			
F: Dictyotaceae			
Dictyota linearis		X	
Dictyota sp$_1$	x		
Padina minor	x	X	x

O: Scytosiphonales			
F: Scytosiphonaceae			
Hydroclathrus clathratus			x
Hydroclathrus tenuis	x		
O: Fucales			
F: Sargassaceae			
Sargassum polycystum	x		
Turbinaria conoides		X	
D: RHODOPHYTA			
C: Rhodophyceae			
O: Bonnemaisoniales			
F: Galaxauraceae			
Galaxaura fasciculata	x		x
Galaxaura oblongata		X	
O: Gelidiales			
F: Gelidiaceae			
Gelidiella acerosa	x	X	x
O: Gigartinales			
F: Gracilariaceae			
Gracilaria sp.	x		
F: Rhodomelaceae			
Acanthophora muscoides			x
Wurdemannia miniata	x		

Table 10. Mean percent frequency (F), relative frequency (RF), mean cover (C), relative cover (RC) of macrophytes collected in Pag-asa Island, Kalayaan, Palawan.

SPECIES	NorthWest Pag-asa		NorthEast Pag-asa		South Pag-asa		Relative Frequency	Relative Cover
	F	C	F	C	F	C		
SEAGRASS								
Thalassia hemprichii	74.038	46.243	80.827	53.797	53.754	37.125	80.166	87.380
Halodule pinipolia					5.303	3.977	2.038	2.522
SEAWEEDS								
Chlorophyta								
Boergesenia forbesii	8.000	0.750					3.074	0.001
Boodlea composita	0.196	0.070	0.668	0.304			0.332	0.237
Bornetella nitida					0.042	0.002	0.016	0.001
Caulerpa serrulata			0.184	0.030	0.542	0.111	0.279	0.089
Dictyosphaeria cavernosa			1.720	0.766			0.661	0.486
Dictyosphaeria verluysii	0.189	0.018	0.230	0022	0.208	0.035	0.241	0.048
Halimeda cylindracea	1.648	0.267	0.804	0.241	4.307	1.559	2.597	1.311

Halimeda discoidea					0.750	0.088	0.288	0.056
Halimeda incrassata			0.336	0.051	0.405	0.036	0.285	0.055
Halimeda opuntia	0.079	0.176	0.598	0.172	0.042	0.004	0.276	0.223
Microdictyon okamurae			0.130	0.020			0.049	0.013
Neomeris annulata	0.157	0.011			0.792	0.037	0.364	0.030
Udotea argentea			0.230	0.147	0.125	0.031	0.136	0.113
Valonia aegagrophila	0.032	0.002					0.012	0.001
Phaeophyta								
Dictyota sp.	11.165	6.319					4.290	4.007
Hydroclathrus clathratus					0.042	0.008	0.016	0.005
Hydroclatrus tenuis	0.032	0.003					0.012	0.002
Padina minor	1.808	0.735	1.000	0.148	2.250	0.544	1.944	0.905
Sargassum polycystum	0.032	0.024					0.012	0.015
Turbinaria conoides			0.046	0.004			0.017	0.003
Rhodophyta								
Acanthophora muscoides					5.553	1.962	2.133	1.244
Galaxaura fasciculata	1.543	0.653			0.042	0.031	0.609	0.434
Gelidiella acerosa	0.178	0.111	0.843	0.393	0.167	0.047	0.133	0.349
Wurdenmannia miniata	0.039	0.004					0.015	0.003
TOTAL							100	100

Ecological indices indicated that among the three stations surveyed, south Pag-asa has the highest diversity index, followed by northwest Pag-asa. The least diversity index was recorded in northeast Pag-asa (Table 11). High dominance and low evenness indices were likewise recorded in this station indicating that a particular macrophyte species is dominating and the distribution of the species is homogeneous.

This species is the seagrass *Thallasia hemprichii* which has a rate of occurrence and dominance of 80.827 % and 53.797%, respectively in this site. Generally, low evenness indices were recorded in the three sampling stations due to the dominance of seagrass species in all sites.

The uses and level of utilization of some of the algal species found in Pag-asa Island are shown in Table 12.

Table 11. Spatial variation in ecological indices of macrophyte communities intercepted in Pag-asa Island, Kalayaan, Palawan.

	NorthWest Pag-asa	NorthEast Pag-asa	South Pag-asa
Total Number of Species	15	11	16
Total Percent Frequency	242.480	327.128	222.965

Total Percent Cover	125.628	194.507	136.794
Simpson's Dominance Index (*c*)	0.741	0.908	0.677
Shannon's Diversity Index (H)	0.584	0.283	0.740
Pielou's Evenness Index (e)	0.396	0.272	0.362

Table 12. List of Seaweed Species Collected in Pag-asa Island, Kalayaan, Palawan and its uses.

Species	Uses and Level of Utilization	
	Uses	Level of Utilization
D: CHLOROPHYTA		
O: Cladophorales		
F: Anadyomenaceae		
Microdictyon okamurae		
O: Siphonocladales		
F: Siphonocladaceae		
Boergesenia forbesii	Source of simple sugars, bio-indicators of radioactive pollution	
Boodlea composita	Source of minerals and simple sugars	
F: Valoniaceae		
Dictyosphaeria cavernosa	Medicine: antimicrobial	low
Dictyosphaeria verluysii		
Valonia aegagrophila		
O: Bryopsidales		
F: Bryopsidaceae		
***Bryopsis* sp.**		
F: Caulepaceae		
Caulerpa serrulata	Human food: Medicine antifungal, lowers blood pressure	low
F: Codiaceae		
Codium arabicum	Human food: Medicine antibacterial and antitumor	low
F: Halimedaceae		
Halimeda cylindracea	Medicine: antibacterial	low

Halimeda discoidea	Medicine: antibacterial	low
Halimeda incrassata	Medicine: antibacterial	low
Halimeda opuntia	Medicine: antibacterial	low
F: Udoteaceae		
Udotea argentea	Source of minerals and medicine	
O: Dasycladales		
F: Dasycladaceae		
Bornetella nitida	Source of simple sugars	
Neomeris annulata	Source of simple sugars	
Neomeris vanbossae	Source of simple sugars	
D: PHAEOPHYTA		
C: Phaeophyceae		
O: Dictyotales		
F: Dictyotaceae		
Dictyota linearis	Medicine and minerals	
Dictyota sp_1	Medicine and minerals	
Padina minor	Source of algin; fertilizer	low
O: Scytosiphonales		
F: Scytosiphonaceae		
Hydroclathrus clathratus	Human food	moderate
Hydroclathrus tenuis	Human food	low
O: Fucales		
F: Sargassaceae		
Sargassum polycystum (Culapu)	Human food; source of algin; with auxin-like substance; controls heavy metal (Pb, Cd) pollution	high
Turbinaria conoides	Human food; source of algin; with minerals	low
D: RHODOPHYTA		
C: Rhodophyceae		
O: Bonnemaisoniales		
F: Galaxauraceae		
Galaxaura fasciculata	Source of sulfated polysaccharide related to carrageenans	low
Galaxaura oblongata	Source of sulfated polysaccharide related to carrageenans	low
O: Gelidiales		

F: Gelidiaceae		
Gelidiella acerosa (Guzo)	Human food; source of agar	high
O: Gigartinales		
F: Gracilariaceae		
Gracilaria sp.		
F: Rhodomelaceae		
Acanthophora muscoides	Human food; source of carrageenan; with growth regulators: gibberellin and cytokinin	low
Wurdemannia miniata		

(Source: Trono and Ganzon-Fortes, 1988 and Trono, 1997)

Threats

Like coral reefs, seagrasses are valuable natural resources that are under direct and indirect human impacts which have led to their decline in several parts of the country. Seagrass meadows are critical coastal nursery habitat for marine fisheries and wildlife. They also function as direct food sources for fish, birds, and seaturtles, major contributors in nutrient cycling processes, and stabilizing agents in coastal sedimentation and erosion processes.

In Pag-asa Island dredging and filling as a result of establishment of ports is recognized as one of the possible major anthropogenic disturbances that could contribute to the destruction of seagrass meadows. The direct and immediate effect of dredging is seagrass and seaweeds mortality due to burial. In addition, there are indirect losses resulting from the disturbance of sediments during dredging operations.

Since seagrass have high light requirements, the decreased light availability associated with sediment resuspension may further contribute to seagrass loss. Furthermore, dredged materials may not be suitable to the colonization and growth of seagrasses. Dredging may also result in hypoxia, which can increase root and rhizome mortality and cause the erosion of seagrass meadows through changes in water movement. Similarly, physical disturbance of seagrass meadows through scarring by boat propellers may often result to losses of seagrass habitat. Further, the establishment of communities in the island would threaten seagrass resources by increased gleaning activities and pollution brought about by domestic wastes and oil pollution from vessels/boats.

VI. ECO-TOURISM AND LIVELIHOOD OPPORTUNITIES IN PAG-ASA ISLAND, PALAWAN, PHILIPPINES

[1]Benjamin J. Gonzales and [2]Marcial V. Bolen

[1]Western Philippines University-Puerto Princesa Campus
[2]Municipality of Kalayaan, Palawan

Introduction

Primary concern of our country today is the prevalent poverty in the coastal areas and the continuous degradation of our natural resources. This complex and interconnected problems have existed for many decades yet solutions still face uncertainties (Gonzales, 2007).

Provision of alternative livelihood has been the battle cry of the government and NGOs to answer the poverty status of our small scale and artisanal fisherfolk and coastal communities across the country. But until now the aforementioned livelihood projects and programs have failed to substantially and significantly raise the social and economic status of Filipino families in the coastal areas and small islands. Hence, we are bound to offer innovative approaches and solutions which are both environmentally and socially achievable and acceptable (Gonzales, 2007).

Initiatives to institutionalize livelihood to add income for fisherfolk are often unsuccessful due to: groups and entities are not well-organized, organizations are not capable or ready to handle micro-enterprise, lack cooperation among members and or officials, sense of values which are contrary to development, insufficient monetary and administrative supports and absence or lack of technical skills and knowledge in running a project or a business.

Dealing with this complex concerns will take more than a decade to enable one community or group to handle a small business to start with. Thus, we must think of other more pragmatic approaches on how we could assist our coastal residents uplift their standard of living. On the other hand, tourism is said to be very related with to the prosperity of small businesses in the community and the society.

It is a fact that the tourism sector or industry has great capacity to influence the socio-economic conditions of many sectors and peoples around the tourism perimeter, especially in coastal and small island communities. The status of tourism could be an indicator of the status of the community when they are well-connected and related. This makes coastal tourism a highly potential medium to respond to the issue on poverty along coastal areas and small islands.

Eco-tourism has gain popularity because majority of tourists visit a place to see and experience the works of Mother Nature. As a result, many tourist establishments and enterprise pour substantial efforts and resources to maintain and enhance their natural resources in order to attract eco-tourism visitors. Hence, the more natural resources to see and enjoy, the more visitors will come, which will in turn enhance the economic turnover of the area, and most likely uplift the socio-economic status of the community and the society therein.

Objective and Methods

The objective of this study is to give recommendations on resource conservation and livelihood opportunities for the residents of Pag-asa Island and to identify ecotourism potential sites, activities, and resources in the island.

Methods used in this study are: 1) actual observation and experiences in the island; 2) interview with residents/fishermen and barangay or municipal officials. Photographs were taken to illustrate the scene and activities for livelihood and eco-tourism perspective in the island. Estimates of CPUE were done among the boat crew, who did hand line fishing during survey dives.

Results and Discussion

<u>Livelihood</u>

Fish

The catch per unit effort (CPUE) of handline fishing in Pag-asa Island was estimated to be 4.2kg/person/hr. compared to 1kg/person/hr in Honda Bay (Gonzales and Bhagwani, 2006).

Figure 20. Diverse species of sea resources caught by spear gun from reefs of Pag-asa Island, May 2008.

The result of fish assemblage study in this report also indicates that the island is still bountiful in terms of fish resources, though indebt researches on the biology and ecology of some fishes with relatively smaller size at maturity is recommended. This advantage could be optimized when these fish resources would be properly managed for long term benefit of Pag-asa

Island stakeholders.

It was observed that there were no facilities to store fresh fish and regular transportation available in the island. This situation makes marketing of fish products difficult, whereby limiting the opportunity for livelihood by island residents. This has made the island residents to resort to drying their fish catch to lengthen its shelf life until transportation becomes available or use it for domestic consumption.

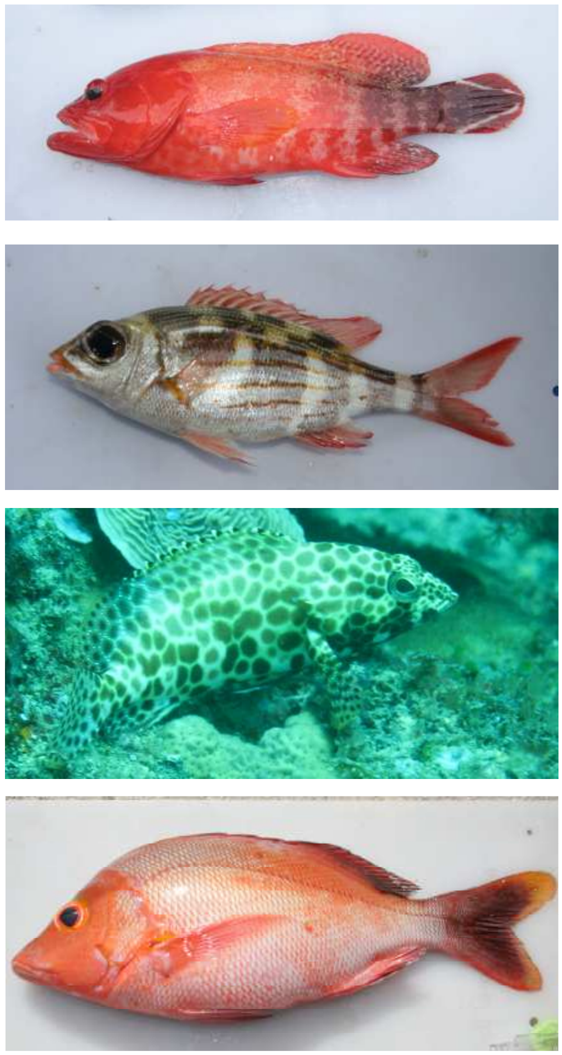

Figure 21. Dominant fish species caught by hand line in Pag-asa Reefs and process as dried fish, from top to bottom: *Epinephelus urodelus*, Lapu-lapu; *Gnathodentex aureolineatus*; Kanoping; *Epinephelus merra*, Lapu-lapu; *Lutjanus gibbus*, Maya-maya

Although drying fish catches is popular in the island, it is not yet commercially known. Dried fish product in the island is unique in such a way that they are caught by hook and line (sometimes by spear gun; Fig. 20), cut in fresh condition, and dried immediately after cleaning either on board the bangca or onshore. In addition, species being dried includes those of serranids (Lapu-lapu) and other high valued fishes (Fig. 21).

A strategy should be developed to promote the dried fish product of the island, capitalizing on the quality of the product, the mode of catching and processing “from hook to sun”, the wilderness and remoteness of Pag-asa Island. Manila market would be exploited, since, Pag-asa Island would most likely to be popular to the people of Luzon when effectively promoted.

The quality of dried fish products could further be improved by training the fisherfolk on proper handling and cleaning of fish catch and dried products to decrease or control bacterial contamination that hastens spoilage of fish meat.

Another livelihood option is, though may be a far possibility and difficult, the provision of live fish holding facilities in the island. Assuming that complete facility for live fishing industry would be available in the island, it could become a commercial center for international trade of live fish, a scheme where residents and the local government would be the direct beneficiary of the enterprise should be in place. This set up will also afford more taxes to the Philippine Government.

This situation might help lessen the fishing effort by foreign fishermen, so that they will buy live fisheries products directly from the island. The idea here is that we sell fish to foreign fishermen, instead of letting them catch our fish, which we do not have the control on how they catch the fish and how many they will harvest.

The danger, however, of this concept is still the regulation of fishing efforts around Pag-asa Island, since when there is big market demand, it follows that people would tend to overfish the resources in order to gain more against the others.

Invertebrates

Lobster, shell, sea urchin, and crab are other potential livelihood commodities for the Pag-asa Islanders. Lobsters could be collected from the wild and placed in an artificial reef located inside the barrier reef for shelter, growing, and to protect them from poachers —until harvest. This scheme does not need nets and holding facilities, yet only needs minimal technology on transport of live lobster for market and a reef were lobsters can take shelter and grow.

Figure 22. Sea urchin, *Tripneustes gratilla*, found abundant in Pag-asa seagrass beds.

Regular transportation would not be a primary problem in this enterprise, because lobsters can be harvested from the artificial reefs as transportation becomes available. A management plan for lobster enhancement and sustainable utilization must be in place, so that harvest would be regulated and long term benefit would be derived from the resource.

We have noticed a number of species of shells (e. g. *pasyak*, *Strombus canarium*) which are abundant in the intertidal zone (between low tide and high tide waterlines). The potential of the meat of these shells as dried commodity should be tested. This was done in *Tahong* (*Perna verides*) of Malampaya Sound, Taytay, Palawan.

On the other hand, the gracious sea urchin (*Tripneustes gratilla*, Fig. 22), is abundant in the seagrass beds, especially in the west side of the island. Sea urchins are known to the locals as *tirik*. The locals gather them for food (gonads). This species is also collected for commercial purposes in the Philippines (Schoppe, 2000).

The gonad of sea urchins is also a popular product called “sea urchin roe” that demands a high market value, found in the markets of Asia and Europe. Thus with proper contacts, logistics, knowledge, and technology, the gonad /roe of the sea urchin in the island is a potential export product.

Nautilus shells also exist in the island as livelihood for some islanders. Studies on the conservation and development of nautilus livelihood are necessary to improve the catch and at the same time conserve this economically valuable, but threatened species.

Seaweeds

Because of strong currents and unpredictable weather conditions, mariculture structures and projects would hardly succeed in the island. However, if properly planned, mariculture could be implemented in the island. Information of year-round climatic, weather, and physical oceanographic study will help discern mariculture possibilities in the island. Knowledge of the islanders on the above will also be valuable inputs to planning the seaweed culture in the island.

For the seaweed, grazing of algae eating (herbivore) fishes is a problem. Thus, thorough planning, back-up by research studies must be done to see the viability of mariculture prospects in the island. For example, studies on the seasonality of the juvenile siganids (*padas*), that feeds on seaweed seedlings, and the location of most suitable site for farming seaweeds.

<u>Resource Conservation</u>

Coral Reefs

Coral reefs serve as refuge for wide variety of fishes and invertebrates. Large coral reefs could provide food and shelter to millions of fish, shrimps, and other creatures that thrive therein. Since Pag-asa Island coral reef cover is relatively poor in condition compared to coral reefs in the mainland, it should be protected in order to rejuvenate and utilized in a sustainable manner. Coral reefs inside "barrier" should be enhanced and nurtured. In this way Pag-asa could protect and steward its own coral reefs in the island.

Coral reef areas in the island should be managed through the establishment of marine protected area as shown in Figure 23 , where a fish sanctuary should be established as a no take and regulated zone to serve as reservoir and generator of marine plants and animals in the area. The reefs should be managed in a way that it would not only generate and enhance the reef ecosystem, but also extend aesthetic and educational values to visitors. Devastated reef areas if properly protected could recover within the span of five to ten years (Veron, 1986). In addition, regular monitoring of the reefs shall be done in order to detect occurrence of changes in reefs' condition.

Seagrass

Seagrasses and other small island plants are life support systems of organisms found in the seagrass and plant community itself, which likewise extends life supports to marine lives down to the coral reef. If we protect the coral reefs we must also protect the seagrass beds and the island tree communities as to provide continues life support to the island's land and reefs' ecosystem.

It is also important to document and monitor beach vegetation and any alteration of this ecosystem should thoroughly consider its importance in the provision of habitat to a variety of faunal species as well as in maintaining coastal stability. Vegetation in small islands like Pag-asa is very critical and directly related to its holding capacity of fresh water in the island. Destruction of vegetation will result to erosion of the sand and will not only result to loss of land area, fresh water, and seagrass beds, but also to loss of biodiversity, which are all negative to tourism.

Considering the benefits derived by coral reefs and other systems from seagrass and algal beds, initiatives toward seagrass and algal protection must be considered in the overall plan for livelihood and eco-tourism.

Land Crab

A community of trees (*Cerbera manghas*; Fig. 23), called by the locals as *Alipata*, was found to thrive more or less central of the island. This tree community was observed to be a critical habitat for a relatively rare species of land crab (*Kuday*) scientifically named as *Gecarcoidea lalandii* (Fig. 23). We named this land crab as the Pag-asa *Kuday* in this report.

G. lalandii belongs to Family Gecarcinidae, under genus Gecarnoidea that has only two species with limited geographical range in Indo-Pacific (Liu and Jeng, 2007).

Although the Pag-asa *Kuday* is distributed in Indo-West Pacific, this species could be the first record in Palawan or may be Philippines. Pag-asa Island could be the only area where this species can be found. Thus, more survey of the islands in KIG and other areas of the Philippines should be carried out to determine the distribution of *G. lalandii* in the country

Figure 23. Top and middle, the Pag-asa *Kuday* (*Gecarcoidea lalandii*), found living in root system of trees (*Cerbera manghas*, bottom) in Pag-asa Island.

The Pag-asa *Kuday* was found to live under the root system of the Cerbera Trees and in low profile rock crevices in the island. Residents said this crab is nocturnal and spawns in the sea at night, which are known characteristics of the same species in Taiwan (Liu and Jeng, 2007). Our initial data and information gathered in the island indicates that there is a consistent decreasing trend in the range and distribution of the Pag-asa *Kuday* population in the island, due to unregulated gathering by humans.

Known ecological functions of the *kuday* (*G. lalandi*i) are: 1) the crab affects seedling diversity in rain forest, 2) the crab hastens leaf litter breakdown, through digestion, 3) the crab helps reduce colonization of exotic plants species in an island, 4) it provides drinking and breeding places for other animals, and 5) aides in aerating the soil (Liu and Jeng, 2007).

Since the particular *kuday* species in the island is rare to Palawan and most likely also in the Philippines, this species including its habitat should be protected from unregulated exploitation. The Pag-asa *Kuday* could be a tourist attraction and might become a livelihood commodity in the future. As such, more studies and documentation on biology and ecology of Pag-asa *Kuday* should be conducted in the island.

Sea turtles

In May 16, 2008 at 5:30 am, a green turtle was found stranded in the southeast portion of Pag-asa Island (Fig. 24). The mother turtle has dug a nest, but we did not find any egg in the nest. According to islanders, the eggs were already taken by other residents who found the nest earlier. The turtle measured 106 cm in total length (TL) and 99 cm in width (W). It took six persons to carry and release the sea turtle in the sea. The turtle was released at 6:25 am the same day, with tag number Ph 0760A. This was the second occurrence of egg laying of sea turtle in the beach during our stay in the island.

The biological and ecological conditions of algae, seagrasses and beaches in the island support the sightings and existence of sea turtles in its waters. This calls for the protection of the environment of such endangered species. Sea turtles laying eggs in the island beach, as well as their eggs shall be protected. Sea turtles are known to home back and lay eggs in the same sites where they were born, thus if eggs are collected after laying, time will come that no turtle will come back to lay eggs in the island.

Sea turtles are legitimate eco-tourism attractant. It is a popular attraction in many tourism sites in the country. People get easily fascinated with its life stages as eggs, baby turtles, and as swimming turtles. Its characteristic of burying and laying eggs in the sand beach and the newly hatched baby turtles rushing from the beach to the sea is a likable scenario for eco-tourism guests.

The Pag-asa Island has a staff to monitor the occurrences of sea turtles in the island, but it still needs more vigilance to attend to the issues on sea turtle egg poaching.

S*tock enhancement*

Figure 24. Island residents and WPU researchers prepare to carry and release the stranded Green Turtle (*Chelonia mydas*) in Pag-asa Island.

Restocking is a resource management tool to increase and sustain the population of a certain species in its natural environment. Restocking the coral reef with identified native species will enhance its productivity through time compared to its natural phase of reproductive process.

Station 9 of Secret Reef in this study (Fig. 2) is a potential stock enhancement site for shells, especially topshell (*Trochus niloticus*). Although there are a variety of organisms considered for restocking, it is recommended to initially restock species already occurring in the area, which are found to be with problems in their conservation status (threatened, endangered, etc) like: topshell, giant clams, abalone, lobsters, etc.

It must be ensured that the individuals for restocking must come from the vicinity of Pag-asa Island and conform with to genetic management principles and other laws regarding restocking.

Artificial reefs

The artificial reef when properly designed and planned will support stock enhancement for growing marine species of concern. However, where natural reefs abound, artificial reef would not be necessary, though it can always serve as an additional substrate to attaching and growing species of corals, and can start a colony that will precede a coral reef and community.

Valuable shells and crustaceans with economic and ecological values like giant clams, lobsters, etc. may be collected and transferred to an area where it could live and protected. In this way, they can improve their reproductive potentials. Protection of marine resources even in our own territory has proven to be difficult, but there are also several successful stories where a protected area becomes source of income both from the increase in fish catch and eco-tourism.

Pag-asa island being the only island with civilians among the Kalayaan Island Group, it has a greater chance for the proper conservation and management of marine resources, which could in turn serve as one of the marine biodiversity hub that would generate and spill-over marine resources to its surrounding areas.

<u>Ecotourism</u>

Zoning (Fig. 25)

For the purpose of proper eco-tourism planning and management, Pag-asa Island and its reefs should be classified into zones for specific use. Areas for eco-tourism activities and biodiversity protection must be spelled-out. In this way policies and regulations would be clear and could become a solid basis for law enforcement.

Here, we proposed to generally assign land-based eco-tourism activity zone in the eastern half of the Pag-asa Island and reserve the western half of the island as no touch (core) and regulated activity zone. Land-based here are areas in the island, extending from the dry, marsh lands to the intertidal zone.

The western half is also the area for military operations. However, the reefs around the island perimeter could be used for eco-tourism activities, as SCUBA diving, fishing, etc., but the shores and interdidal (200m from shoreline) in the western half of the island should be declared as core (no touch) zone, excluding pier area. The military unit and the municipality, including stakeholders must consult each other as to the restrictions of activities on land for security and safety of both visitors and inhabitants.

Although this zoning proposal is ideal, it should be validated and consulted with the Municipality of Kalayaan and Barangay Pag-asa stakeholders. This validation and consultation would ensure that various stakeholders have contributed, participated, and formed part of the planning process of the eco-tourism proposal of the municipality.

Cottages (Fig. 25)

Infrastructures with light material should be established in locations where there will be no or least impacts to the resources and habitats. Identified sites are mostly in sandy beach portion of around the island, which must also conform to the security protocols of the military unit.

For the construction of heavy and massive eco-tourism infrastructures, geological evaluation as to the quality and capacity of the island to carry such should be conducted before decisions should be made. Meanwhile, cottages made of light materials are advisable.

The eastern halves of the north and south beaches of the island are recommended for light cottages. The western halves of these beaches shall be left undisturbed in order to protect and maintain the near shore marine diversity around the island. However, the beaches in these areas could be used by visitors for camping.

In establishing cottages, wind speed and other conditions during the northeast (*Amihan*) and southwest (*Habagat*) monsoons should be considered.

Swimming Area (Fig. 26)

Recommended swimming areas are practically located around the island with beaches. However for safety purposes the eastern half of the northern shorelines are most recommendable.

1. The north portion of the island is ideal for swimming with its clear blue and green waters and white coral sand beaches. However, children should be accompanied by adults, because there are rocky patches that may injure young swimmers. Swimmers must also look out for sudden occurrences and changes in direction of sea currents.

2. The south shore beach of the island is an alternative swimming area for guests and visitors, with a relatively shorter beach than the northern shore. The beaches here are equally beautiful with that in the northern beaches. However, only the eastern half of the south beach is recommended for swimming. This is to conserve and protect the lifeforms in the western half of the beach from disturbances, which could be brought about by swimmers.

3. The waters in the east of the island are relatively deep and frequented by unpredictable strong currents, thus not recommended for swimming.

4. The near shore of the island in the west is covered with regenerating corals, seagrass beds and sea urchin, which will be generally not good as swimming area, since corals, and seaweed beds will be stepped upon by the swimmers.

Pier Area (Fig. 26)

There is only one ideal docking area identified for large vessels, located in the west of the island. This area is suitable for docking because it's the only area in the island having the shortest distance to deeper water. However, this area is also covered with seagrass beds, growing corals, and with considerable number of sea urchin.

It is recommended therefore that the proposed pier design should be in such a way that the physical structure will allow seawater to flow through under the pier. As such, seagrasses and lifeforms therein would still have a chance to thrive. In addition, preventing the water to flow in its natural course would cause impact to the shoreline or beaches, which would likely influence the shape of the island and probably decrease the area of the island.

Small boats may dock on sandy beaches anywhere around the island during high tide, as presently practiced, but must observe environmentally safe engine operation and maintenance with regards to fuel and oil (e. g., bilge pump discharge of water contaminated with oil or fuel, changing engine oil).

Snorkeling and SCUBA Diving (Fig. 27)

Snorkeling

The areas inside the "barrier" can practically be snorkeling areas. However, like the swimming activity, precautions on unpredictable strong currents should be considered. Standby boats should be always be available and avoid snorkeling during the rushing in and out of the water during high tide and low tides.

Snorkeling areas must be characterized by a relatively shallow water depth, but deep enough to prevent divers to physically come in contact with the corals.

Experienced snorkelers may venture areas in the eastern and northern sides of the island, near the drop off, while novice ones may enjoy snorkeling in selected sites inside the "barrier" reef of the island, where anemone and anemone fishes can often be encountered. Sea urchins in the wild can be observed in west station.

Boats with transparent bottom could be used for underwater world viewing by non-swimming and diving guests.

Experience skin divers may also try the patches of reefs in the southeast of the island. Some sites are good both for snorkeling as well as SCUBA diving. More areas for skin dive should be scouted to accommodate more divers in peak season.

SCUBA Dive

Potential sites for SCUBA diving are located at the north, east and southeast of the Pag-asa Island and in Secret Island. Although coral reefs in these sites may not be so attractive, divers could experience viewing abundant and different kinds of fishes, a number of which not found in mainland Palawan.

For divers who pleasures unique underwater features may dive in the north, northwest, southeast, and Secret Reef Stations to view the fascinating reef grooves, sculptured by nature through constant wave action. These grooves serve as home to many organisms inhabiting the reef around the island. Stations with most pronounced reef grooves are Stations 3, 5, and 10 (Figs. 2 and 5)

Divers who wish to see *Tridacna spp.* (giant clams), may dive in the vicinity of Station 2 (Figs. 2 and 8), south of the island. On the other hand a diver may encounter, even in daytime spiny lobsters in their wild habitat in Stations 6 and 9 (Fig. 2), though other areas should be surveyed for existence of lobsters. For different species of invertebrates, divers shall try Station 3.

The south eastern dive sites in the vicinity of Station 3 are characterized by steep drop offs with schools of large individuals of snappers (maya-maya), tunas, and acanthurids (Labahita). This area has the most number of fish species observed. Before the drop offs, some of these areas have reef flats, which are good for snorkeling. Dolphins were also observed during our dive in Station 3.

Proper precautions must be exercise when diving in Station 2, because we observed some discarded condemned cannon shells in the area.

It is recommended that proper precaution should be in place to protect the coral reefs and other life forms while diving:

1. Collection of corals, shells, etc.
2. Destruction of corals through improper wading or swimming in reefs
3. Pollution (Plastic bags, food bags, etc.)
4. Improper anchorage of boats.
5. The use of seacrafts with engines over the reefs are discouraged, e. g., waterski.

Fishing Areas

Recommended fishing areas are found in drop offs around the island. Another area is the patches of reef in the southeast of the island (Station 3; Fig. 2). Patches of corals in the southeast of the island is a promising area for hand line fishing (Kawil). Schools of large *maya-maya* and *labahita* were observed in this area during the actual survey.

In the fishing area, it should be clear that only fishes should be caught, using handlines or pole and lines. Extraction of shells and other invertebrates should be prohibited. Fishing areas should be distinct from diving areas, because fishing may disturb fishes in diving areas. Visitors must not fish in areas designated as diving sites.

Fish feeding Area

Fish feeding activity may be done in the areas for diving both SCUBA and snorkeling. Fish feeding will attract fishes to stay in a reef. Additional food will supplement their energy for growth and reproduction.

Figure 25. Map showing the proposed zoning of the Pag-asa Island, and the areas for beach cottages (blue triangle shapes).

Fish feeding will enable visitors to see and observed fishes in the reef longer and at closer range. Aside from SCUBA and skin diving, it is recommended to use an underwater observation glass to offer more fun and convenience to fish loving visitors.

It should be noted that feeding areas should not be in the same place with fishing areas. Feeding fishes could be disturbed by the fishing activities and fishes may stay away from the feeding area. Once the fishes are domesticated by feeding, feeding could be used by unscrupulous fishermen to gain more catch. Diving areas and feeding areas could be the same.

Eco-tourism generally does not encourage fish feeding, since it affects the capability of the fish to look for its own food in the wild. Fishes will tend to become dependent on the food regularly given to them, thus weakening its ability to find his own food in the competitive underwater world. As such, it is important to observe or conduct formal studies on this topic.

Figure 26. Map of Pag-asa Island showing the north, south, east, and west shores, with recommended swimming areas (round orange), and the pier area (black ring).

Skin Spear Fishing

Spear fishing without the aide of Self Contained Underwater Breathing Apparatus (SCUBA) or compressor is an interesting underwater sport. This kind of sports could be done in selected areas around the island. Our survey did not have opportunities to survey spear fishing areas, but the islanders and the boat crew are recommended guides for this activity.

Spear fishing without the assistance of breathing apparatus gives a sporting chance for the fish to escape his hunter. This circumstance has advantages, because aside from adding to the thrill of the sports, it also serves as a regulating means not to over fish the area.

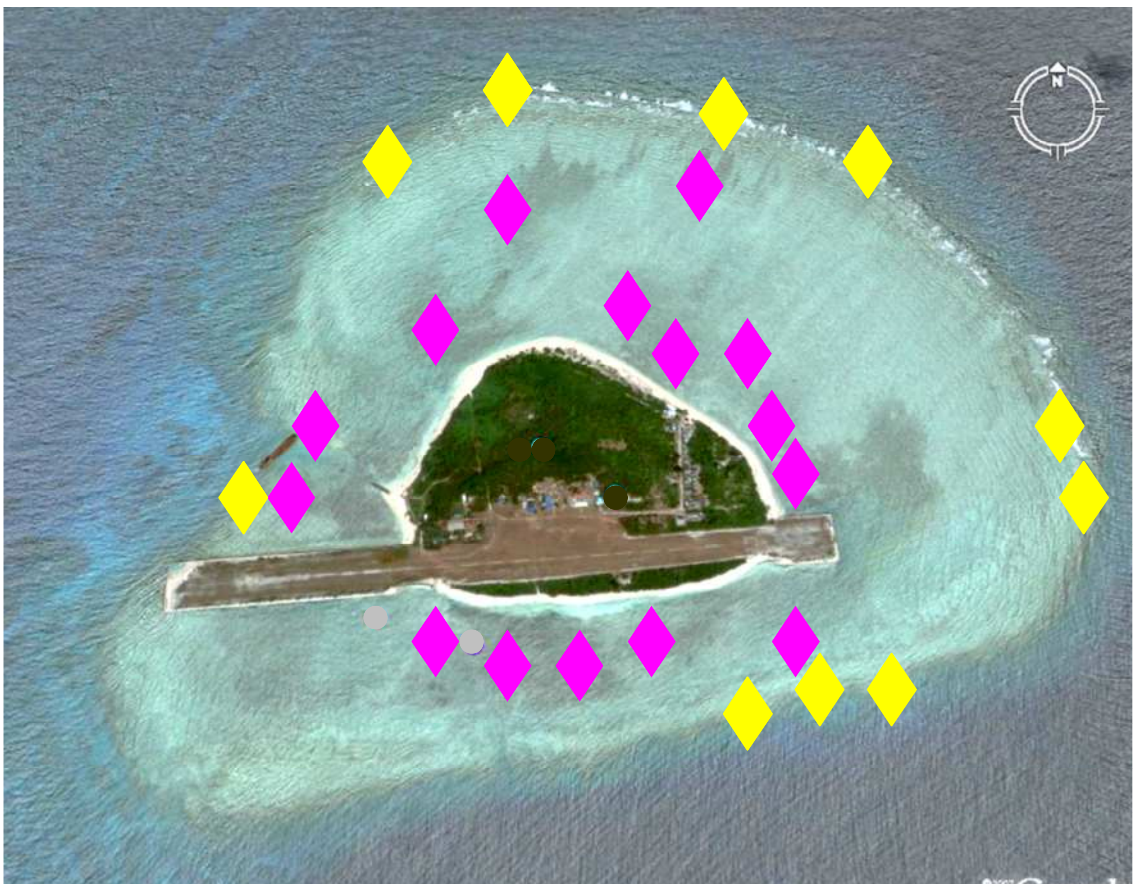

Figure 27. Map of Pag-asa Island showing the recommended SCUBA dive sites (yellow diamond), and snorkeling sites (violet diamonds).

VII. GENERAL CONCLUSION AND RECOMMENDATION

The Pag-asa Island in particular and Kalayaan Island Group in general, has high capacity to support a fishery with significant importance as source of food and economic potentials for adjacent countries and in the whole Southeast Asia. It is manifested in the result of this study that although with relatively poor coral reef condition, the fishes in the area are still diverse and abundant. How much more if the reefs will recover? With better percentage cover and improved conditions of coral reefs, it is easy to deduce that the kinds and volume of fish stocks in KIG could remarkably increase.

Thus, it is urgent that proper management of Pag-asa Island marine resources and that of the KIG should be put in place. Claimant countries shall meet and come into terms on how they could jointly protect and manage the area for sustainable development, before this vast coral reef resource will continue to deteriorate. Their strategies must consider the priority of mitigating destructive methods of fishing used in the area.

Meanwhile, we are fortunate that the goals of the Municipality of Kalayaan, which are parallel to sustainable development, should be pursued, since it is also ideal for a developmental endeavor to start small and at local-based, with a vision and commitment to grow and later serve as examples to be replicated by others who wait and see.

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Appendix A. List of reef fishes found in Pag-asa Island, Palawan with its categories: Target (TGT), Major Families (MF), & Indicator Species (IND) and distribution (Percentage)

FAMILY	SPECIES	TGT	MF	IND
ACANTHURIDAE	*Acanthurus maculiceps*	X		
	Acanthurus albimarginatus	X		
	Acanthurus binotatus	X		
	Acanthurus chronixis	X		
	Acanthurus dussumieri	X		
	Acanthurus glaucopareius	X		
	Acanthurus maculiceps	X		
	Acanthurus ngricans	X		
	Acanthurus nigrofasciatus	X		
	Acanthurus nigroris	X		
	Acanthurus olivaceus	X		
	Acanthurus pyroferus	X		
	Acanthurus pyroferus yg.	X		
	Acanthurus triostigus	X		
	Acanthurus xanthpoterus	X		
	Acanthurus triostigus	X		
	Ctenochaetus binotatus	X		
	Ctenochaetus striatus	X		
	Naso lituratus	X		
	Naso lituratus yg. Ad	X		
	Zebrasoma flavescens	X		
	Zebrasoma scopas	X		
APOGONIDAE	*Apogon compressus*		X	
	Apogon nigrofasciatus		X	
	Cheilodipterus macrodon		X	
AULOSTOMIDAE	*Aulostomus chinensis*		X	
BALISTIDAE	*Melichthys niger*		X	
	Melichthys sp.		X	
	Melichthys vidua		X	
	Sufflamen chrysopterus		X	
	Sufflamen frenatus		X	
	Pseudobalistis flavimarginatus		X	
	Rhinecanthus aculiatus		X	
	Xanthichthys auromarginatus		X	
BLENNIDAE	*Aspidontus taeniatus*		X	
	Plagiotremus laudandus laudandus		X	
	Plagiotremus rhinorhynhcos		X	
	Salarias fasciatus		X	
CAESIONIDAE	*Caesio tile*	X		

	Pterocaesio tille	X		
CARANGIDAE	*Caranx ignobilis*	X		
CHAETODONTIDAE	*Chaetodon auriga*			X
	Chaetodon auripes			X
	Chaetodon baronessa			X
	Chaetodon citrinellus			X
	Chaetodon kleinii			X
	Chaetodon lineolatus			X
	Chaetodon ornatissimus			X
	Chaetodon punctatofasciatus			X
	Chaetodon spiculum			X
	Chaetodon trifasciatus			X
	Chaetodon unimaculatus			X
	Chaetodon vagabundus			X
	Chaetodon wiebeli			X
	Chaetodon xanthurus			X
	Forcifiger flavissimus			X
	Forcifiger longirostris			X
	Hemitaurichthys polylepis			X
	Heniochus acuminates			X
	Heniochus monocerus			X
	Heniocus chrysostomus			X
CIRRHITIDAE	*Cirrhilabrus scottorum*		X	
	Cirrhites arcatus		X	
	Cirrhitus pinnulatus		X	
	Paracirrhites arcatus		X	
	Paracirrhites forsteri		X	
FISTULARIDAE	*Fistularia commerssonii*		X	
	Fistularia petimba		X	
GOBIIDAE	*Valenciennea strigata*		X	
HAEMULIDAE	*Plecthorinchus picus*		X	
HOLOCENTRIDAE	*Adiorex sp.*		X	
	Myripristis murdjan		X	
	Myripristis pralinia		X	
	Sargocentron cornutum		X	
	Sargocentron caudimaculatum		X	
	Sargocentron ittodai		X	
	Sargocentron rubrum		X	
	Sargocentron tiere		X	
	Sargocentron violaceum		X	
KYPHOSIDAE	*Microcanthus strigatus*		X	
LABRIDAE	*Bodianus anthioides*		X	
	Bodianus mesothorax		X	

	Cheilidipterus macrodon		X	
	Cheilinus celibicus		X	
	Cheilinus chloropterus		X	
	Cheilinus chlorourus		X	
	Cheilinus diagramus		X	
	Cheilinus trilobatus		X	
	Cheilinus undulatus		X	
	Cheilnus diagrammus		X	
	Cheilo enirmes		X	
	Chlorourus sordidus		X	
	Chlorurus bleekeri		X	
	Choerodon fasciatus		X	
	Coris batuansis		X	
	Coris gaimard		X	
	Coris picta		X	
	Coris aurilineatus		X	
	Gomphosus varius		X	
	Epibulus insidiator		X	
	Halichoeres biocellatus		X	
	Halichoeres hertzfeldii		X	
	Halichoeres hortulanus		X	
	Halichoeres marginatus		X	
	Halichoeres melanurus		X	
	Halichoeres scapularis		X	
	Halichoeres trimaculatus		X	
	Hemigymnus fasciatus		X	
	Hemigymnus melapterus		X	
	Hologymnosus doliatus		X	
	Hologymnosus rhodonotus		X	
	Labroides bicolor		X	
	Labroides dimidiatus		X	
	Labropsis pictorales		X	
	Labropsis xanthonota		X	
	Macropharyngodon meleagris		X	
	Oxycheilinus diagrammus		X	
	Oxycheilinus unifasciatus		X	
	Pseudoanthias bicolor		X	
	Pseudoanthias sp.		X	
	Pseudocheilinus octotaenia		X	
	Pseudocheilinus evanidus		X	
	Pseudocheilinus hexataenia		X	
	Pseudocheilinus octotaenia		X	
	Stethojulis maculata		X	

	Stethojulis strigiventer		X	
	Stethojulis trilineata		X	
	Thalassoma amblycephalum		X	
	Thalassoma cupido		X	
	Thalassoma hardwicke		X	
	Thalassoma jansenii		X	
	Thalassoma lunare		X	
	Thalassoma lutescens		X	
	Thalassoma quinquevitatum		X	
	Thalassoma trilobatum		X	
LETHRINIDAE	*Gnathodentex aurilineatus*	X		
	Gnathodentex grandoculis	X		
	Monotaxis grandoculis	X		
LUTJANIDAE	*Aphareus furca*	X		
	Lutjanus carponotatus	X		
	Lutjanus kasmira	X		
MICROSDESMIDAE	*Nemateleotris magnifica*		X	
MONACANTHIDAE	*Amanses scopas*		X	
	Cantherhines pardalis		X	
	Cantherhines sp.		X	
	Pervagor melanocephalus		X	
MURAENIDAE	*Gymnothorax javanicus*		X	
MULLIDAE	*Parupeneus barberinus*		X	
	Parupeneus bifasciatus		X	
	Parupeneus cyclostomus		X	
	Parupeneus indicus		X	
	Parupeneus mulitifasciatus		X	
	Parupeneus trifasciatus		X	
NEMIPTERRIDAE	*Scolopsis*	X		
	Scolopsis lineatus	X		
OPLEGNATHIDAE	*Oplegnathus fasciatus*		X	
	Ostracion meleagris		X	
PINGUIPEDIDAE	*Parapercis cephalopunetata*		X	
	Parapercis cylindrica		X	
	Parapercis hexophtalma		X	
	Parapercis millepunctata		X	
POMACANTHIDAE	*Centropyge bispinosus*			X
	Centropyge flavissimus			X
	Centropyge heraldi			X
	Centropyge vrolikii			X
	Genicanthus melanospilos			X
	Pygloplites diacanthus			X
POMACENTRIDAE	*Ambyglyphidodon aureus*			X

	Ambyglyphidodon leocogaster			X
	Amphiprion clarkii			X
	Amphiprion percula			X
	Anampses caeruleopunctatus			X
	Anampses melanurus			X
	Anampses meleagridis			X
	Anampses neoguinaicus			X
	Chromis dimidiatus			X
	Chromis margaritifer			X
	Chromis retrofasciatus			X
	Chromis richardsonii			X
	Chromis sp.			X
	Chromis sp. Yg.			X
	Chromis ternatinsis			X
	Chromis weberi			X
	Chromis weberi yg.			X
	Chromis xanthura			X
	Chromis xanthurus			X
	Chryseptera biocellatus			X
	Chryseptera cyanea			X
	Chrysiptera biocellata			X
	Chrysiptera hemicyanea			X
	Chrysiptera parasema			X
	Chrysiptera starckii			X
	Dascyllus aruanus			X
	Dascyllus reticulatus			X
	Dascyllus trimaculatus			X
	Dischistodus melanotus			X
	Hemiglyphidodon plagiometopon			X
POMACENTRIDAE	*Neoglyphidodon melas*			X
	Neoglyphidodon nigroris			X
	Neoglyphidodon polyacanthus			X
	Paraglyphidodon melas			X
	Plectroglyphidodon dickii			X
	Plectroglyphidodon lacrymatus			X
	Plectroglyphidodon leucozonus			X
	Pomacanthus imperator			X
	Pomacanthus sexstriatus			X
	Abudefduf vaigiensis			X
	Pomacentrus vaiuli			X
	Pomacentrus coelestis			X
	Pomacentrus alexander			X
	Pomacentrus bankanensis			X

	Pomacentrus imitator			X
	Pomacentrus imperator			X
	Pomacentrus lepidogenys			X
	Pomacentrus moluccensis			X
	Pomacentrus nagasakiensis			X
	Pomacentrus nigroris			X
	Pomacentrus nigromarginatus			X
	Pomacentrus rhodonotus			X
	Pomacentrus trimaculatus			X
	Pomacentrus wardi			X
	Pomachromis richardsoni			X
SCARIDAE	*Bolbomitopon bicolor*	X		
	Calostumus splindens	X		
	Scarus dimidiatus	X		
	Scarus flavipectoralis	X		
	Scarus forsteni	X		
	Scarus frenatus	X		
	Scarus frontalis	X		
	Scarus ghobban	X		
	Scarus globiceps	X		
	Scarus niger	X		
	Scarus oviceps	X		
	Scarus prasiognathos	X		
	Scarus rubroviolaceus	X		
	Scarus sp. (brown)	X		
	Scarus sp. (blue)	X		
SCORPAENIDAE	*Dendrochirus zebra*		X	
SERRANIDAE	*Cephalopholis cyanostigma*	X		
	Cephalopholis merra	X		
	Cephalopholis urodelus	X		
	Gracila albimarginata	X		
	Liopropoma multilineatum	X		
SIGANIDAE	*Siganus argenteus*	X		
SYNODONTIDAE	*Saurida gracilis*		X	
	Synodus variegatus		X	
TETRAODONTIDAE	*Arothron nigropunctatus*		X	
ZANCLIDAE	*Zanclus cornotus*		X	
Total 34	248	54	113	81
Percent	100	21.77	45.46	32.66