Article

Coral reef assessment and monitoring made easy using Coral Point Count with Excel extensions (CPCe) software in Calangahan, Lugait, Misamis Oriental, Philippines

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Abstract
Coral reef communities are considered as the most diverse marine ecosystems that provide food, shelter and protection to marine organisms. It provides many important benefits to humans but often a subject to impairment through human activities. Cascading human influences and climate change appeared as a reason behind its decline. Thus, coral reef monitoring methods are substantial. This study utilized Coral Point Count with Excel extensions (CPCe) software, as a means to increase efficiency of coral reef monitoring efforts because it automates, facilitates and speeds the process of random point count analysis and can perform image calibration, planar area and length calculations of benthic features. The method was used to estimate community statistics of benthos based on captured still images for every 1m marked across four 50m transect line (total 200 m) at 4.6-5.6m depth. Transect images were assigned with 30 spatial random points for identification. Multiple image frames were combined for each transect length supplying datasheet containing header information, statistical parameters species / substrate type (relative abundance, mean and standard deviation) and Shannon-Weaver and Simpson's Index calculation for species diversity. Generated transect datasets were statistically analyzed to give quantitative population estimates over the area of interest. Data from individual frames were combined per transect to allow both inter- and intra- site/transect comparisons. This study reports the current status of coral reefs across Calangahan, Lugait, Misamis Oriental, Philippines and proved the efficiency of CPCe as a tool in reef assessment and monitoring. Results showed that most common genera *Porites* and *Acropora* were dominant, with *Porites lobata* as the most abundant coral species in the area. Moreover, results also showed that there were various diseases present affecting corals leading to increased mortality.

Keywords coral reef monitoring; species diversity; *Porites*, *Acropora*; Lugait; Misamis Oriental.

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1 Introduction

Coral reefs are biologically intricate and extremely valuable underwater ecosystems, characterized by high diversity and density of life. They are often found at shallow depths in tropical waters, held together by the massive deposits of coral-secreted calcium carbonate structures. These marine habitats are known to be the foundation of a large variety of marine species hence, yields critical support for human life (Norris, 1993). In addition, coral reefs are both environmental indicators and coastline protectors that also provide extensive tourism opportunities. Noteworthy, are its important roles in biodiversity conservation, biological productivity and ecological balance (Wu and Zhang, 2012). However, despite its major contributions, coral reefs are recognized as one of the most endangered habitats of the planet (Carpenter et al., 2008), due primarily to the cascading human impacts and global warming.

In Southeast Asia, coral reefs garner the highest level of biodiversity amongst the world’s largest aquatic systems. The Philippines, a prime country in Southeast Asia, is part of the Coral Triangle and is acknowledged as the Amazon of the Sea (UNICO, 2012), because of its comprehensive marine species and coastal reserves. With more than 7, 000 islands and warm ocean waters, it is surrounded by about 26, 000 km^2 of coral reefs (Ohandley, 2003). However, coral reef damage had become a serious concern. Catibog-Sinha and Heaney (2006) under Haribon Foundation reported that only 5% of Philippine coral reefs are in excellent condition, whereas 32% of it is already severely damaged. Apparently, coral declination rates in the country are alarmingly increasing. Hence, there is a need to efficiently assess and monitor reefs even at the regional and local level (Rogers, 1988; Rogers et al., 1994).

Nowadays, varieties of computer software are extensively utilized in the field of research as advancement to technology. One of which is the Coral Point Count with excel extensions (CPCe) program, founded by researchers of the National Coral Reef Institute. It is a visual basic software designed to quickly and efficiently calculate statistical coral coverage over a specified area through the aid of transects photographs (Kohler, 2006). These transect images are being assigned with spatial random points for user’s further identification. It can also perform both image calibration and area analysis of the benthic features, and has the ability to automatically generate analysis in Microsoft Excel. Thus, CPCe is a highly significant useful tool, particularly in coral reef monitoring, assessment and conservation.

Since the CPCe software is not well-established in the Philippines, accordingly, the present study was undertaken to report coral reef status across Calangahan, Lugait, Misamis Oriental, Philippines using Coral Point Count with Excel Extensions (CPCe) software. Lugait, is a second class municipality in Misamis Oriental who opened its doors to industrialization. Now, hundreds of hectares have been converted into industrial and commercial lands. The coasts of Lugait, are partly occupied by industries and are suitable for anchorage and navigation. Small time fishermen were also dominant in the area although, some parts have already been converted to marine reserves. Hence, this study would not only serve as monitoring efforts and update of coral diversity in Calangahan, Lugait, Misamis Oriental but also provide baseline data for future corals and CPCe-related studies in the Philippines.

2 Materials and Methods

2.1 Sampling site and procedure

Sampling was conducted on the month of April 2015 in Calangahan, Lugait, Iligan City [outside the marine protected area (MPA)], location was around N 8º22’07”, E 124º15’39” (Fig. 1). Self Contained Underwater Breathing Apparatus (SCUBA) diving and Photoquadrat Method (PQ) were employed in laying transects and obtaining photographs for study procedure. Digital images were acquired using Canon Power Shot SX260 HS, 20x optical zoom digital camera; with WP-DC46 underwater waterproof case (up to 40m/130 ft depth capacity) mounted on a 1.5m high improvised underwater monopod. Four transect lines were laid out, with each transect having a length of 50 meters and depth of around 4.6 meters (transects 1 and 2) to 5.6 meters (transects 3 and 4). Still images were captured for every 1m marked across the four 50m transect line. Hence, fifty photographs were taken for each transect, with a total of 200 photographs. Photographs were analysed through the use of the CPCe software by Kohler and Gill, 2006.

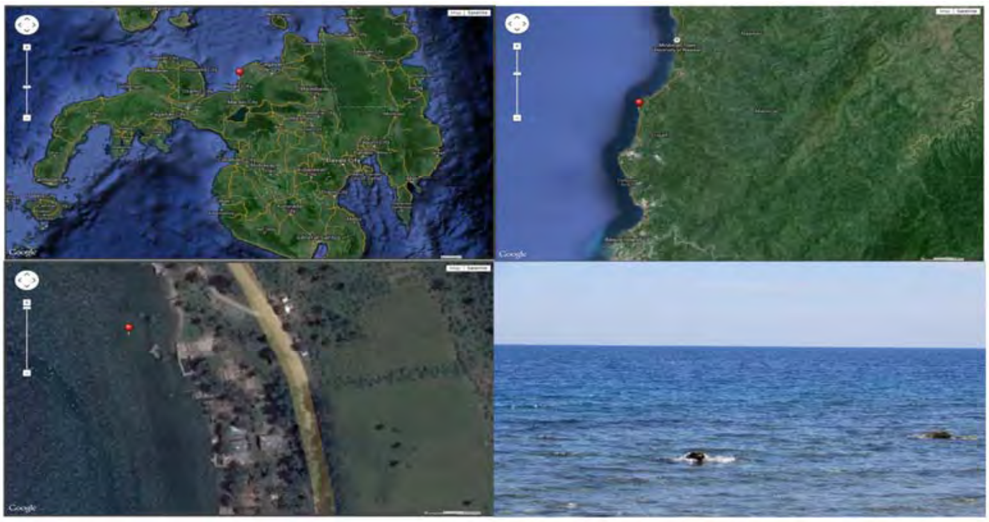

Fig. 1 Study site: Calangahan, Lugait, Misamis Oriental, Philippines around N 8º22'07", E 124º15'39"

2.2 CPCe Operation and Data Analysis

CPCe program was designed specifically to quickly manage and effectively calculate statistical coral coverage over a specified area. The frequency of corals / subtrates, identification and data analyses were run by specifying a digital image, defining a frame border, overlaying random points and saving the data to file (Kohler and Gill, 2006). Underwater photographic frames were overlaid by a matrix of randomly distributed points. In this case, thirty (30) random points were overlaid and generated in the whole frame of each photos and used for identification (Fig. 2). Point overlay was used to characterized the benthos, or estimate what percentage of each type of organism and substrate are in the image (Stopnitzky, 2014). The species code data for each frame was stored in a .cpc file which contains the image filename, point coordinates and the identified data codes. The data from individual frames can be combined to produce both inter- and intra transect/site comparisons via automatically generated Excel spreadsheets. In the meantime, the transect datasets can be statistically analyzed, to give quantitative population estimates including species diversity estimates over the area of interest. Individual image frames were analyzed separately. Multiple frames were combined for a single transect datasheet containing header information, statistical parameters of each species/substrate type (relative abundance, mean and standard deviation) and diversity indices (Shannon-Weaver and Simpson's) were calculated for each transect (Kohler and Gill, 2006). Moreover, the software can also perform planar measurements (length and area of selected benthic features), in situ measurements for determination of growth trends over time. A significant feature also is that spreadsheets were generated directly in Microsoft excel for analysis based on supplied species/substrate codes which make it more convenient and fast. The ready-made codes for list of species were supplied by the software for identification, however new codes were added in the notepad file for species not on the list and editing was also done. The software has built-in guide and references with respect to coral identification and diseases.

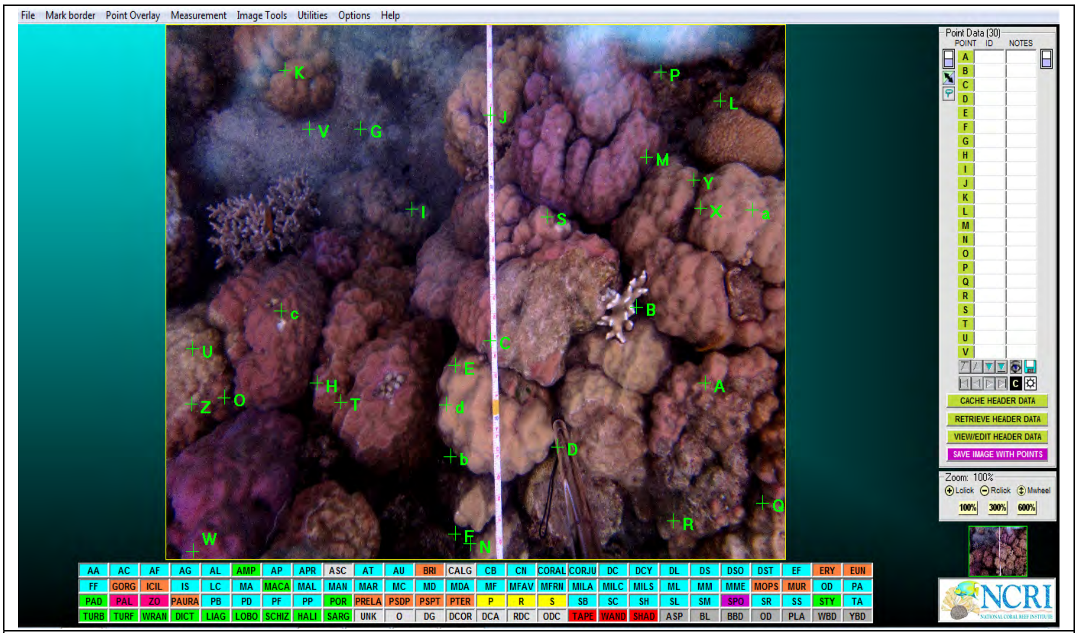

Fig. 2 Screenshot of sample image with overlying thirty (30) random points automatically generated by CPCe software. Available coral and substrate codes are shown underneath the image. Data entry area is on the right.

3 Results and Discussion

Coral reefs are considered as one of the most diverse and valuable ecosystems on Earth. It provides structural habitat and support for hundreds to thousands of species per unit area than any other marine environment (Reaka-Kudla, 1997). This existing biodiversity is considered the key to potential new discoveries for the 21st century. In addition, coral reefs buffer adjacent shorelines from wave action and prevent erosion, property damage and loss of life. It provides protection for highly productive wetlands along the coast, as well as ports and harbours and the economies it supports. Healthy reefs contribute to local economies through diving tours, fishing trips, hotels, restaurants, and other businesses near reef systems by providing jobs to local communities.

CPCe is designed specifically to quickly and efficiently calculate statistical coral coverage over a specified area. Underwater photographs were processed and individual image frames were analyzed for species identification/substrate, relative abundance and diversity.

One of the features of CPCe software is that, it directly analyzes and input the data in Microsoft excel spreadsheets. Built-in major categories were identified in four transects. The categories were the following: corals, gorgonians, sponges, zooanthids, macroalgae, dead coral with algae, coralline algae, diseased corals, and others (Table 1).

A total mean of 30.11% was computed for live corals. Meanwhile, dead corals tend to have a higher mean percentage (43.06%). This implies that ecological factors deteriorating the community of coral reefs could be present. Some possible causes of high mortality rate of corals in the area are as follows: anthropogenic alterations, macroalgal growth and the fast-occurring diseases. Weijerman et al. (2014) stated that both nutrients (resources) and grazing pressure (consumers) can influence the growth of macroalgae.

Table 1 Major Categories with mean percentage found in each transect.

Major Category (% of transect)	MEAN				
	Transect 1	Transect 2	Transect 3	Transect 4	TOTAL
Corals (C)	30.52	26.79	29.77	33.38	30.11
Gorgonians (G)	0.00	0.00	0.00	0.00	0.00
Sponges (S)	0.00	0.50	0.34	2.07	0.75
Zooanthids (Z)	0.00	0.20	3.10	5.77	2.27
Macroalgae (MA)	1.39	3.62	6.23	0.90	3.04
Other Live (OL)	0.21	0.14	0.34	0.14	0.21
Dead Coral with Algae (DCA)	22.48	47.43	52.86	49.45	43.06
Coralline Algae (CA)	0.00	0.00	0.00	0.00	0.00
Diseased Corals (DC)	30.94	3.96	0.00	0.62	8.88
San, Pavement, Rubble (SPR)	14.36	17.36	7.19	7.19	11.52
Unknowns (U)	0.00	0.00	0.17	0.48	0.16
Tape, Wand, Shadow (TWS)	4.33	2.47	2.60	3.53	3.23
Sum (excluding tape+shadow+wand)	100.00	100.00	100.00	100.00	100.00

Seventeen species of corals belonging to twelve genera were identified using the CPCe software (Fig. 3). The most dominant species fall under the two common genera: *Acropora* and *Porites*. Under the genus *Acropora* were *A. cervicornis*, *A. listeri* and other unidentified *Acropora* species. *Porites lobata* was the most dominant species, having a mean of 21.79 % (Fig. 3). *P. lobata* are hermatypic scleration corals (Pätzold, 1984) and survives well when transplanted (Clark and Edwards, 1995). They have an average of 30% of live hard coral cover on tropical reefs (Raymundo et al., 2005). These frequently dominating species are reef-building organisms in tropical seas, which come from large wave resistant structures through rapid upward growth (Pätzold, 1984). Generally, reef-building corals exhibit a wide range of shapes. For instance, branching corals have primary and secondary branches. Digitate corals look like fingers or clumps of cigars and have no secondary branches. Table corals form table-like structures and often have fused branches. Elkhorn coral has large, flattened branches. Foliase corals have broad plate-like portions rising in whorl-like patterns. Encrusting corals grow as a thin layer against a substrate. Meanwhile, the massive corals dominating the area were ball-shaped or boulder-like and may be small as an egg or as large as a house of the genus *Porites*. Noteworthy, is that reefs dominated by massive corals (also known as boulder or mound corals) are relatively slow growing. However, they are considered as very stable profiles, because they are seldom damaged by strong wave action unless they are dislodged from their holdfasts. Massive and submassive corals are resistant to strong water currents, and are therefore commonly found in shallow and mid-depth waters (NMFS, 2001; Huang, 2008; Tao, 1999).

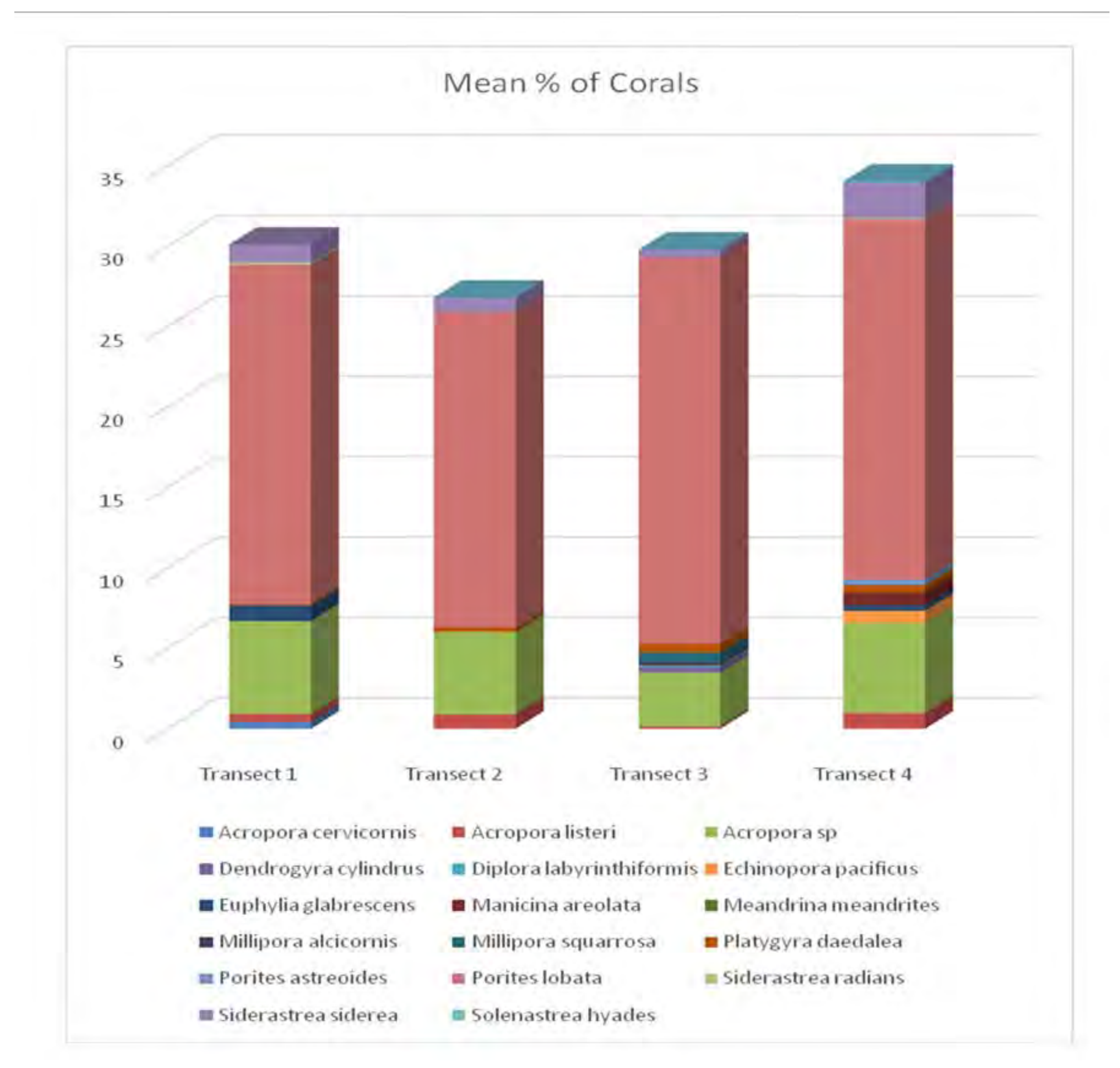

Fig. 3 Percentage of corals in the four transect lines in Calangahan, Lugait, Misamis Oriental.

To preserve biodiversity in a given area, it is pertinent to understand how diversity is impacted by different management strategies. Because diversity indices provide more information than simply the number of species present (i.e., they account for some species being rare and others being common), they serve as valuable tools that enable biologists to quantify diversity in a community and describe its numerical structure. Shannon-Weaver and Simpson's Indices were also automatically calculated by CPCe software for each transect including the overall value (combining data from transect 1-4). Table 2 shows the diversity of corals in the four transects. Although, diversity values were close to each other, transect 1 is considered as relatively diverse (H=1.41; D-1=0.74) compared to other transects. In contrast to this, transect 4 holds the least diversity (H=0.99; D-1=0.56). The Shannon index (H) increases as both the richness and the evenness of the community increase. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4 (Magurran, 2004). But here the overall value for Shannon diversity index (H) is only 1.32 (for all transect) and 0.68 for Simpson's index (1-D) which denote a relatively disturbed area. Levels of disturbance have different effects on diversity. Corals found in the area were mostly common coral species under genera *Porites* and *Acropora* that are relatively slow-growing and resistant to strong water currents in shallow and mid-depth waters. Efforts were also made by people dwelling beside the sea to make sure that corals continue to thrive in a non-Marine Protected Area (MPA) such as this. However, low diversity could be likely due to the occurrence of diseases which has caused degradation in the coral reef community.

Table 2 Shannon-Weaver and Simpson's Index of diversity.

Transect	Shannon-Weaver Index (H)	Simpson Index of Diversity (1-D)
1	1.41	0.74
2	1.27	0.66
3	1.09	0.59
4	0.99	0.56
Overall (1-4)	**1.32**	**0.68**

There are many factors leading to marine degradation. Pollution on coastal marine environment can destruct the natural living species in coral reef community. Hodgson (1990) stated that both natural and man-made destruction can affect the deterioration of coral reefs. In tropics, sedimentation input from terrestrial sources can damage economically important coral reef community. Sediment deposition on coral reefs occurs naturally and is also caused by man-made disturbances such as dredging that can result in the death of scleractinian corals by an unknown mechanism (Hodgson, 1990). Some of the deteriorating condition of the coastal resources mentioned by Indab and Suarez-Aspilla (2004) can be attributed to a number of factors, such as over-fishing, use of destructive fishing methods, pollution conflicting government policies and non-enforcement of laws.

Moreover, the most serious factors in the decline of coral reefs were diseases affecting them (Weil, 2004). Coral diseases generally occur in response to biological stresses, such as bacteria, fungi and viruses, and nonbiological stresses, such as increased sea surface temperatures, ultraviolet radiation and pollutants. One type of stress may exacerbate the other (NMFS, 2001).

In this study, the occurrence of various diseases affecting corals were also assessed and documented since the software contain codes and references to common coral diseases. Yellow blotch disease, white pox disease, white band disease, ulcerative white spot disease, bleach coral point and other diseases (Black-band disease, discolored spots/ dark spot syndrome, brown-band disease, red-band disease, pigmentation response and growth anomalies) were identified (Fig. 4). *Porites lobata,* being the most numerous also appeared to be the most affected by diseases. These results were comparable with the previous work of Raymundo et al., 2005. The Porites ulcerative white spots disease (PUWS), pigmentation response and tumor growth (growth anomalies) were commonly observed in the genus *Porites* in the four transects. These diseases may either regress or progress to full tissue-thickness ulcerative that coalesce and occasionally resulting in colony mortality (Raymundo et al., 2003).

The frequency of coral diseases has increased significantly over the last decade, causing widespread mortality among reef-building corals. It is perceived, that many scientists believe the increase is related to deteriorating water quality associated with human-made pollutants and increased sea surface temperatures. These factors may allow for the proliferation and colonization of microbes. However, exact causes for coral diseases remain elusive. The onset of most diseases likely is a response to multiple factors. Moreover, mechanisms by which many diseases act upon the coral polyp are not well known, however, effects that these diseases have on corals has been well documented. Black-band disease, discolored spots, red-band disease, and yellow-blotch/band disease appear as discolored bands, spots or lesions on the surface of the coral. Over time, it will progress across or expand over the coral's surface consuming the living tissue and leaving the stark white coral skeleton in their wake. The other diseases, such as rapid wasting, white-band, white-plague and white-pox, often cause large patches of living coral tissue to slough off, exposing the skeleton beneath. Once exposed, the coral's limestone skeleton can be a fertile breeding ground for algae and encrusting invertebrates. The colonization and overgrowth of the exposed coral skeleton by foreign organisms often results in the health of the entire colony taking a downward spiral from which it seldom recovers (NMFS, 2001; Borger, 2005; Raymundo, Couch and Harvell, 2008).

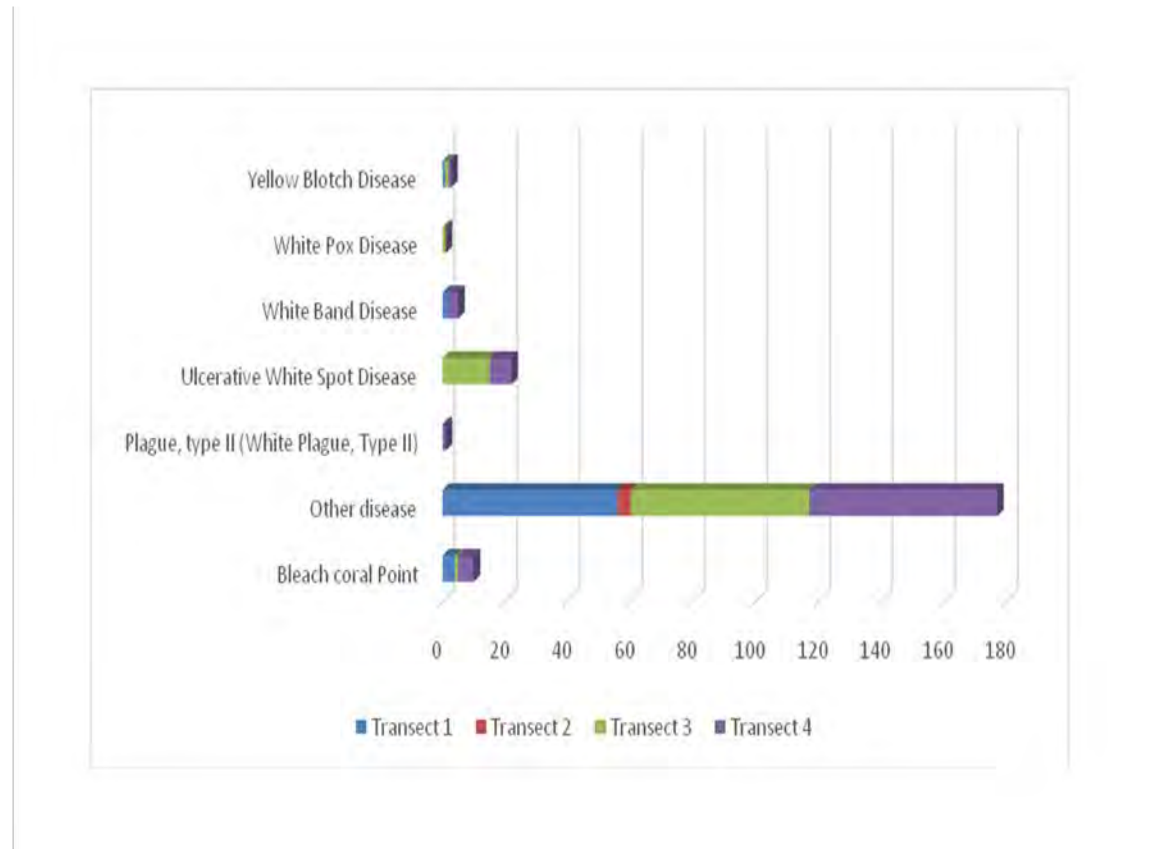

Fig. 4 Diseases present in corals found in four transects in Calangahan, Lugait, Misamis Oriental.

Apparently, 'the big four,' human activities that threatened sustainability are: climate change, land and marine based pollution, habitat degradation and over-fishing. Many of these impacts have obvious and immediate effects, such as smothering or fragmentation of coral to the point of mortality. However, one phenomenon which has regained the attention of researchers and managers are diseases. Diseases affecting corals have increased both in frequency and severity and there are a lot to consider about the nature of diseases and outbreaks for management actions.

Moreover, over the past several years many methods for survey and monitoring programs have been developed such as video transecting technique that rely on permanent markers for long-term studies (Aronson et al., 1994), however, the repeated measures approach can be costly and impractical for sampling on a few places or on a few reefs. This study features an independent sampling approach that photographs long transects and analyze by point counts, hence, offers wide applicability, especially where human and financial resources are limited (Aronson and Swanson, 1997; Carleton and Done, 1995; Bak and Luckhurst, 1980). This study proved the efficiency of CPCe as a tool in coral assessment for monitoring purposes and provided a baseline data on assessing diseases on reefs. Thus, the basic knowledge gained on coral diseases help improve monitoring efforts and aide in proper recognition and related issues of coral health (Hughes, 1992, 1989). Through studying diseases and establishing baseline data prior to crisis, one is armed with better knowledge for appropriate management options toward a given situation. In this respect, monitoring, research, and restoration all are essential to safeguard coral reefs. Conservation management and strategies are vital. However, to ultimately protect coral reefs, legal mechanisms may be necessary in the long run.

4 Conclusion

Coral Point Count with Excel Extensions (CPCe) software was used for Coral reef assessment and monitoring purposes in Calangahan, Lugait, Misamis Oriental. In this study, CPCe software provided a means to increase efficiency of coral reef monitoring efforts. This study provided a baseline data on assessing diversity and diseases on reefs. It yield *Porites lobata* as the most abundant coral species present in the area and showed a wide occurrence of diseases among corals which led to high mortality rate. Whether these effects may be due to natural or man-made destructions, the present assessment are essentially vital for conservation management.

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