Year-Long Monitoring Of Coral Recruits And Its Correlation To The Abiotic And Biotic Factors In Coral Garden And Angel's Cove, Talicud Island, Island Garden City Of Samal

Bagani Fidel A. Evasco

Environmental Science Department Natural Sciences and Mathematics Cluster, [2]Bachelor of Science in Environmental Science, Ateneo de Davao University, Philippines
ghostwriter052599@gmail.com

Abstract: The study focuses on coral recruits and their correlation to biotic and abiotic factors. Coral Recruits were assessed in two sites, namely Coral Garden and Angels Cove in Talicud Island, Island Garden City of Samal. They were found at varied depths: 6 meters, 13 meters, and 20 meters, with a duration period of at least 12 months, specifically between January – December 2017. The pairwise correlation between coral count and abiotic and biotic factors was also analyzed using Spearman's Rho, and the correlation result was true in all sites. Multi-correlation between coral count and abiotic and biotic factors across all depths was analyzed through Principal Component Analysis, which showed no differences between the two sites. The data collection method utilized SCUBA, and observation is done through visual observation and the utilization of a Camera as a photo documentation of the settlement found on the four sides concrete marine block installed in the study sites. The coral recruit and algae have developed a symbiotic and mutualistic relationship in 13m and 20m depths. In comparison, they have a parasitic relationship at 6m depth as per observation that there was a massive decrease of corals in shallower waters (6m). At the same time, a massive increase in algae was observed instead. In terms of abiotic factors, the study also found that there have been no significant changes that took place specifically along benthic waters as compared to the surface water. The massive increase of algae can be observed in the shallow waters, and leaving coral mortality can be attributed to the fact that the study sites have high anthropogenic activities, such is also evident across many parts of the globe. High anthropogenic activities have been the cause of the decline of coral recruits and increased chances of coral mortality.

Keywords: Abiotic and Biotic Factors, Coral Garden and Angel's Cove, Coral Recruits, Spearman's Rho, Samal, Philippines

1. Introduction

Philippines have one of the most extensive coral reefs in the world, next to Indonesia, and it can be found in the heart of the Coral Triangle a region recognized to be a global center of marine biodiversity and a global priority for conservation [1]. The total reef areas of the Philippines cover around 27,000-44,000km2 [2] and part of this wide stretch of abundance is the coral reef found in Samal, which has a total of 53 identified coral genera out of 73 coral genera found in the Philippines (IGaCos Comprehensive Land Use Plan 2008-2017). Abundant reef areas can be found in IGaCos, the following areas are the identified areas for this study which is Angel Cove situated within Brgy. Dadatan that covers 5 has. and Coral Garden within Brgy. Linosutan that covers 35.5 has.

As revealed by several studies, that international scientific community has difficulty in determining baseline data on for monitoring and collecting continuous data on coral larva recruitment and settlement and as well the abiotic and biotic factor; the same gaps and situation is true vis-a-vis to the situation here in the Philippines.

Naturally, corals are the principal reef builder [3] and they are among the most diverse and complex ecosystems in the world in terms of biodiversity and productivity yet the most fragile. But the increasing frequency and intensity of anthropogenic and climate-related disturbances, particularly coral bleaching and altered storm regimes, are predicted to significantly reduce coral population sizes in the next few decades resulting to coral decline [4].

Despite such disturbances in their habitat, coral reefs can recover either by re-growth from remnant live coral tissue on surviving colonies or by propagation from broken fragments following storms or other high-energy events . Corals can also repopulate itself through larval replenishment involves the dispersion of larva, so that populations that routinely receive larval subsidies from external sources are more likely to recover and avoid degradation [5].

To note, data on coral larva has been utilized to assess healthy corals and also it has been utilized to project future trajectory of coral population [5] [6] [7]. Despite of its important contribution in understanding the dynamics of coral recruitment and post-settlement, carrying out a study on coral larva, would mean an arduous and challenging task especially in surveying its population.

Several studies have been conducted that discussed and presented about coral reproduction [8] and recruitment [10].

To grasp the life cycle of coral reefs it is very important to note that the growth of this important marine resource through understanding the process of Coral Spawning. Baird et al [11] argues that Coral spawning takes place during full moon and the drifting planulae (minute coral larvae) will eventually settle in the substrate during low tide without current. Accordingly, some corals are male that release clouds of sperms, nearby a female that will also release some eggs; while other species of corals are both male and female, release packages of eggs already prewrapped in sperms. Bundles of eggs and sperms brood-casting to the surface to mix with others coming from further along the reef. Eggs and sperms are release within a certain hour to a certain month which maximize the chances of cross fertilization. In the end, the fertilized egg, drifted away from the reef [12].

Coral recruitment is the process by which drifting planulae (coral larva) attach and establish themselves as members of the reef community . It also provides essential habitat and perform a host of important tasks that maintain the health and integrity of these systems, as it has significant value in generating, storing and providing energy within reef ecosystems. It is vital that changes in these organisms are detectable. However, without a historical backdrop of baseline information on their abundance, species identity and structure across space and time, it is impossible to determine whether changes in these parameters are due to natural variability or are cause for concern.

On the other hand, the recruitment and settlement of coral larva exist in regions or places where climate change, upwelling, or internal waves drive the variability of critical abiotic factors such as temperature, salinity, dissolved oxygen, and nutrient supply (Roik, Rothig et al., 2016). As cited by Roik, Rothig et al., (2016) also revealed that "anomalies and changes of abiotic factors (such as above-average summer temperatures or increased coastal nutrient input) can drive shifts in the ecology and composition of coral reef benthic invertebrate assemblages" (p.2).

With the dearth of data and literature that comprehensively study the status of coral reefs and as well as the monitoring and data collection with regards to coral larva in the Philippines setting, thus this study attempts to bridge this gap. This inquiry also attempts to help the community to better understand coral reef resilience, restoration and conservation.

The problems raised in this study are despite the fact that coral recruitment is an important indicator of coral reef resilience, local stakeholders have limited scientific knowledge with regards to the ecological factors affecting Coral recruitment situated in Talicud Island. This study is study investigated coral recruitment in two sites in Talicud Island: Coral Garden and Angel's Cove. Mainly this study will compare average abiotic and biotic factors in two sites, 3 depths across 12 months. Perform pairwise correlations on abiotic and biotic factors in two sites, 3 depths across 12 months. Discover latent dimensions among abiotic and biotic factors including their distribution and determine the distribution of sites on vectors and depths of abiotic and biotic factors and determine abiotic and biotic factors in two sites, 3 depths across 12 months.

2. Statement of the Problem:

Despite the fact that coral recruitment is an important indicator of coral reef resilience, local stakeholders have limited scientific knowledge with regards to the ecological factors affecting Coral recruitment situated in Talicud Island.

Moreover, this study investigated coral recruitment in two sites in Talicud Island: Coral Garden and Angel's Cove. This study will; 1. Compare average abiotic and biotic factors in two sites, 3 depths across 12 months; 2. Perform pairwise correlations on abiotic and biotic factors in two sites, 3 depths across 12 months; 3. Discover latent dimensions among abiotic and biotic factors including its distribution; 4. Determine the distribution of sites on vectors and depths of abiotic and biotic factors; 5. Determine abiotic and biotic factors in two sites, 3 depths across 12 months.

3. Materials and Methods

Data Collection and Analysis is divided into three phases: Installation, Data Collection and Interpretation and Data Analysis.

3.1 Installation

This phase involves the installation of the materials needed for the research. This took place on the following dates November 5, 13, 20 and 30, 2016 of which the researcher installed the total of 24 marine blocks in Coral Garden and Angel's Cove (12 marine blocks). Before the researcher submerged, there was a transect line that served as marker prior to the installation of marine blocks, with a measurement of 25 m long and 15m width in a rectangular shape. Once the transect line has been installed and identified properly, the installation of marine blocks then followed by progression with 4 marine blocks being installed per schedule.

3.2 Data Collection Procedure:

Data Collection has been divided into two phases namely the on-site collection of samples and testing of samples.

3.2.1 On-site Collection of Samples

On-site collection of sample includes methods in order to collect the sample needed for the study. It should be noted that there are variations of methodology utilized to get the samples. The following are as follows:

3.2.1.a Modified Grab Sampling

This data collection involved an approximately 250ml plastic container and 330ml BOD bottle were utilized to collect water samples within 6m, 13m and 20m depth from each study sites.

3.2.1.b Modified Photo – Quadrat

This data collection method utilized SCUBA and observation is done through visual observation and the utilization of Camera, as a documentation of the settlement found in the concrete pole bases installed in the study sites. Photo documentation covered the four sides of these concrete pole bases. It should be noted that based on anecdotal experience as a technical diver, each dive is bounded by time and certain depth, given the fact that during diving a diver's body absorbs compressed nitrogen from his breathing gas and this compressed nitrogen is trapped in his tissues and the deeper the dive, the more rapidly a diver will absorb nitrogen and the shorter his no-decompression limit will be.

3.2.1.b Modified Photo – Quadrat

Table 1. Abiotic Factors, Methods, Equipment Used and Units

Abiotic Factors	Methods/Equipment Used	Units
pH	PASCO multi parameter/ pentype	pH units
Temperature	PASCO multi parameter/glass thermometer/ Scubapro dive computer	Celsius
Salinity	PASCO multi parameter / Pentype Salinometer	ppt
Conductivity	PASCO multi parameter	microsiemens
Dissolved Oxygen (DO)	Gravimetric Winkler Method	mg/L

This data collection method utilized SCUBA and observation is done through visual observation and the utilization of Camera, as a documentation of the settlement found in the concrete pole bases installed in the study sites. Photo documentation covered the four sides of these concrete pole bases. It should be noted that based on anecdotal experience as a technical diver, each dive is bounded by time and certain depth, given the fact that during diving a diver's body absorbs compressed nitrogen from his breathing gas and this compressed nitrogen is trapped in his tissues and the deeper the dive, the more rapidly a diver will absorb nitrogen and the shorter his no-decompression

limit will be. Therefore, the longer a diver stays underwater, the more compressed nitrogen he/she absorbs and if this cannot be controlled the diver experiences decompression sickness which would later take toll on his physical body and based on many cases there are divers who ended up being physically paralyzed.

As mentioned above, that the recording of the sample took place on the spot, therefore the testing samples are done in the following procedure below.

3.2.2 Testing of sample:
The grab sampling consisted of 4 replicates per depth which were submitted to determine the abiotic factors.

To determine the dissolved oxygen, water samples were collected using the BOD bottles insuring that there were no bubbles trapped in it. Then per BOD bottle is added with 3 different reagents as preservatives: manganese sulfate solution, alkali-iodide-azide solution, and sulfuric solution.

3.4 Data Management
The measurements and the documentation of data were all recorded on the spot in the logbook and PASCO multi parameter software called SPARKvue. It should be noted that the logbook and field logs were kept securely. All observations during the sampling, preparation of chemicals and all other pertinent information such time, date, depth, boat dive buddy, dive site, tide and weather were all recorded. Field bottles such BOD and plastic jars were regularly checked and maintained.

3.5 Data Analysis
The biotic factors through the modified photo-quadrat the results were analyzed through GeoGebra 5 Software for the coral and algae count, analyzing the photo with 10 x 10 grid points (Figure 4).

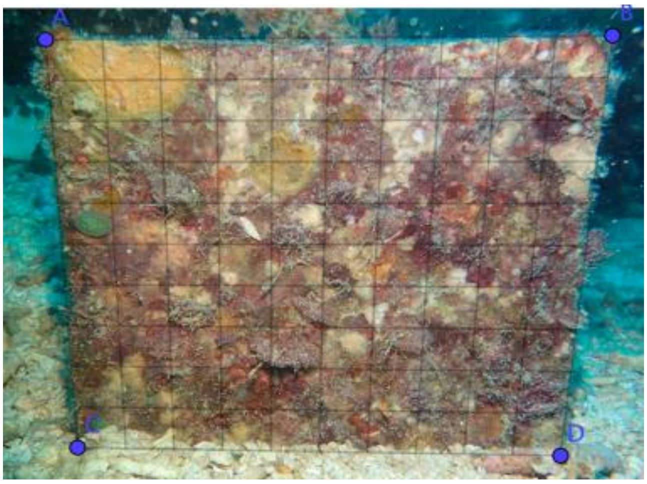

Figure 1. Modified Photo-Quadrat

The identification of coral larvae and its growth is done through the images produced by Viyakarn et al, 2015, that indicated the "Eight Stages of Larval Development" (Figure 5), which served as a basis also for manual counting. Manual counting is done through for example in one gravid colony of coral consists is equivalent to 6 coral counts in 6 quadrats (See Figure 3, point A). But if there are two minute larvae settled in one quadrat for example, it can be counted only as one. However, if there is one minute coral and one colony of algae settled in one quadrat, the count is one coral and one algae, but if there is an existing gravid colony but overlaps with algae then the count is exclusive only for algae.

So, after collecting the results of the coral and algae count, the mean of the coral and algae count of each depth per site were calculated. Knowing that there were data for the abiotic and biotic factors were already collected the results were then tabulated utilizing R version 3.4.0 and R Studio version 1.0.143 for computing statistics. While Mann-Whitney test, Spearman's Rho, and Principal Components Analysis (PCA) Biplot correlation was utilized to determine the relationship between the abiotic and biotic factors.

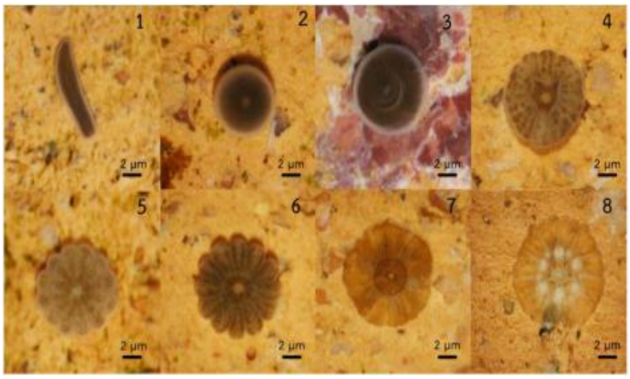

Figure 5. Eight Stages of Larval Development (Viyakarn et al., 2015)

3.6 Statistical Methods for Analysis

The following statistical methods for analysis utilized for this study were as follows: Spearman's Rho was utilized to determine the coefficient correlation between biotic and abiotic factors, while Mann – Whitney test was used to determine the 95% confidence interval, and Principal Component Analysis (PCA) BIplot was also utilized to determine the latent dimension, depths and vector of the total variation.

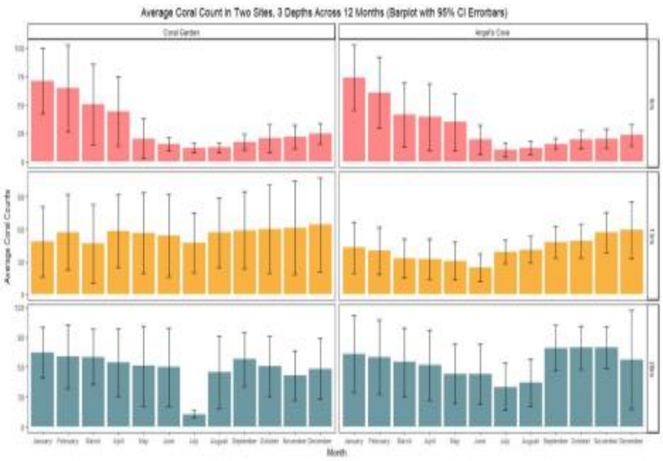

Figure 3. Average Coral Count in Two Sites, 3 Depths across 12 Months

Spearman's Rho is a statistical measure of the strength of a monotonic relationship between paired data and is often used to measure the dependence in a pair of non-continuous random variables.

Mann – Whitney "nonparametric tests based on rank, assumes equal variances in the two populations from which the two samples being compared are taken. However, there are instances that some researchers usually use the Mann–Whitney U test without examining whether the variances are equal. Also, it is used "to test the null hypothesis that two samples come from the same population (i.e. have the same median) or, alternatively, whether observations in one sample tend to be larger than observations in the other" (Upton, G. and Cook, I., Dictionary of Statistics, 2014).

Principal Component Analysis (PCA) BIplot is a "multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components, and to display the pattern of similarity of the observations and of the variables as points in maps.

4. Discussion and Result

4.1 Site Selection

Angel's Cove and Coral Garden can be found along Davao Gulf area, particularly Talicud Island, Island Garden City of Samal, in spite of the fact that the sites are teeming with vast and rich marine ecosystem as compared to other areas within Davao Gulf; yet studies related to Davao Gulf have been limited. Hence the fulfillment of this study to fill that gap. The researcher also selected the following these study sites knowing that these areas have been identified with highly anthropogenic activities such as diving, snorkeling and other eco-tourism related activities that may somehow impact the marine ecosystem (see figure 1).

4.2 Average coral count with abiotic and biotic factors in two sites, 3 depths across 12 months

The estimates of average coral count in two sites, 3 depths across 12 months. Error bars represent 95% confidence intervals are shown in (Figure 3). The degree of overlap between error bars indicates whether the differences or results are most likely to be due to chance or sampling error. The less the overlap between error bars, it is most likely the differences or results are not due to chance or sampling error.

At Coral Garden (Figure 3), the average coral count among 6 m, 13 m, and 20 m in January, February, March, April, May, June, October, November, and December have overlapping error bars, implying that the differences in average coral count is most likely due to chance or sampling error. In July, 6 m and 20 m overlap but the upper fences are very close to the 13 m error bar implying differences in average coral count is likely due to chance or sampling error. In August, 13 m and 20 m overlap but the upper fences are very close to the 6 m error bar implying differences in average coral count is likely due to chance or sampling error. In September, 6 m and 13 m overlap implying that the differences in average coral count is most likely due to chance or sampling error. However, the upper fence of 6 m is quite far from the lower fence of 20 m implying that the difference in average coral count is less likely due to chance or sampling error.

At Angel's Cove (Figure 4), the average coral count among 6 m, 13 m, and 20 m in January, February, March, April, May, June, and December have overlapping error bars, implying that the differences in average coral count is most likely due to chance or sampling error. In July and August, it is likely that the differences in average coral count is most likely due to chance or sampling error between 6 m and 13 m, but less likely between 20 m and 13 m and between 20 m and 6 m. In September, October, and November it is likely that the differences in average coral count is most likely due to chance or sampling error between 13 m and 20 m, but less likely between 6 m and 13 m and between 6 m and 13 m and between 6 m and 20 m.

Mann-Whitney tests reveal no significant differences in average coral count among depths in all months.

The estimates of average algae count in two sites, 3 depths across 12 months. Error bars represent 95% confidence intervals are shown in (Figure 4). The degree of overlap between error bars indicate the whether the differences or results are most likely to be due to chance or sampling error. The less the overlap between error bars, it is most likely the differences or results are not due to chance or sampling error.

At Coral Garden (Figure 7), the average algae count among 6 m, 13 m, and 20 m in January have overlapping error bars implying that the differences in average coral count is most likely due to chance or sampling error. In February, March, April, May 13 m and 20 m had 47 overlapping bars implying that the differences in average coral count is most likely due to chance or sampling error. However, because the error bars in 6 m do not overlap with the error bars of 13 m and 20 m it is most likely the differences or results are not due to chance or sampling error. In June, July, August, September, October, November, and December 20 m and 13 m and 20 m and 6 m have overlapping error bars implying that the differences in average coral count is most likely due to chance or sampling error. However, because the error bars in 6 m do not overlap with the error bars of 13 m it is most likely the differences or results are not due to chance or sampling error.

At Angel's Cove (Figure 3), the average algae count in January, February, March, April, May, and June have overlapping error bars implying that the differences in average coral count is most likely due to chance or sampling error. In August, September, October, November, and December 20 m and 13 m and 20 m and 6 m have overlapping error bars implying that the differences in average coral count is most likely due to chance or sampling error. However, because the error bars in 6 m do not overlap with the error bars of 13 m it is most likely the differences or results are not due to chance or sampling error, except for July.

Mann-Whitney tests reveal no significant differences in average algae count among depths in all months.

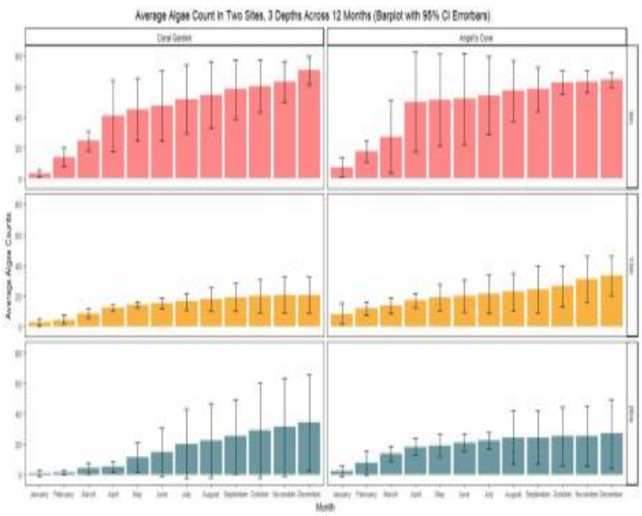

Figure 4. Average Algae Count in Two Sites, 3 Depths across 12 Months

The estimates of average pH in two sites, 3 depths across 12 months are shown in (Figure 4).

At Coral Garden and Angel's Cove in January, February, March, April, May, June, July, August, September, October, November, and December differences in average pH is most likely due to chance or sampling error. The absence of error bars reflects the lack of variation because of constant values at each depth.

Mann-Whitney tests reveal no significant differences in average pH among depths in all months. These values are also true for temperature (oC), salinity (ppt), conductivity (microsiemen) and dissolved oxygen (mg/L)).

Figure 5. Average pH in Two Sites, 3 Depths across 12 Months

4.3 Pairwise correlation between coral count, abiotic and biotic factors.

Table 2. Correlation matrix of response variables

	Coral Count	Algae Count	pH	Temperature	Salinity	Conductivity
Algae Count	-0.70*					
pH	-0.21*	-0.12				
Temperature	-0.09	0.14	-0.10			
Salinity	0.13	-0.11	-0.13	-0.40*		
Conductivity	-0.25*	0.11	0.19	0.09	-0.12	
Dissolved Oxygen	-0.11	0.03	-0.16	0.20*	-0.15	0.26*

Asterisk (*) has a correlation that is close to 1 or -1.

The correlation matrix in (Table 2) shows that Coral Count has very strong correlation with Algae Count (-0.70), it means that algae count rapidly increases in shallower depth, but also increased in other deeper depths. But moderately weak with pH (-0.21) and Conductivity (-0.25), and weak correlation between Salinity, Dissolved Oxygen and Temperature, as these factors has no direct effect on the algae and coral population. Algae Count has weak correlation with pH, Salinity, Temperature, Conductivity and Dissolved Oxygen.

While, pH has weak correlation with Temperature, Salinity, Conductivity and Dissolved Oxygen; Temperature has moderately strong correlation with Salinity (-0.40), this manifest that it affects the increase of algae population due to photosynthetic activity. But moderately weak correlation with Dissolved Oxygen (0.20) and weak correlation with Conductivity. Salinity has weak correlation with Conductivity and Dissolved Oxygen and lastly, Conductivity is moderately weak correlation with Dissolved Oxygen (0.26), as these factors has no direct effect on the algae and coral population.

The strength of correlation between any two variables can range from 0 to 1 (regardless of sign), where weak = 0.1, moderate = 0.3, and strong = 0.5. Thus, the correlation between coral count and algae count is very strong, and the rest of the pairwise correlations are either moderate or weak.

As cited in many studies it has been argued that high anthropogenic activities may cause decline of corals in shallower depths and there is a tendency for the prevalence of algal bloom. However, if the identified area/s, is/are already identified as a Marine Protected Area, then anthropogenic activities are no longer allowed and are considered as a violation. With this situation, the reinforcement of MPA would ensure limited if not an absence of anthropogenic activities, thus would eventually lesser the prevalence of algal bloom and coral decline which may lead to restoration of coral reef system in the area [6].

4.4 Multi-correlation between coral count, abiotic and biotic factors across all depths

Principal Components Analysis of the response variables extracted two components or latent dimensions that could explain 53.2% of the total variation . The first component had high loadings for coral count and algae count and the second component had high loadings for dissolved oxygen, pH, conductivity, and temperature . Thus, the result of the first component may be considered as the biotic dimension and the second component as the abiotic dimension.

By creating a PCA Biplot on sites and observations of sampling units, as shown (Figure 5 & 6), the results of PCA can be visualized by plotting site and the response variables on component 1 (x-axis) and component 2 (y-axis) in which the response variables are shown as arrows and observations or sampling units as dots.

The placement of vectors (response variables) depend on the quantity and quality of its loadings (correlation) on a principle component. For example, the vectors coral count and algae count are relatively the nearest to component 1 because both have the highest loadings on component. However, both vectors point to opposite directions because coral count has a positive loading on component 1 and algae count has a negative loading on component 1 and are negatively correlated. Vectors that point in the same direction and are relatively close have similar response profiles. In the Biplot, pH and conductivity are close to each other, point to the same direction, have high loadings on component 2, and are positively correlated. If the angles between vectors are 0 degrees or 180 degrees, then the correlation is +1 or -1. The closer the angle between vectors to 90 degrees, the lower the positive correlation. The closer the angle between vectors to 270 degrees, the lower the negative correlation.

The dots are color-coded according to sites. Dots that are close together correspond to sampling units or observations that have similar scores on the components displayed on the Biplot. The dots also correspond to observations that have similar values on the vectors (response variables). Because vectors point towards increasing values, the closer the perpendicular projection of dots to where the vector arrow head points, the greater the value of the observations. The succeeding plot reveals that the same is true for dots that are located in the opposite direction of the vector arrow heads.

Apparently, the observations in Angel's Cove (Figure 7) and Coral Garden (Figure 6) are similar, because the dots fail to cluster per site (color). The colored circles represent the 95% confidence ellipses for Coral Garden and Angel's Cove. The overlapping 95% ellipses show the similarity between observations in Angel's Cove and Coral Garden.

The PCA Biplot on depth and observations or sampling units show response variables as arrows and observations or sampling units as dots.

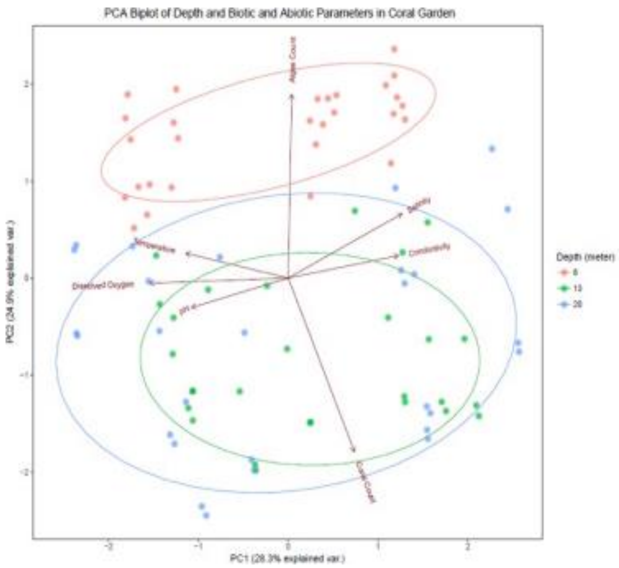

Figure 6. PCA Biplot of Depth and Biotic and Abiotic Parameters in Coral Garden

The dots are color-coded according to depths. Dots that are close together correspond to sampling units or observations that have similar scores on the components displayed in the Biplot. The points also correspond to observations that have similar values on the vectors (response variables). Apparently, the observations in 13 m and 20 m are similar, because the dots fail to cluster by depth (color) and the 95% ellipse for 20 m completely overlaps the 95% ellipse for 13 m. However, observations at both 13 m and 20 m tend to cluster as opposite to the observations made at 6m. The Biplot shows that observations at both 13 m and 20 m depths tend to have higher coral count, higher salinity, lower algae count, lower conductivity, and lower temperature compared to observations at 6 m.

On the other hand, the observations at 6 m depth appear to form a cluster near the arrow heads of the vectors for algae count, temperature, and conductivity; which means that at 6 m it has been observed that it has higher algae count, higher temperature, and higher conductivity and lower coral count and lower salinity as compared to the observations made at 13 m and 20 m depths.

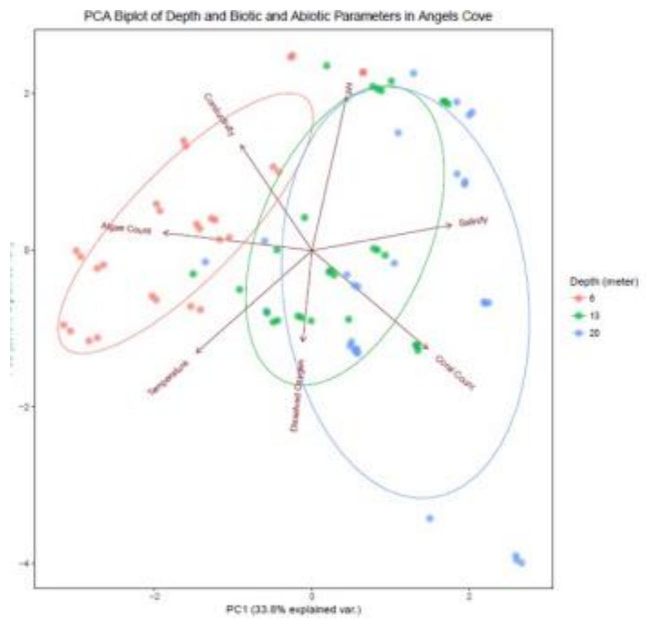

Figure 7. PCA Biplot of Angel's Cove Dive Sites and Biotic and Abiotic Parameters

Summary and Conclusion

Summary of findings as shown in Table 1, that at 13 m and 20 m depths tend to have higher coral count, higher salinity, lower algae count, lower conductivity, and lower temperature. While it has been observed that at 6m depth, it has higher algae count, higher temperature, and higher conductivity and lower coral count and lower salinity as compared to the observations made at 13 m and 20 m depths.

The study focuses on the coral recruits and its correlation to biotic and abiotic factors. Coral Recruits was assessed in two sites namely Coral Garden and Angels cove in Talicud Island, Island

Garden City of Samal and were found at varied depths: 6 meters, 13 meters and 20 meters with a duration period that covers at least 12 months specifically within January - December 2017.

Average coral count with abiotic and biotic factors in two sites, 3 depths across 12 months has been observed. By utilizing Mann-Whitney test the one-year trend results showed the average population count and measured abiotic factors are the same at both sites (see Table 4). While Coral counts across all depths has been decreasing from January to July and there was an increase has been observed during August to December, as this is due to the massive coral spawning that took place during these months and this is true across all depths at both sites. The test also notes a significant increase of algae count that took place from January to December across depths at both sites. However, Mann-Whitney test reveals no significant differences among biotic and abiotic factors during the last 12 months.

Table 4. Average biotic and abiotic parameters in two sites, 3 depths across 12 Months

Depth (m)		**Angel Cove**			**Coral Garden**		
		N	Mean	Std. dev,	N	Mean	Std. dev,
6	Coral Count	48	30.83	22.04	48	31.23	23.18
	Algae Count	48	47.10	21.47	48	44.46	22.04
	pH	48	8.07	0.28	48	8.09	0.33
	Temperature	48	29.38	0.86	48	29.15	0.81
	Salinity	48	32.91	1.23	48	33.64	1.47
	Conductivity	48	29602.37	25289.87	48	29955.95	25593.32
	Dissolve Oxygen	48	3.99	3.42	48	4.06	3.47
13	Coral Count	48	41.71	14.29	48	56.00	20.81
	Algae Count	48	20.81	9.32	48	14.44	7.19
	pH	48	8.08	0.29	48	8.14	0.35
	Temperature	48	29.03	0.74	48	29.02	0.73
	Salinity	48	34.33	0.84	48	33.80	1.03
	Conductivity	48	29722.83	25399.37	48	30102.29	25724.02
	Dissolved Oxygen	48	3.88	3.33	48	4.03	3.46
20	Coral Count	48	63.92	21.89	48	58.98	22.85
	Algae Count	48	19.33	10.36	48	16.81	16.13
	pH	48	8.10	0.32	48	8.18	0.38
	Temperature	48	28.95	0.77	48	28.89	0.67

Salinity	48	34.78	0.79	48	33.81	1.09
Conductivity	48	27794.05	24027.89	48	29940.53	25584.61
Dissolved Oxygen	48	3.95	3.40	48	3.95	3.41

Pairwise correlation between coral count, abiotic and biotic factors was also analyzed using Spearman's Rho, and the result of the correlation were true in all sites. At 6m, where there is a strong correlation of Coral count and Algae count; Temperature and Salinity is a moderately strong correlation and Dissolved Oxygen is a moderate strong correlation. At 13m, where there is a moderate correlation of Coral Count and Conductivity. At 20m, where the is a moderately weak correlation of Coral Count and pH also in Dissolved Oxygen and Temperature.

Multi-correlation between coral count, abiotic and biotic factors across all depths was analyzed through Principal Component Analysis, where it showed lack of differences between two sites. Given the overlapping of 95% ellipse in Coral Garden between 20m and 13 m; and overlapping of 95% ellipse in Angel's Cove between 13 m and 6m and between 13m and 20m.

With the data gathered, the coral recruit and algae have developed a symbiotic and mutualistic relationship found in 13m and 20m depth, while they have a parasitic relationship at 6m depth as per observation that there was a massive decrease of corals in shallower waters (6m) (McCook et al., 2001), while there was a massive increase of algae was observed instead, in oppose to the study conducted by Frankowiak et al, 2016. In terms of abiotic factors, the study also found out that there has no significant changes that took place specifically along benthic waters as compared to that of the surface water. With this result, it should be noted that the study sites have been identified as high anthropogenic activities (J.E. Smith et al, 2006), this can be seen as one of the factors that attributes to the incidence of massive increase of algae can be observed in the shallow waters and leaving coral mortality which can "subsequently opens more space for settlement and growth of algae" (J.E. Smith et al, 2006, p. 843). Accordingly, the incidence of algal bloom took place in the study sites (Manalo, 2017) and the same phenomenon has been observed in this study of which it can be attributed to the increasing anthropogenic activities not only in the study sites but across the world, of which may lead to the decline of coral recruits and increased chances of coral mortality (J.E. Smith et al, 2006, p. 843).

Recommendations

Generally, high incidence of anthropogenic activities in the island has impacted the recruits and growth of both coral and algae. Various studies may have pointed out various factors affecting to this phenomenon, however concrete and doable solutions must take in place to help preserve our marine resources otherwise we run at risk with depletion and devastation. Taking into consideration other dimensions of development such as economic, political and social knowing that our marine resources has connected us one way or another with this the researcher recommends the following:

1. Conduct further studies that may provide a more coherent view on coral recruitment by including other biological, chemical, and physical parameters; and comparing sites exposed to the northeast monsoon to sites exposed to the southwest monsoon;
2. Invest in Image Processing using CoralNet Beta software for more accuracy in the exact location of the block, specie identification to coral and algae and its count as it is more efficient and practical instead of manual and observational counting;
3. Conduct further studies that focus on nutrient enrichment to understand coral physiology and survival;
4. Create a group that will conduct the next studies since the studies will entertain a year long monitoring process;
5. Identify more areas in IGaCoS under MPA to prevent further depletion of coral reef system and marine resources in the island;
6. Strengthen mechanism that will regulate anthropogenic activities in the area;
7. Longitudinal study on the monitoring on coral and algae species along Davao Gulf;
8. Succeeding researches must focus on specie-specific studies of both Algae and Corals to thoroughly study the spawning, recruitment and settlement including the life cycle of these important marine species.

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