TO WHAT EXTENT IS ALGAE COVER ON REEFS IN DAUIN, NEGROS ORIENTAL, PHILIPPINES AFFECTED BY ABUNDANCE OF HERBIVOROUS FISH SPECIES AND SEASONAL CHANGES?

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To what extent is Algae cover on reefs in Dauin, Negros Oriental, Philippines affected by abundance of herbivorous fish Species and seasonal changes?

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Summary

The health of a tropical reef and its inhabitants is determined by the existence and variety of corals. Coral development depends on having bare substrate on which coral polyps can attach themselves and grow. However, this would be inhibited by the presence of algae cover on substrate. Reducing the algae cover would allow for more area to be exposed for coral growth.

Studies have shown that algae cover as part of benthic composition in coral reef ecosystems may be affected by the presence of different types of herbivorous fish that either scrape, graze or browse the algae cover. In addition, algae cover presence and growth may also be influenced by seasonal changes in the environment.

The aim of this study was to gain a better understanding whether and how herbivorous fish and their feeding modes are impacting the algae cover in the Dauin area of Negros Oriental in the Philippines, either prohibiting or cultivating coral growth and thus eventually affecting the health of the reef. The secondary aim was to establish whether there was a need for further regulation for commercial fishing operation that catch specific fish species affecting the algae cover.

This study looked at data provided by the Institute of Marine Research in the Philippines, having data from underwater surveys from 19 sites with different key data elements, reflecting the type of fish, benthic composition including algae cover taken during the 2019-2020 wet/rainy and dry seasons.

The data was analyzed and described in r and rStudio, using a variety of descriptive statistical methods to, in particular, establish correlation between the key factors: abundance herbivorous fish as measured by biomass, percentage of algae cover, and whether seasonal changes had any influence.

Analysis of the data showed a significant correlation between the abundance of herbivorous fish in specific seasons, more fish was found during the wet season than in the dry season. Similarly, it was found that there is also a significant positive correlation between the season and the existence of algae cover, with a higher percentage algae cover during the dry season. However, on the other, hand it was found that there is no significant correlation between the abundance of the total herbivorous fish group on the algae cover, irrespective of the season.

While the results indicate that as a whole herbivorous fish have no significant impact on the algae cover, there are certain species and genera, as well as the browser niche group within the herbivory fish group that through their feeding habits affect the algae cover in the Dauin research area, i.e., by removing algae, baring the substrate for coral polyp attachment and thus coral growth. Species that had some effect on algae cover included *Acanthurus maculiceps, Amphiprion perideraion, Chrysiptera bleekeri, Chrysiptera rollandi, Hipposcarus longiceps, Pomacentrus chrysurus, Pomacentrus geminospilus, Pomacentrus lepidogenys, and Pomacentrus opisthostigma.* The genus found to have an effect was the genus Pomacanthus, the Angelfish.

It was concluded that, at this stage, without further research on other factors such as fishing practices one cannot suggest the development of additional regulation to reduce overall commercial fishing. However, the follow-on research may investigate in more details the feeding patterns of certain species of damsel, surgeon, and parrot fish as well as all of the angelfish genus as they do reduce the

algae cover and would therefore allow for additional coral growth. The result from that research could then possibly indicate the need for additional legislation to protect these particular fish species.

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Table of Abbreviations

Abbreviation	**Description**
AIMS	Australian Institute for Marine Science
CI	Confidence Interval
CPCe	Coral Point Count with Excel extensions
DO-SVS	Diver Operated Stereo Video System
EM	EventMeasure V5.25
IMR	Institute for Marine Research
MPA	Marine Protected Area
SCUBA	Self-Contain Underwater Breathing Apparatus

1. Introduction

The oceans are a key source of protein, providing 20 percent of the animal protein for more than 3.3 billion people; it is estimated that in regions such as Southeast Asia, and small island developing states, a total of 50% of the population get their average per capita intake of protein from fish (FAO, 2020). Besides an important source of protein for the vast majority of the population, it is also a major source of income and livelihood for many, with the global fish production generating over USD375 billion (Vroom et al., 2013). With an ever-increasing population around the world, the need to protect the sources of food becomes even greater, especially the ocean and reef ecosystems.

Coral reefs are seen as an important source of protein, especially for hundreds of millions of people living in coastal communities around coral reefs (ARC Center of Excellence in Coral Reef Studies, 2013). Coral reefs have seen a significant decline in their health in recent years, whether due to climate change, pollution, overfishing, or other factors (Descombes et al., 2015; Pandolfi et al., 2003). Since there is a strong correlation between a reef's health and the abundance of fish, the decline in coral reef health has also seen a decline in reef fish species, that form the basis of the diet of a large percentage of the population (Díaz-Pérez et al., 2016) With a declining reef health, due to overfishing (with harmful fishing practices such as the use of dynamite and poison), pollution, and expanded human interaction (population growth in coastal areas and tourism), herbivorous fish populations on coral reefs have declined by 50% around the world (Edwards et al., 2013). Corals require bare substrates, such as exposed rock, in order to settle and grow upon and develop into a reef (Kuffner et al., 2006). Herbivorous fish graze on algae providing bare substrate and facilitate the recruitment of corals to a reef (Burkepile & Hay, 2008; Lewis, 1986; Paddack et al., 2006).

In the Philippines, ever increasing anthropogenic pressures have thus also seen a decline in fish, including herbivorous fish (Anticamara, Go, Ongsyping, Valdecañas, & Madrid, 2015; Green, White, Flores, Carreon, & Sia, 2003; Nañola, Aliño, & Carpenter, 2011). Due to declining reef health, herbivorous fish populations on coral reefs have declined by 50% around the world, some of which are of great importance to fishermen as a source of food and income (Edwards et al., 2013).

The key species that will be the focus of this report are the herbivorous fish. Within the herbivory group there are different niche groups that affect the benthic cover in different ways, the three main functional groups are: scrapers/excavators, grazers/detritivores, and browsers (Green & Bellwood, 2009). Each has a different feeding technique that impacts how and to what degree the benthic composition changes. Scrapers/excavators both feed on algal turf and scrape away some of the underlying reef substrate while feeding; they limit the establishment of macro algae. An example of fish found within the scraper niche include those from the *Scaridae* (Parrotfish) family. Grazers and detritivores also limit the growth of macro algae by grazing on algal turfs, in addition to feeding on sediment and biological animal materials; *Pomacentridae* (damselfish) are examples of grazers. Browsers continuously feed on macroalgae, but only target specific algal components. They limit the growth of larger algae and prevent overgrowth; browsers include species from the *Siganidae* (Rabbitfish) family, and some species found within the *Acanthuridae* (Tangs) family (Green & Bellwood, 2009).

The Philippines is an island nation comprised of around 7,100 islands, with most of islands and coastline defined by submerged and fringing coral reefs (A.T., H.P., & T., 2000; S. J. Green et al., 2003). It has a fast-growing population of approximately 108 million in 2020 (Plecher, 2020). The Philippines itself is located within the coral triangle, the most biodiverse biosphere on the planet, containing 76% of the world's corals, and 37% of the worlds reef species (Foale et al., 2013; Veron et al., 2011). 70% of the Filipino population lives within coastal areas, with 1.6 million people working within the fisheries sector (Suh & Pomeroy, 2020); the fisheries sector is highly regarded for its ability to provide both food and job security, which is very significant in a country with high poverty rates and an ever growing population (Suh & Pomeroy, 2020; The World Bank, 2018). The fisheries sector is not the only sector benefiting from the rich ocean environment, the ocean-related tourism sector is also one of the largest contributors to the economy, employing nearly 5 million Filipinos, and sees nearly as many foreign visitors annually(The World Bank, 2018). In addition, the Philippines is one of the largest exporters of aquarium fish, with an approximate income of US$ 2.7 Million annually (Muyot et al., 2019).

The Philippines has two major seasons, referred to as the wet/rainy season and the dry season. The wet season lasts from August to January, which includes frequent typhoons and tropical storms causing a monthly average 260mm of rainfall, and relatively low temperatures, around 24.1°C. The dry season lasts from February to July and is split into two sub-seasons: the cool dry, and the hot dry seasons. In general rainfall decreases to a monthly average of only 85mm in the dry season, while temperature increases to 29.1°C. Average water temperatures are highest around June, at the end of the dry season, reaching 30°C. Inversely, the lowest average water temperatures are found during February, where temperatures are around 27°C (AmbiWeb GmbH., n.d.; Waters et al., 2019).

The area that will be discussed within the scope of this thesis is the Dauin areas in the Negros oriental province. Dauin is a small town, 15 kilometers south of the provincial capital Dumaguete. Due to the increasing pressures of growing demand for food from the sea, and the strain of dwindling fish populations, Dauin started to establish community managed Marine Protected Areas (MPAs) in the early 2000s, These MPAs cover a total of 64 hectares of coral reef and are run and monitored by the local government (Bianchessi, 2012; The World Bank, 2018; Waters et al., 2019). The hope with and purpose of these MPAs is to create a protected ecosystem to enhance reef resilience and foster fish populations as other successful community led MPAs have shown (Lester et al., 2009). The Dauin MPAs have been a great success over the years and its efforts to build resilient reef systems have been replicated at other sites in the Philippines. However, continued monitoring of its reef ecosystems and rehabilitative efforts as well as enforcements by the MPA's management are necessary to ensure continued reef health (Bianchessi, 2012; Rohrer, 2017).

The Institute for Marine Research in the Philippines (IMR), is a new grassroot conservation non-profit organization that is focusing on data collection in and around the coastal reefs of Dauin, in Negros Oriental, the Philippines. Their aim is to conduct long-term, fin-scale research in the area, and provide scientific evidence to "educate, transform and encourage locally led marine conservation strategies within the Philippines." (*Institute for Marine Research*, n.d.). IMR has a number of long-term goals and research questions as part of their Dauin Long-Term Reef Monitoring Project, using local and international research fellows to support achievement of their goals. This report looks at one of their research questions “How do seasonal variations affect benthic cover and fish assemblage?”.

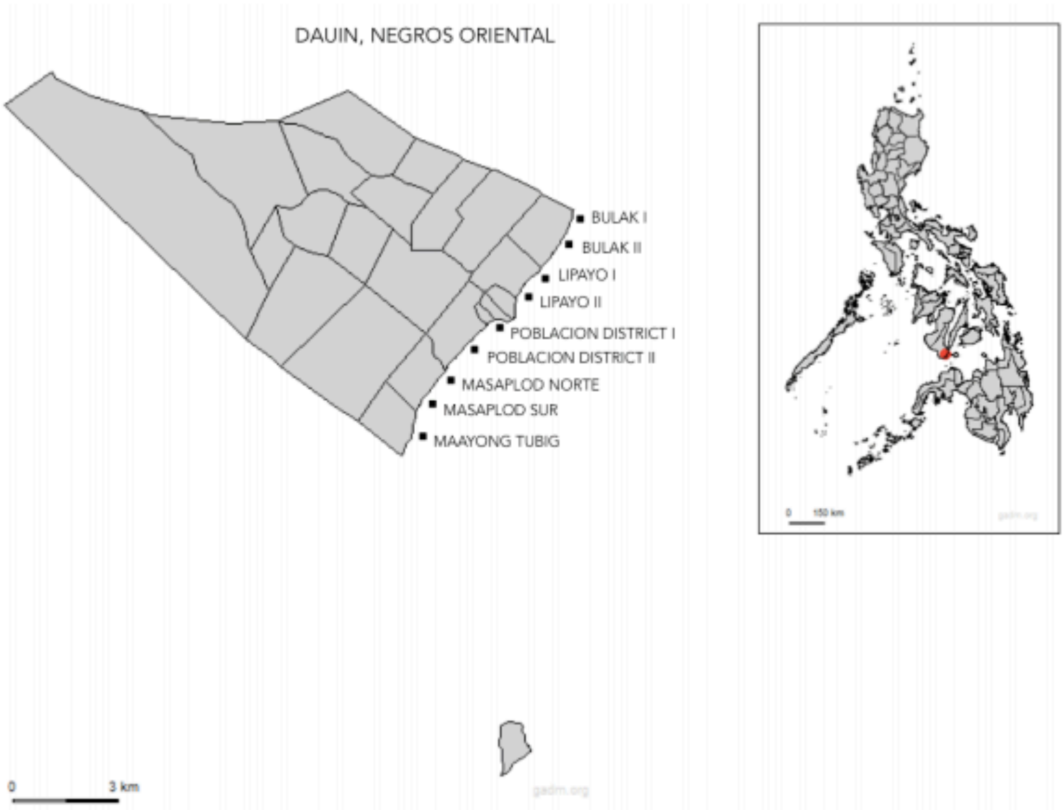

FIGURE 1. LOCATION OF THE MUNICIPALITY OF DAUIN AND IMRS SURVEY SITES ON NEGROS ORIENTAL, THE PHILIPPINES. MAPS SOURCED FROM GADM DATABASE OF GLOBAL ADMINISTRATIVE AREAS (2015) UNDER A CC BY LICENCE, USED WITH PERMISSION (WATERS ET AL., 2019)

1.1. Problem Statement

The health of a reef and the abundance in herbivorous fish is sustained by the extent of algae availability in the coastal waters accessible for the fishing population in the Philippines. It is currently unknown how fishing of commercially important herbivorous fish is impacting algae cover in coastal areas around Dauin, in the Philippines. It is also not known whether changes in the algae cover are due to removal of herbivorous fishes, or due to natural variation in seasons.

1.2. Research Goal/Aim

The main objective of this study is to identify what affect, if any, the presence of herbivorous fish has on the algae cover within the Dauin area of the Philippines. Specific focus will be paid to herbivorous fish with economic importance. Different types of herbivorous niche groups also play a role within this, as some herbivorous niche groups may have more pronounced impact on the benthic composition than others due to feeding behavior and diets; this will also be investigated. The secondary aim is to identify what role seasonal changes in the Philippines play, if any, with regards to the abundance of fish and/or algae cover. By the end of this project, the additional knowledge and understanding gained may be used to help guide and implement protective legislation.

1.3. Research Questions

1.3.1. Sub Question 1 – What is the current state of the fish and benthic composition within the research area?

Having a good background understanding of the current situation with regards to the occurrence of fish and presence of algae cover within the study area, will help to contextualize the data presented throughout this project and assist with structuring the data in a logical manner.

1.3.1.1. What is the current abundance of commercial and herbivorous fish in the research area?

A good understanding of the abundance of fish, more importantly the commercially important fish species, will provide an overview for further analysis. Describing the abundance of fish within the project area, may also indicate areas where overfishing, in general, is already occurring. It can also highlight, if relevant, the need for conservation/legislative measures.

1.3.1.2. What is the benthic composition within the research area?

A summary of the current state of the benthic composition of the respective research sites will be described; this will look in particular at what percentage of the reef surface consists of corals, algae, bare substrate, among others. The percentage of algae cover will be the main focus of the next sections. This data can highlight the need for potential (protective) legislation for areas that are particularly low in terms of coral cover.

1.3.2. Sub Question 2 – What is the correlation between abundance of herbivorous fish and algae cover?

1.3.2.1. How does presence of herbivorous fish impact percentage algae cover?

The primary aim is to determine the impact present herbivorous fish in general has on algae cover as part of the benthic composition in the research areas. It is assumed that feeding/scraping patterns of herbivorous fish will impact the amount of algae present, which in turn will impact the ability for coral to settle and propagate. The higher the abundance of herbivorous fish, the lower the percentage of substrate covered by algae, allowing for a higher percentage of coral cover.

1.3.2.2. How does Herbivorous niche type impact percentage Algae Cover?

Within the herbivorous fish spectrum, there are three different niche groups of importance for this study; the scrapers/excavators, the grazers, and the browsers. Each of these niche groups within the herbivory group could have differing impacts on benthic composition, especially with regard to algal clearing.

1.3.2.3. How does the abundance of Fish Species impact the percentage of Algae Cover?

As with the different herbivorous niche types mentioned above, different fish species/families may have more or lesser impact on benthic composition, due to e.g., feeding behavior, diets. The biomass of the different species of herbivorous fish will be compared to identify their effect on the benthic composition. In addition, genera will also be investigated.

1.3.3. Sub Question 3 – How does Season affect the key factors?

Seasonal changes can play a role in several parts in the coral ecosystem. Firstly, in terms of the abundance of fish and secondly within the changing structure of the coral reefs, including algae cover as part of the benthic composition. The following sub questions will explore the changes caused by the difference of the wet and dry seasons in the Philippines.

1.3.3.1. What is the seasonal difference in the abundance of fish?

The abundance of fish may change between the wet and dry seasons as temperature changes and/or migratory patterns may impact the fish populations. By establishing that the changes seen within the ecosystem are due to seasonal shifts, and not due to anthropogenic factors i.e., overfishing, may contradict the need for regulations, if the fluctuations are natural. Additionally, the seasonal difference for each site was also investigated, to see if there are any sites where there have been any significant changes in fish abundance between the seasons.

1.3.3.2. What is the seasonal difference in algae cover?

As with the fluctuations in the abundance of fish, benthic composition, particularly the algae cover, may also be affected by seasonal changes. Increases in temperature during the hotter months may lead to differences in natural growth of the algae cover. Just as likely, coral cover may decrease due to natural destruction during typhoon season. Additionally, the seasonal difference for each site was also investigated, to see if there are any sites where there have been any significant changes in algae cover between the seasons.

1.3.3.3. Is there a correlation between the abundance of fish, algae cover and seasonal changes?

To determine whether the changes in the algae cover are natural i.e. seasonally affected, and/or whether anthropogenic factors affecting the fish stock are responsible, data will be analyzed for possible correlations between the algae cover and fish abundance. If the majority of the changes in benthic composition are due to seasonal changes, implementing legislation with regard to fishing may not have any effect.

1.4. Hypothesis

1.4.1. Sub Question 1 – What is the current state of the fish and benthic composition within the research area?

1.4.1.1. What is the current abundance of commercial and herbivorous fish in the research area?

Based on previous studies in the area, the fish stocks are doing well in areas where there is already some form of legislation in place; fish abundance/biomass may be up to three times higher in areas where there is protection in place (Paderanga, 2020; Rohrer, 2017). It was expected that the large majority of the fish found within the area would be predatory carnivores, while herbivorous fish species would contribute a smaller percentage to the total fish stock.

1.4.1.2. What is the benthic composition within the research area?

Studies by other individuals on the benthic composition within similar community MPAs around the Philippines have shown that the coral cover is relatively low, with around 25% coral cover, and that algal cover can range from 2% to 12% (Bayley et al., 2020; Rohrer, 2017). It is expected that the benthic composition will show moderately low coral cover of around 25%, and low to moderate cover of algae at around 10-15%.

1.4.2. Sub Question 2 – What is the correlation between abundance of herbivorous fish and algae cover?

1.4.2.1. How does presence of herbivorous fish impact percentage algae cover?

The general consensus in regard to herbivory and benthic communities states that with an increase in density of herbivorous fish, there will be a decrease in the overall algae cover with an inverse increase in corals, in some case up to 22% (Burkepile & Hay, 2008; Lewis, 1986). It is expected that areas with lower herbivorous fish populations will have a higher percentage of algae cover compared to areas with higher and more active herbivorous fish activity.

1.4.2.2. How does Herbivorous niche type impact percentage Algae Cover?

Each of the three functional groups, scrapers/excavators, grazers/detritivores, and browsers, have their own role within the ecosystem. However, the niche(s) that will most likely affect the algae cover would be the Excavators and the Browsers. Excavators, due to their ability to remove large chunks in one go, will have the most profound impact on the reef structure, by removing dead/dying coral, and clearing space for new recruitment. The browsers on the other hand are most efficient at clearing out algae that inhibits the settlement of coral larvae (Green & Bellwood, 2009).

1.4.2.3. How does the abundance of Fish Species impact the percentage of Algae Cover?

Like the niche representation above, different fish species will have different effects on the benthic composition. Several species have been identified that will have a greater effect than others, among those are the Parrot fish, most importantly, surgeonfish (including Tangs), damselfish, and rabbitfish (Gonzalez-Bernat, 2019; Parola, 2020; Williams et al., 2016). There is expected to be a lower algal growth in areas where these species/genera are more abundant.

1.4.3. Sub Question 3 – How does Season affect the key factors?

1.4.3.1. What is the seasonal difference in the abundance of fish?

Different seasons have been shown to cause change in the abundance of fish and/or in the presence of certain fish species, particularly the reef associated species (Abesamis & Russ, 2010; Bellwood, 1988; Wilson et al., 2014). The primary factor contributing to the variation is thought to be weather dependent; the abundance of certain species have been shown to decrease during the wet season and increases during the hotter dryer season as a result of more productive reef environment (Abesamis & Russ, 2010; Bellwood, 1988; Waters & Brand, 2020). It is assumed that the fish abundance within the research area will follow a similar trend.

1.4.3.2. What is the seasonal difference in algae cover?

Based on initial research done in the area, it is suspected that there will be some change in benthic composition between the wet and dry seasons. The general trend indicates that there will be a significantly higher percentage cover of algae in the dry season, as opposed to other benthic components, such as coral and bare substrate. This is due to a number of factors including factors such as temperature and light being higher during the dry season, causing accelerated growth (Waters & Brand, 2020).

1.4.3.3. Is there a correlation between the abundance of fish, algae cover and seasonal changes?

Based on the assumptions inferred in the last sections, where both the abundance of herbivorous fish and the percentage of algal cover will increase during the dry season, it is difficult to say what the outcome may be. It may be that there is no difference in correlation across the different season, due to the increase in algal cover which in turn leads to an increase in fish abundance due to an increase in food availability, causing a positive feedback loop (Waters & Brand, 2020).

2. Methodology

2.1. Data Collection Methods

The data used within the scope of this project was already collected by the staff and students of the Institute of Marine Research (IMR) in the Philippines. This was done from March 2019 to December 2020, across both the wet and dry seasons each year. The following section covers the methodology used by IMR to collect data on Fish Biomass and Benthic Composition from the research sites.

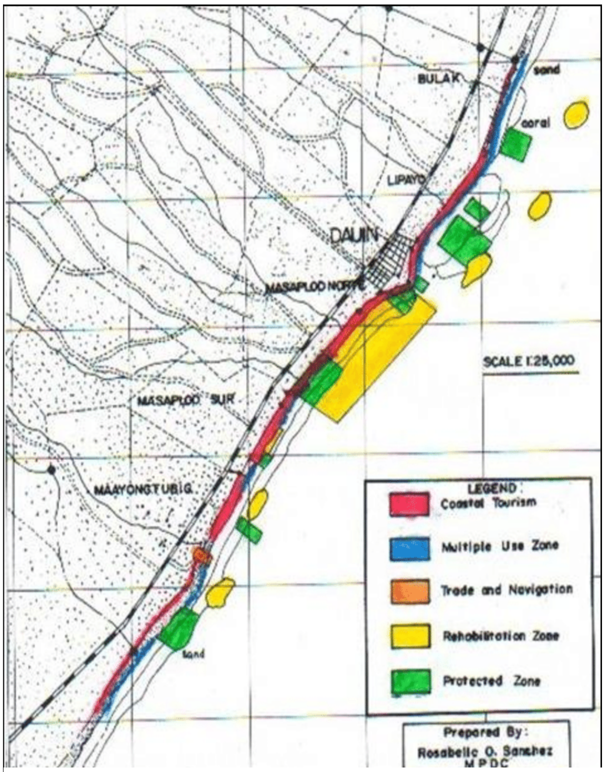

FIGURE 2. MAP SHOWING THE CURRENT ZONING FOR THE COASTAL ARIA AROUND DAUIN, INCLUDING RECREATION, TRADE, AND PROTECTED AREAS (MPAS); (BIANCHESSI, 2012)

The survey area for this project is limited to 19 core sites from eleven different locations, of which 9 are MPAs, while 2 are not; the MPAs are Poblacion District I & II, Masaplod Norte, Sahara, Lipayo, Baluk, Masaplod Sur, Lipayo, and Mayoong Tubig. These locations were selected based on a variation in reef composition and differences in the fish and benthic communities, as well as accounting for varying degrees of municipal zoning and depth (Waters et al., 2019).

For each of the 19 core sites, a single 50m transect was run parallel to the reef crest. Transects were located at depths of 1-6m and 7-12m. Surveys were conducted twice a year to cover the dry season (February – July) and the wet season (August – January) (Waters et al., 2019).

2.1.1. Biomass Data/Fish Surveys

Fish biomass surveys were completed using a Diver Operated Stereo Video System (DO-SVS). The DO-SVS uses two synchronized GoPro Hero 5 Black cameras to record fish presence along a 50m transect. The cameras are held 0.5m above and parallel to the substrate. The cameras are angled 20° downwards. The operator maintains a steady pace along the 50m transect, taking approximately 5-6 minutes.

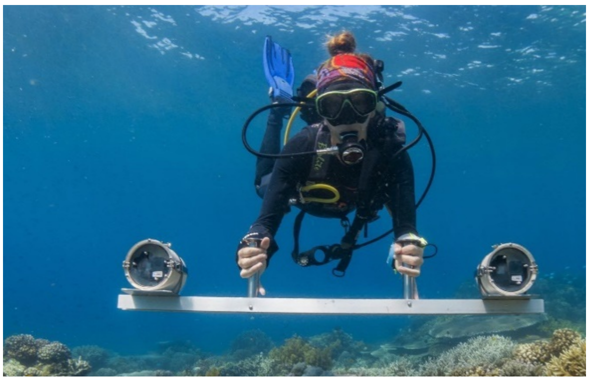

FIGURE 3. DIVER USING DO-SVR SYSTEM TO VIDEO OF REEF FISH, SOURCE: INSTAGRAM/@INSTITUTE.MARINERESEARCH

EventMeasure V5.25 is used to synchronize the SVS footage and extract data, including measuring fish biometrics. EventMeasure resolves center points of each individual fish encountered into distances on a three-dimensional coordinate system. Each fish has been identified to a species level where possible; some exceptions were made for fish that could not be identified. If the fish is in view of both cameras, the 3D software may produce measurements of size and biomass. Fish Biomass is calculated using the equation [1]:

$$W = aL^b$$

$$W = Weight\ (g), L = Length\ of\ Fish\ (cm), a\ \&\ b\ = species\ specific\ allometric\ constraints$$

Fish identification, where possible, is completed through the use of FishBase. Allometric constraints for each fish species has also been attained through FishBase (Froese & Pauly, 2020). Allometric constraints are species specific measurements from different points on the body that are always proportional for each species. Additionally, their commercial status has also been determined through FishBase; they have been classified as either "No" (not commercially important), "Minor", "Commercial", and "Substance Fisheries", for the purposes of this report commercial fish are Fish classified as either "Commercial" or "Substance Fisheries", as these are considered the most important in terms of economic impact.

Herbivorous niche groups were determined based on previous studies done (A. L. Green & Bellwood, 2009); although not all species were identified in past research, inferences were made within genera due to similarities in diets.

2.1.2. Benthic Composition

Benthic compositional assays were conducted following the Australian Institute for Marine Science (AIMS) methodology (Jonker et al., 2008). Images are taken at 1-meter intervals along a 50m transect, each at a height of 0.5m above the substrate. A GoPro was used to capture a total of 50 images per transect. Analysis of the captured images was done through CPCe software (Kohler & Gill, 2006).

Figure 4. Sample image of CPCe, with random points applied, Source: Instagram/@institute.marineresearch

Each image was overlaid with 30 randomly distributed pointed across the full image and used to identify benthic characteristics. The benthic composition was characterized by a predetermined code covering all Indo-pacific Scleractinian coral genera, octocorals, hydroids, bivalves, other hexacorals (anemones, corallimorphs and zoanthids), sponge growth forms, "other live" (ascidian, crown of thorns starfish, cyanobacteria, other e.g., fish), algae, seagrass, dead coral and abiotic, such as sand, bare substrate and rubble (Waters et

[1] For further details on *Fish Biomass* data collection see Waters et al. (2019).

al., 2019). All data was exported to an Excel spreadsheet, preserving the major identification groups, and individual points. For the purpose of this research only algae cover was analyzed

For further detail on *Benthic Composition* data collection see Waters et al. (2019).

2.2. Analysis Methods

R and R-Studio were used for primary data analysis, in combination with various statistical packages to facilitate the tests need to be carried out. These packages included lmerTest, emmeans, stats, plyr, readxl, ggplot2, ggforce, xlsx, ggeffects, rcompanion, psycho, and reshape2.

2.2.1. Testing Assumptions and Transformations

The data was found to be neither normally distributed, nor have homogenous variance. A Levene's test indicated that the data did not exhibit homogenous variance $(p > 0.05)$. Kolmogorov-Smirnov and QQ-plots indicated that the data was not normally distributed $(KS: p > 0.05)$. Certain transformations were carried out to make the data more normally distributed. A cube root transformation was used on the algae cover data to create a normal distribution, as it offered a normal distribution without too much alteration of the data.

2.2.2. Sub Question 1 – What is the current state of the fish and benthic composition within the research area?

2.2.2.1. What is the current abundance of commercial and herbivorous fish in the research area?

An overview of the current fish population was created using descriptive statistics. This gives an idea of the number of fish in the research area, both by number count of individual species, and total biomass. Additional information was gathered on those fish considered to be of commercial importance, as well as fish with herbivorous feeding habits. This information is presented in additional graphs and tables.

2.2.2.2. What is the benthic composition within the research area?

A benthic composition overview has been created, by looking at the percentage of each benthic component at each site. The percentage and composition of each research site has been calculated and analyzed. A particular focus was placed on the percentage of Algae cover at each location. This has been presented in additional tables and graphs.

2.2.3. Sub Question 2 – What is the correlation between abundance of herbivorous fish and algae cover?

2.2.3.1. How does presence of herbivorous fish impact percentage algae cover?

The relationship between the presence of herbivorous fish, and their impact on percentage of algae cover was analysed using linear mixed models (LMM), and the LMER package in R/RStudio. To conform to the testing assumptions of the test, the data for mean percentage algae cover was transformed using a cube root transformation, as mentioned above. Additionally, a Pearson correlation test to determine the direction of any trends has been implemented. Additional graphs have also been created.

2.2.3.2. How does Herbivorous niche type impact percentage Algae Cover?

To compare the relationship between the presence of the herbivorous niche groups and the algae cover, a linear mixed model is implemented again. An initial LMM was carried out to determine if solely the presence of all the fish species within the niche group have an impact. A secondary Tukey's post-hoc test was carried out to determine the effect of each individual niche group. For each step graphs have been produced. Additional Pearson Correlation tests have been carried out for each Niche type to see how strong or weak the correlation was.

2.2.3.3. How does the abundance of Fish Species impact the percentage of Algae Cover?

A linear mixed modal was used to determine what the relationship of the different fish species is on the algae cover. Additionally, a LMM was carried out for each of the Genera of herbivorous fish. Additional Pearson Correlation tests were carried out for each species of the species and genera that were found to have a significant effect, to see how strong or weak the correlation is.

2.2.4. Sub Question 3 – How does Season affect the key factors?

2.2.4.1. What is the seasonal difference in the abundance of fish?

As the Levene's test showed no homogeneity of variance and the Kolmogorov-Smirnov test indicated the data was found not to be normally distributed, the ANOVA was dropped in favour of the Kruskall-Wallis H test, the non-parametric equivalent of an ANOVA. For each test a standard significance was used for comparison ($p = 0.05$). Results were presented in chart form.

2.2.4.2. What is the seasonal difference in algae cover?

As the Levene's test showed no homogeneity of variance and the Kolmogorov-Smirnov test indicated the data was found not to be normally distributed, the ANOVA was dropped in favour of the Kruskall-Wallis H test, the non-parametric equivalent of an ANOVA. For each test a standard significance was used for comparison ($p = 0.05$). Results were presented in chart form.

2.2.4.3. Is there a correlation between the abundance of fish, algae cover and seasonal changes?

A linear mixed model was implemented to find the correlation between the abundance of herbivorous fish and percentage algae cover between the two seasons. The model used the mean herbivorous fish biomass and the cube root transformed mean algae cover as variables, with the season as a fixed factor. The results are also presented graphically with a scatterplot, with a regression line and confidence bands.

3. Results

3.1. Sub Question 1 – What is the current state of the fish and benthic composition within the research area?

3.1.1. What is the current abundance of commercial and herbivorous fish in the research area?

In total 62,929 individual fish, across 114 different genera, were counted in the Dauin research area over the course of the research period (2019-2020), giving a total weight of 1,215 kilo, or 1.2 tons of fish [2]. Of those 6,987 from 47 genera were considered commercially important, or are considered to be part of substance fisheries, accounting for 489 kilo of fish, such as the *Thalassoma lunare, Amphiprion clarkii, and Chlorurus bleekeri*.

FIGURE 5 *POMACENTRIDAE* (DAMSELFISH), SOURCE: INSTAGRAM/@INSTITUTE.MARINERESEARCH

Of the overall number of fish, the most abundant species present were the Ternate Chromis (*Chromis ternatensis, n=10,407*), followed by the Lemon Damsel (*Pomacentrus moluccensis, n=6,841*), Charcoal Damselfish (*Pomacentrus brachialis, n=5,748*), the Reticulated Damselfish (*Dascyllus reticulatus, n=4,095*), and the Black-Bar Chromis (*Chromis retrofasciata, n=3,694*) [2]. The most abundant fish genera were identified as two different genera of Damselfish (*Pomacentrus, n=18,366, Dascyllus, n=5,998*), Chromis (*Chromis, n=18,198*), Anthias/Basslets (*Pseudanthias, n=2,727*), and Fusiliers (*Pterocaesio, n=2,557*) [3].

FIGURE 6. ANTHIAS (*ANTHIADINAE*) SWIMMING WITH A BARRACUDA (*SPHYRAENA*), SOURCE: INSTAGRAM/@INSTITUTE.MARINERESEARCH

A total of 27,769 fish were identified as being "Herbivorous"; this accounted for an approximate biomass total of 327 kilograms of fish. This makes up nearly half of the fish identified, 44%, and make up 27% of the total weight of the fish identified. In line with the most common fish species found in Philippines waters, the 5 most abundant fish were 5 different species of Damselfish, (*Pomacentrus moluccensis, n=6,841; Pomacentrus brachialis, n=5,748; Dascyllus reticulatus, n=4,095; Pomacentrus coelestis, n=2,516; Pomacentrus amboinensis, n=2,218*) [4].

When looking at the different locations within the research area, the sites with the most number of fish were the transect at 10m deep at site Mayoong

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[2] For Full Table of Fish see Appendix i.
[3] For Full Table of Genus see Appendix ii.
[4] For Full Table of Herbivorous Fish see Appendix iii.

Tubig ($n = 6{,}178$), the transects at both depths at Poblacion District II ($5m: n = 4{,}144$; $10m: n = 6{,}035$), and the transects at both depths of Poblacion District I ($5m: n = 3{,}874$; $10m: n = 4{,}379$) [5].

3.1.2. What is the benthic composition within the research area?

Of the two most important benthic composition components, the average coral cover for the entire testing site is 20.89%, while the average algae cover is 12.05%. Another interesting benthic components of note was dead coral, which made up 7.99% of the benthic composition. The remainder or 47.27% of the benthic environment of the research area was classified as "Abiotic", consisting of sand, rubble and bare rock (See Figure 2). When looking at the different locations, the locations with the most coral cover are Poblacion District II (43.37%), the MPA at Masaplod Sur (42.82%), and Poblacion District I (39.62%), while the areas with the lowest Coral cover are Bulak at 5m (7.80%), Masaplod Norte (2.16%), and Bulak at 10m (2.15%). For Algae, the locations with the most algae cover are Mayoong Tubig (26.04%), Poblacion District I (20.53%), and Masaplod Norte (20.02%), while the sites with the lowest algae cover are outside the MPA at Masaplod Sur (5.76%), Bulak (5.73%, and Sahara (4.68%). Both Depths at Bulak (5m & 10m) have a high percentage of abiotic benthic cover (69.62% & 85.55 resp.), with Sahara and Lipayo also presenting with high abiotic benthic cover with 77.07% and 74.13% respectively [6]. The MPA status had no effect on the outcome as the three lowest scoring and the three highest scoring in terms of coral, algae, and abiotic cover were all MPA's.

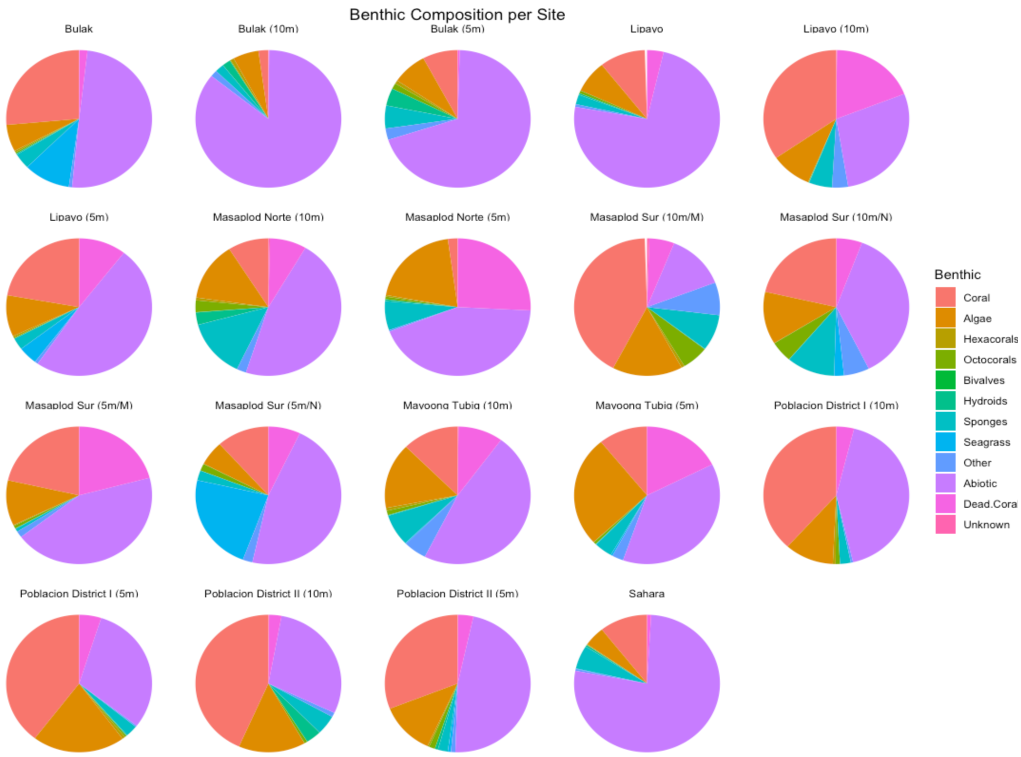


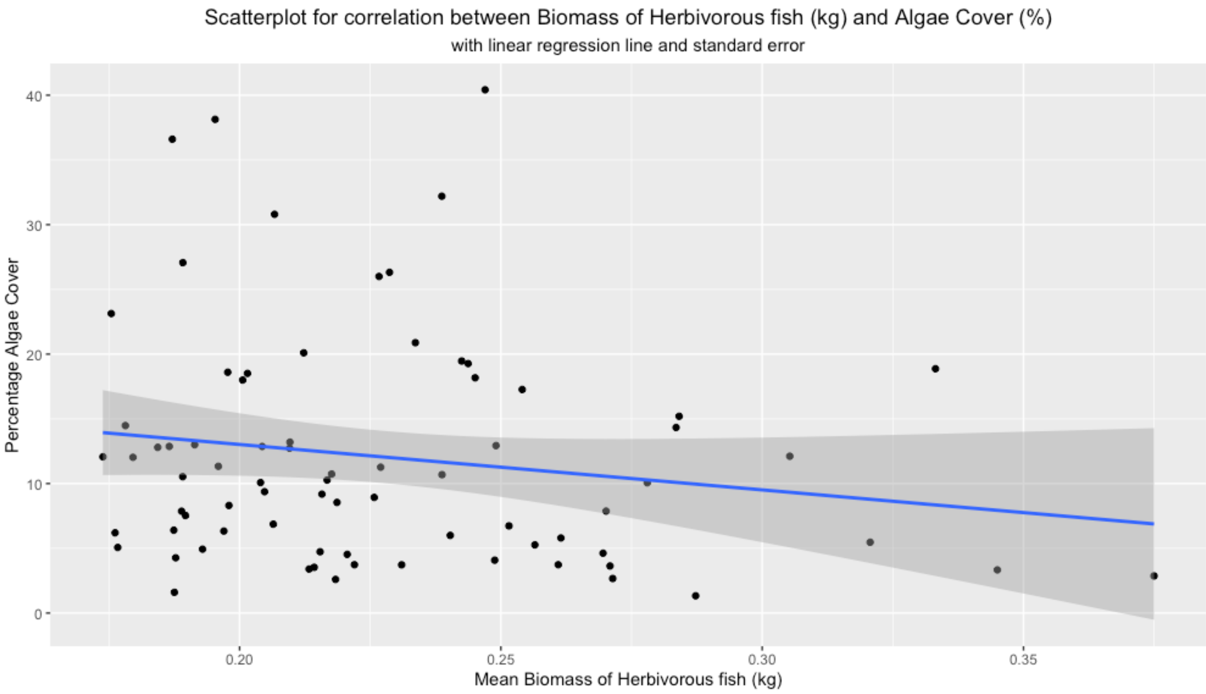
FIGURE 7. PIE CHARTS SHOWING BENTHIC COMPONENT DISTRIBUTION PER SITE

[5] For Full Table of Total Fish per Location see Appendix iv.
[6] For Full table of Benthic Composition per Site see Appendix v.

3.2. Sub Question 2 – What is the correlation between abundance of herbivorous fish and algae cover?

3.2.1. How does presence of herbivorous fish impact percentage algae cover?

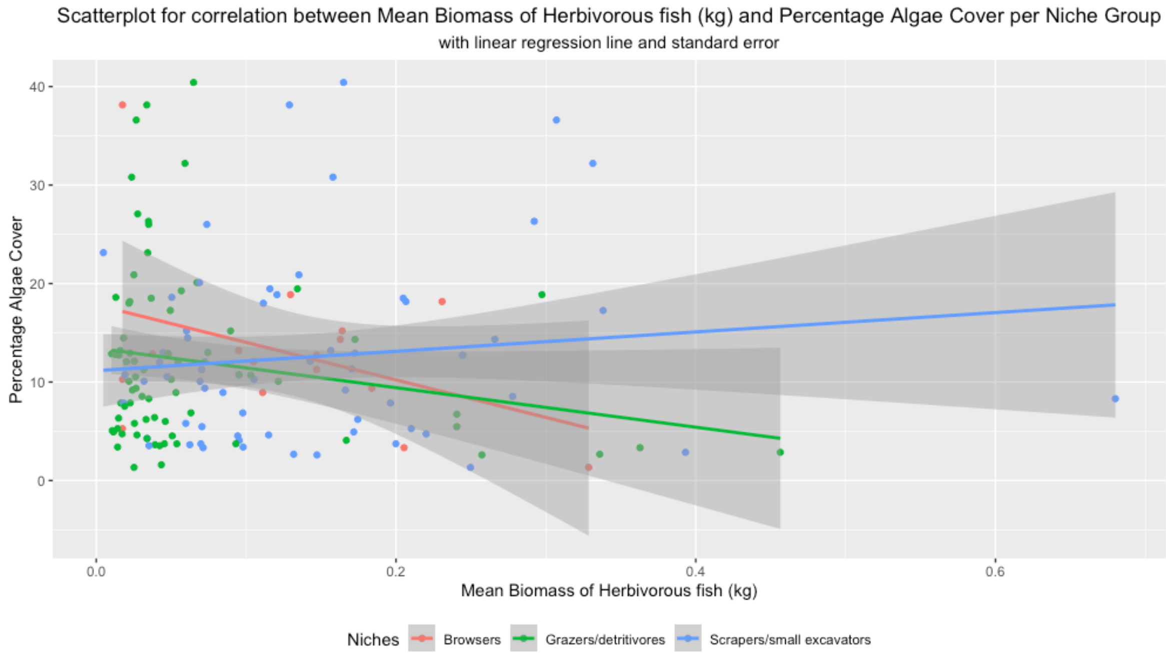
There is no correlation in the presence of herbivorous fish and the percentage of algae cover, $(lmer: p = 0.0654)$. The accompanying scatterplot (Graph 1), shows a large spread in the data, which does not follow a trend. A Pearson correlation test to determine the trend of data indicated a non-significant weak negative correlation, which is also seen in the aforementioned graph $(r = -0.177\, n = 74\, , p = 0.1256)$.



GRAPH 1. SCATTERPLOT WITH REGRESSION LINE AND CONFIDENCE INTERVAL (SHADED AREA) SHOWING CORRELATION BETWEEN ALGAE COVER (%) AND HERBIVOROUS FISH BIOMASS (KG) (CURRENT PLACEHOLDER)

3.2.2. How does Herbivorous niche type impact percentage Algae Cover?

When we further divide/split the herbivorous fish group in their different niche groups (browsers, grazers, scrapers) still no significant correlations were observed between the algae cover and herbivorous fish biomass, as indicated by the linear mixed effect model ($LMER: p = 0.561$)[7]. Interestingly however, there are opposite patterns observed for browsers/grazers and scrapers



GRAPH 2. SCATTERPLOT WITH REGRESSION LINES AND CONFIDNCE INTERVALS COMPARING MEAN ALGAE COVER (%) AND MEAN FISH BIOMASS (KG) SPERATED BY NICHE TYPES

The accompanying scatterplot (Graph 2) also shows a high spread in the data, with no real correlation observable. Although there is a negative correlation presented for both the Browsers and the Grazers, the data expresses a large spread, and is not significant. The scrapers, although presenting with a positive correlation, also exhibit a large spread. This is corroborated by the results of the Pearson correlation test. The Browsers exhibited a weak negative correlation between their abundance and the algae cover ($r = -0.393, n = 14, p = 0.132$). The same can be said for the Grazers, although they exhibit a weaker correlation ($r = -0.198, n = 73, p = 0.088$). The scrapers on the other hand presented a weak positive correlation ($r = 0.120, n = 61, p = 0.349$).

With regards to commercial value, 2 of the 4 species within the Browser niche were identified as being commercially important, 11 of the 19 identified species from the grazer niche were identified as commercially important, and for the scraper niche, 3 of the 18 species were commercially important[8].

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[7] For Full table of number of Individuals per Niche see Appendix vi.

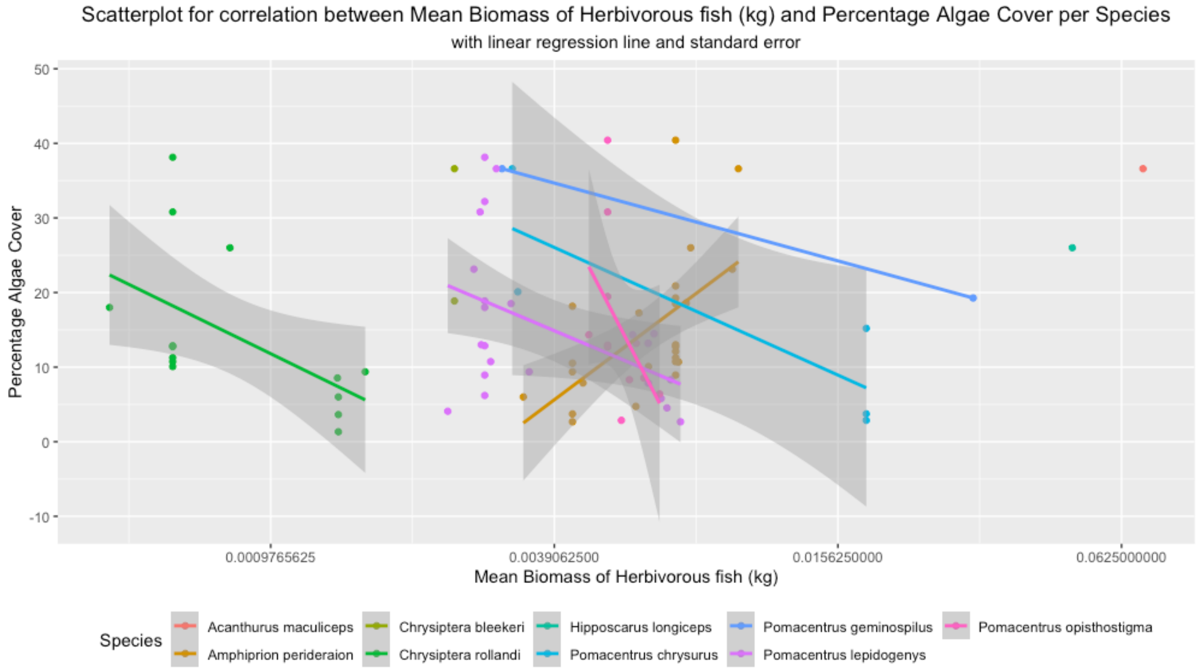
[8] For Full List of Species with each Niche Group see Appendix vii.

3.2.3. How does the abundance of Fish Species impact the percentage of Algae Cover?

The results of the model indicated that fish species was not a determining factor in the herbivorous fish impact on the algae cover $(LMER: p = 0.065)$. However, when compared individually, there were a number of fish species who were shown to have an effect on the algae cover. The species with significant impact on the benthic composition can be seen in table 1 below. The Pearson correlation test, showed a moderate negative correlation between these species and the percentage algae cover. However, the Pearson test for the *Amphiprion perideraion* indicated a positive correlation, as also visible on the accompanying scatterplot (Graph 3). Only the *Acanthurus maculiceps* was identified as being of commercial importance.

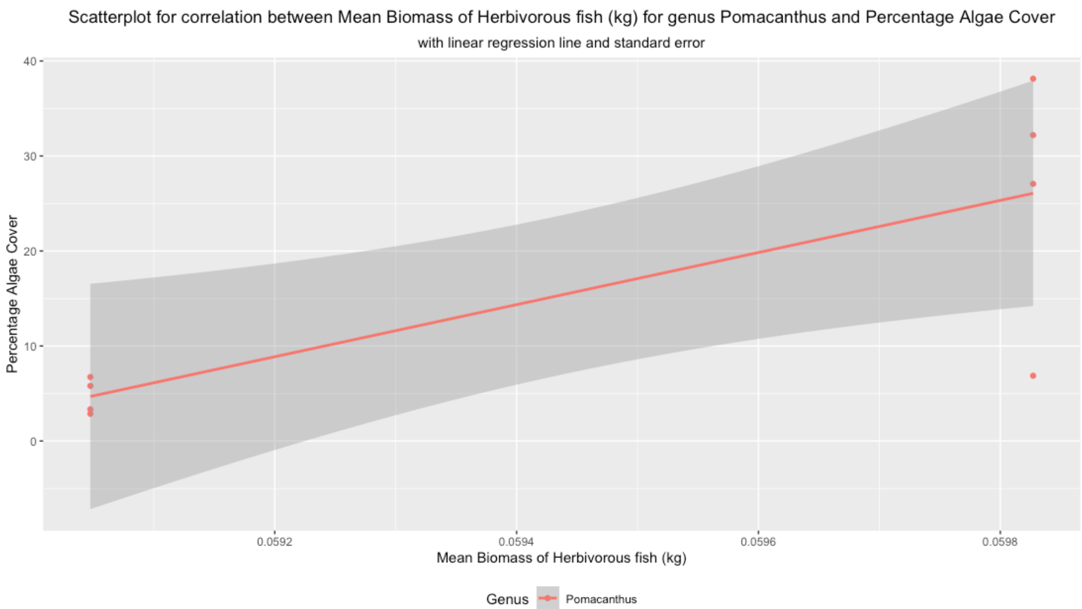
FIGURE 8 *AMPHIPRION PERIDERAION*, SOURCE: WIKIMEDIA/NICK HOBGOOD (2006)

Table 1. Correlation of Significant Species				
Scientific Name	Common Name	N-value	R-value	Sig.
Acanthurus maculiceps	Freckled Surgeonfish	1	Not enough observations	0.0023
Amphiprion perideraion	Punk Skunk Clownfish	25	0.637	0.0101
Chrysiptera bleekeri	Bleeker's damsel	2	Not enough observations	0.0267
Chrysiptera rollandi	Rolland's Damselfish	14	-0.568	0.0282
Hipposcarus longiceps	Pacific Longnose Parrotfish	1	Not enough observations	0.0423
Pomacentrus chrysurus	whitetail damselfish	5	-0.837	0.0150
Pomacentrus geminospilus	Sabah damsel	2	Not enough observations	0.0126
Pomacentrus lepidogenys	Scaly damsel	23	-0.480	0.0148
Pomacentrus opisthostigma	Brown damsel	11	-0.481	0.0453



Graph 3. Scatterplot with Linear Regression Line with Confidence Intervals showing Correlation between Mean Biomass (kg) and Percentage Algae Cover per Species

Additional testing at genus level indicates no significant difference in the presence of different Genus of fish against the overall algae cover ($p = 0.371$) . The only Genus indicated to have an impact on the Algae cover are those from the genus Pomacanthus, the Angelfish ($r = 0.787, n = 8, p = 0.000665$). However, the genus Pomacanthus, was found to be of no commercial importance.



Graph 4. Scatterplot with Regression Line and Confidence Intervals showing the Correlation between the Mean Biomass of Genus *Pomacanthus* and percentage Algea Cover

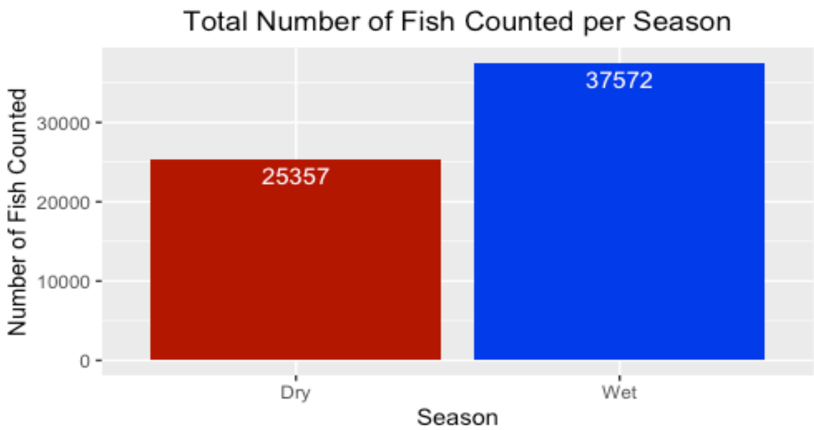
3.3. Sub Question 3 – How does Season affect the key factors?

3.3.1. What is the seasonal difference in the abundance of fish?

The number of herbivorous fish is significantly higher during the wet season, compared to the dry season. In all cases, more fish were identified during the wet season, during both years and overall (See Table 1.).

Table 2. Table of Fish counts per Season per Year		
Year	Dry	Wet
2019	6,870	13,990
2020	18,487	23,582
Total	25,357	37,572

The analysis indicates that there is a significant difference in the abundance of fish between the two seasons, $X^2(2) = 503.95, p < 2.2e^{-16}$. When looking at solely the herbivorous fish, the results indicate that there is again a statistically significant difference in the abundance of fish between the seasons, $X^2(2) = 155.82, p < 2.2e^{-16}$. The bar chart below indicates similar.

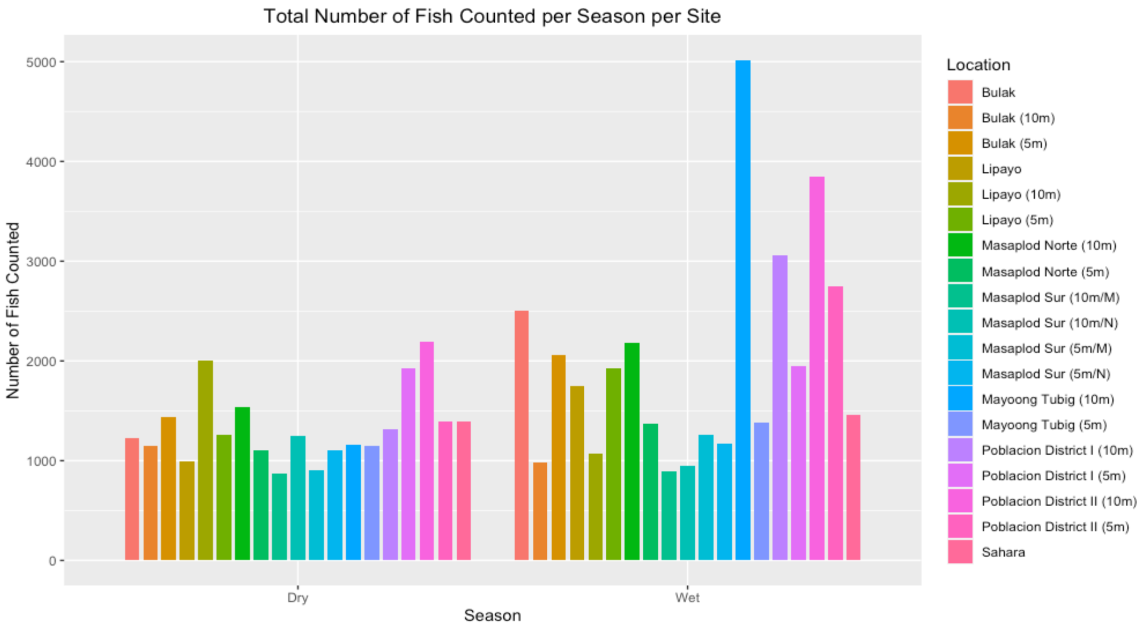


GRAPH 5. BAR CHART SHOWING THE TOTAL NUMBER OF FISH COUNTED PER SEASON

There is also a statistical difference when comparing the herbivorous fish at the different sites per season $(p < 0.05)$. It was found that there was a significant difference in the herbivorous fish abundance between the wet and dry season at the locations Bulak (5m), Lipayo (10m), and Masaplod Norte (5m)[9].

Season Comparison	Sig.
Wet:Bulak (5m)-Dry:Bulak (5m)	0.0002010000
Wet:Lipayo (10m)-Dry:Lipayo (10m)	0.0000113000
Wet:Masaplod Norte (5m)-Dry:Masaplod Norte (5m)	0.0000001840

[9] For Full table of between site comparison per season, for both total fish and herbivorous fish see Appendix viii.



Graph 6. Bar Chart Showing the Total number of Fish counted per Season Per Site

3.3.2. What is the seasonal difference in algae cover?

The mean algae cover was significantly higher during the dry season $(x = 12.46, SD = 17.77)$, as opposed to the wet season $(x = 11.65, SD = 14.71)$.The result of the test indicates that there is statistically significant difference between the seasons with respect to algae cover, $X^2(2) = 6.1773, p = 0.0129$.

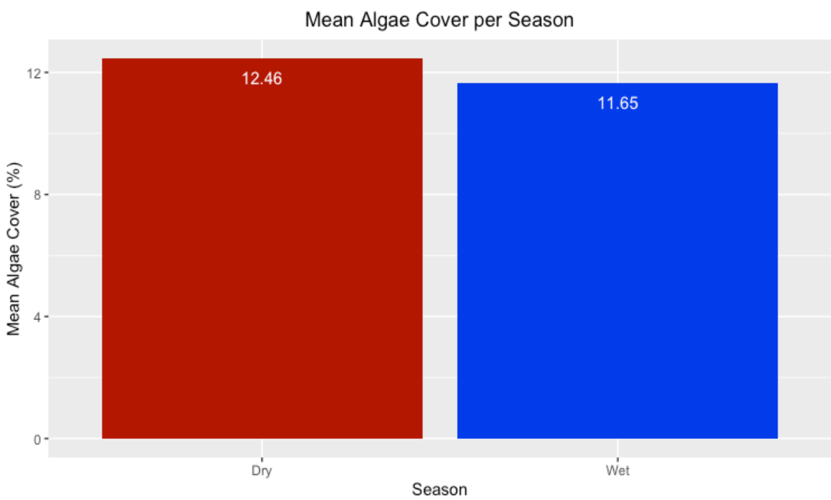


Figure 7. Bar Chart Showing the Mean Algae Cover (%) Per Season

When comparing the algae cover between sites, there is statistically significant difference in the season algae cover between a number of different locations, these locations being Mayoong Tubig (5m), Poblacion District I (10m), and Poblacion District II at both 5 and 10 meter depths [10].

[10] For Full table of Location comparison per season see Appendix ix.

Season Comparison	Sig.
Wet:Mayoong Tubig (5m)-Dry:Mayoong Tubig (5m)	0.000001
Wet:Poblacion District I (10m)-Dry:Poblacion District I (10m)	0.010658
Wet:Poblacion District II (10m)-Dry:Poblacion District II (10m)	0.004233
Wet:Poblacion District II (5m)-Dry:Poblacion District II (5m)	0.022668

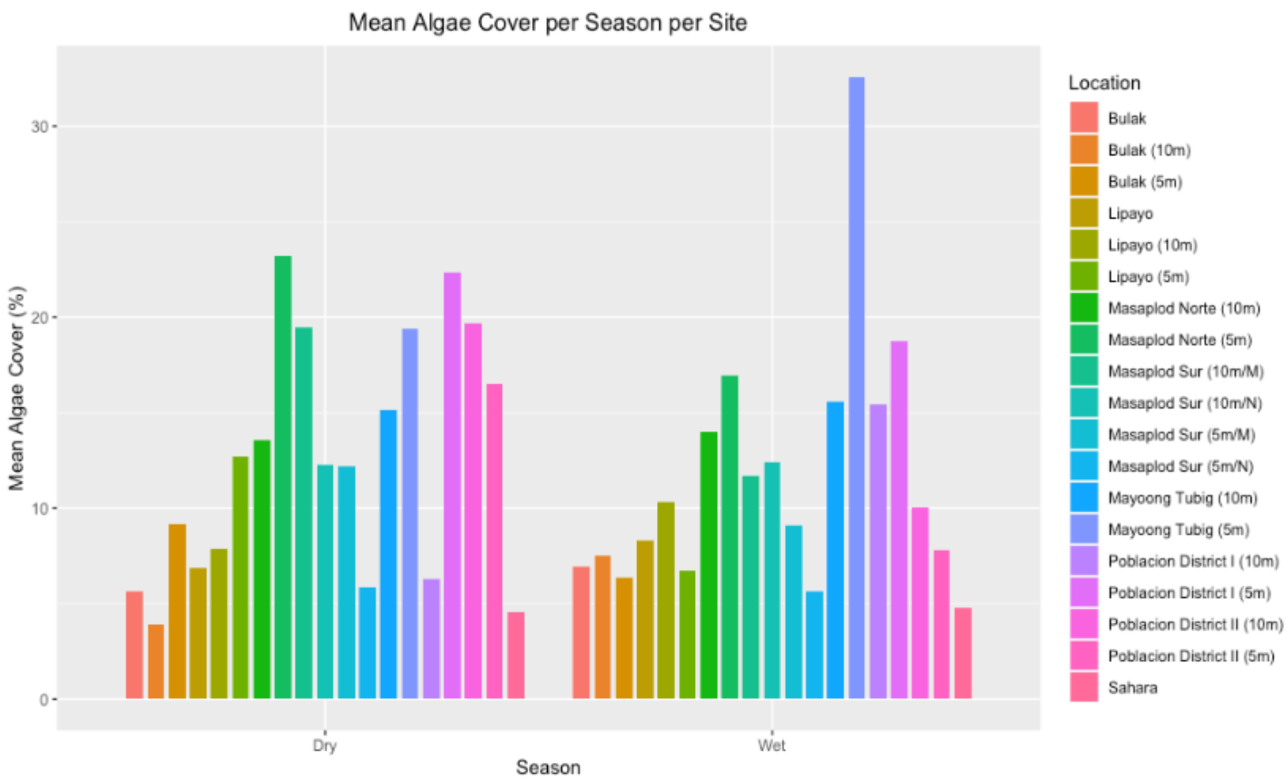
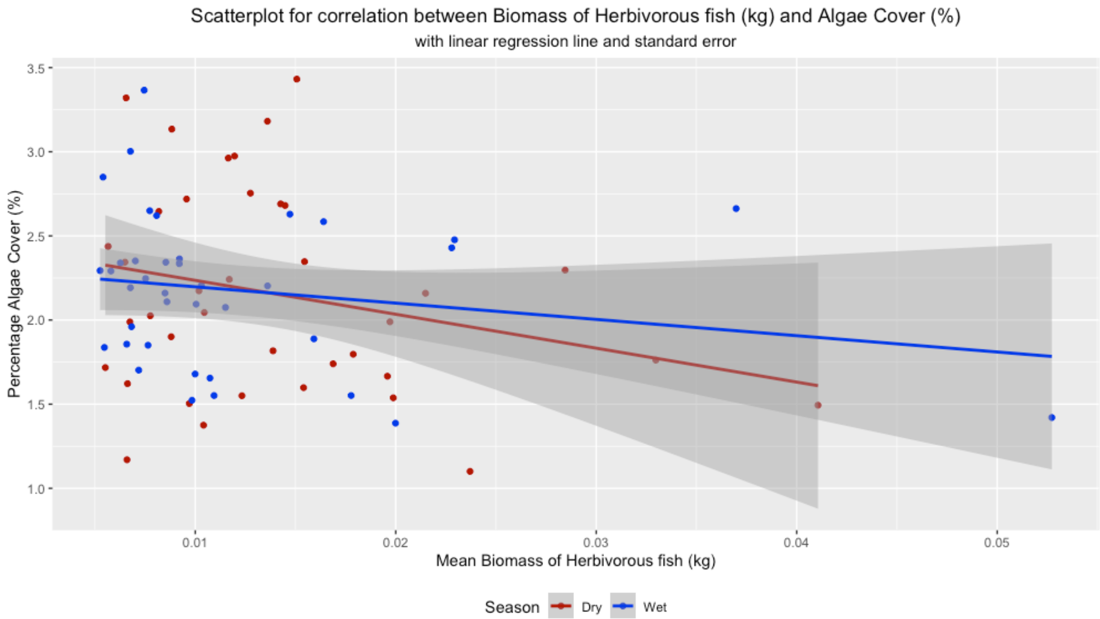


FIGURE 8. BARCHART SHOWING MEAN ALGAE COVER (%) PER SEASON PER SITE

3.3.3. Is there a correlation between the abundance of fish, algae cover and seasonal changes?

When comparing the difference in abundance of fish and algae cover, season was found not to have an effect on the correlation $(LMER: p = 0.0785)$. When looking at each of the season independently using the post-hoc for the linear mixed model, there was again no difference in the correlation between the abundance of herbivorous fish and the algal cover, for either the wet season $(p = 0.231)$, nor the dry season $(p = 0.125)$. As seen in the accompanying graph, both seasons show a negative correlation; as the mean biomass of herbivorous fish increases, the algae cover decreases. However, the correlation is very weak and most datapoints fall outside the standard error.



GRAPH 9. LINED SCATTERPLOT SHOWING CORRELATION BETWEEN BIOMASS AND ALGAE COVER PER SEASON

4. Discussion

In short, the results of the study indicate that the overall and herbivorous fish population is similar to what can be ordinarily expected in Philippine coastal areas. Furthermore the benthic cover in terms of coral is below what is considered by the Australian Institute of Marine Science to be healthy (Australian Institute of Marine Science, 2021), although the algae cover is considered to be good for a reef, but the percentage of abiotic substrate is abnormally high for a reef.

The study also shows that there are some species, genera, and niche groups that have an effect on the algae cover on the reefs, due to feeding removing algae and allowing the settlement of coral polyps. The seasonal effect on both the benthic composition and the fish abundance matched past literature. This is discussed in more detail below.

4.1. Sub Question 1 – What is the current state of the fish and benthic composition within the research area?

With regards to the composition of commercial and herbivorous fish, the observed populations in the research area reflect fish community compositions for other similar coral reefs both in the same research area, and around the Philippines (Paderanga, 2020; Rohrer, 2017). A similar number of species was found as in previous studies; the majority of the fish species were from the family *Pomacentridae*, as was found to be consistent with similar research (Asian Development Bank., 2014; Paderanga, 2020; Rohrer, 2017).

This study found an average of 20% coral cover and 12% of algae cover, but with significant outliers in some research sites due to a large percentage of abiotic substrate. According to past research, the average benthic composition for coral reefs in the Philippines consists of around 25% coral cover, and around 12% of Algae cover (Bayley et al., 2020; Waters & Brand, 2020).

Historically, the benthic composition has been trending away from coral dominated to an algae dominated reef ecosystem, due to an number of both anthropogenic and natural factors, with a lot of the coral reefs in the Philippines experiencing a coral-algae phase shift, as the coral cover decreases and is replaced by algae (McManus et al., 2000; Narsico et al., 2015). Past surveys around the Philippines have shown that the trend started decades ago; in the 80's there were already signs of declining reefs as more and more reefs were starting to show 25-50% coral cover and lower (Gomez et al., 1994; Licuanan & Gomez, 2000).

In relation to this a special note must be made of the abundance of abiotic substrate as main benthic composition in a number of the research sites [11]. Abiotic substrate, consisting of bare rock, sand, and rubble made up the majority of the benthic components of such sites. There have been a number of anthropogenic factors identified for the existence for such large swaths of barren ocean floor, such as a) the use of dynamite or poison for fishing, b) pollution and runoff causing eutrophication leading to

[11] "These sites span the variation in coral reef composition, benthic and fish communities across the Municipality, and account for the zoning history of its associated no-take marine protected areas. (Waters & Brand, 2020)"; The writer of the study had no influence on the selection of the sites and transects.

coral death, c) climate change causing mass die-off of corals, and d) natural events such as extreme wave action and tropical storms that the Philippines is known for (Gomez et al., 1994; Hughes et al., 2007; Panga et al., 2021; Roth et al., 2018).

According to the Australian institute for Marine Science, a coral reef "with >30%-50% hard coral cover as being high value" and is considered healthy (Australian Institute of Marine Science, 2021). There are a couple of sites within the research area that meet these criteria, but most of the sites have a coral cover of less than 25%. Meeting these requirements highlights the importance of having an adequate herbivorous fish population. With three MPAs showing the largest coral cover as well as three MPAs with the lowest coral cover, it did not indicate that the MPA status was a significant contributing factor for better coral cover, or even lower algae cover for that matter. With the successful management of the MPAs over the last decade, one can only conclude that this difference is random and natural, without significant interference of other factors, such as human interventions (Bianchessi, 2012; Rohrer, 2017).

The percentage algae cover was generally considered good; the recommended algae cover for a healthy reef is less than 25% (Licuanan & Gomez, 2000; Zamani & Madduppa, 2011). The average algae cover for each site falls well below this margin; there was only one site having a mean alga cover above 25%.

4.2. Sub Question 2 – What is the correlation between abundance of herbivorous fish and algae cover?

The results of the analyses show that merely the presence of the whole group of herbivorous fish does not have a measurable significant impact on algae cover. However, herbivorous fish are a very large group, and can be divided into smaller niche groups, and individual species. There were some species, and one genus that were found to have a significant effect on the algae cover.

There was a non-significant, weak negative correlation observed between the presence of herbivorous fish compared to the percentage of algae cover. Although the correlation was not significant, the trend exhibited conforms with past research that had shown that the higher the number of herbivorous fish capable of grazing/scraping/eating the algae, the lower the percentage of algae cover (Apdillah et al., 2020). It can be assumed that there are other factors that contribute more to a change in algae cover. Based on previous research, the use of dynamite and poison in destructive fishing practices, pollution from high coastal populations, natural occurrences such as sedimentation and runoff have all been identified as reason for changing algae and other benthic cover (Panga et al., 2021).

Prior research suggested that the excavators and browsers would have the largest effect on the algae cover (A. L. Green & Bellwood, 2009; Smith, 2017). Although niche type as factor was found to not be significant, the individual niche groups did have some effect. The browsers were found to have the most effect, as they are responsible for keeping the faster growing macro algae in check (A. L. Green & Bellwood, 2009). They were also shown as being the most important herbivory niche to reversing the coral-algae phase shift that is currently affecting a lot of the world's reefs (Puk et al., 2016). The grazers also had an impact although to a lesser extent as compared to the browsers. The grazers have the most impact on the epiphytical algae, which accounted for a large percentage of the algae found within the research area as seen in comparable studies (Smith, 2017; Waters & Brand, 2020). The scrapers represent an unexpected anomaly, the research indicated that the presence of scrapers increased the algae cover within the research area.

It was initially expected that specific known herbivores species and genera such, as parrotfish, surgeonfish and damselfish would be identified as having the most impact (Gonzalez-Bernat, 2019; Parola, 2020; Williams et al., 2016), which was found to be true to an extent. As overall fish species were not found to be a significant factor, certain individual species were found to be important. There are a number of possible reasons as to why fish species as a group may not be as important as looking at each individual species itself. One study suggests that a more focused view is needed when looking at individual herbivorous species impacts on algae cover (Dell et al., 2020). Another study indicates that not all herbivores fish eat equally, there are some that eat more than others, or their methods of eating means different amount and types of algae are consumed, or selective feeding on only certain types of algae all contribute to variations in impact on algae cover (Polunin et al., 1995). Of the species identified as significant, one had a positive relationship, however, the correlation of the presence of *Amphiprion perideraion* and the possible effect on the algae cover are not indicative of a causal relationship.

Although no significant data was again found for herbivorous fish Genus as a whole, the presence of *Pomacanthus,* or Angelfish were identified as having a marginal impact on the algae cover. Angelfish, who are considered both carnivore and herbivore, have in the past been identified as key species when it comes to grazing on reefs, and play an important role in clearing bare substrate for the settlement of new reef polyps (Bakus, 1966; Hofstede, 1998). Angelfish were not initially expected to have an impact, because they have a much more varied diet, and although algae does form part of their diet, there are other equally important food groups that form part of the Angelfish diet.

4.3. Sub Question 3 – How does Season affect the key factors?

The results of the seasonal variation indicated that there was a significant change in both the abundance of herbivorous fish and the percentage of algae cover, individually, with the two measured seasons. This indicates that the changes occurring within the research area are not solely based on the direct anthropogenic activities, and thus seasonal changes play a part in both the abundance of herbivorous fish and algae cover.

The fish population increased significantly during the wet season, contrary to what was anticipated. It was initially predicted that due to increases in reef productivity during the dry season, the dry season would have a higher abundance of fish (Abesamis & Russ, 2010; Bellwood, 1988).

One study showed a low abundance of fish during the latter part of the wet season, when temperatures were lower, and winds were stronger due to the monsoon season. The lower temperatures leading to a lower reef productivity, and stronger winds, which lead to more wave action and more turbidity and therefore less sunlight, have been cited as reasons for low abundance in fish (Abesamis & Russ, 2010).

However, other studies say the opposite, showing a higher abundance of fish during the wet season, from the months of November to April, with the most significant change abundance recorded during the month of December and the transitional months thereafter. One of the studies cites a higher abundance of fish due to fish congregating to shelter from rougher conditions present during the stormy wet season (Kohno et al., 1999). Another research done in the same area matches what was found during the study, i.e., an increase in the abundance of fish, although not significantly (Waters & Brand, 2020).

The timing of the data collection, which occurred mostly during the earlier months of each season, may be the reason for the inconsistencies in the expected results.

With regards to the benthic composition of algae cover, results from the study were found also to be significantly different, as expected. Prior studies within the area had shown significant change in the algae cover between the two seasons, although no immediate reasoning for this trend was given (Waters & Brand, 2020). The study data indicated a higher percentage of coral cover during the dry season as opposed to the wet season; this is consistent with the earlier studies where it was concluded that algae density and abundance was higher during the drier months because of on average more sunlight hours, thus higher seawater temperatures leading to more productivity, while at the same time and calmer/less turbulent conditions as compared to the stormy wet season (Echem & Metillo, 2011).

To build upon these findings, with significant correlation between season and abundance of fish and seasons affecting significantly the algae cover, it was remarkable to find that there was no significant correlation between algae cover and abundance of herbivorous fish. As there has not been any similar research undertaken, the validation of these results cannot be conclusive and further study is needed.

5. Conclusion

The aim of this project was to gain a better understanding whether commercially important, herbivorous fish are impacting the algae cover in the Dauin, in the Philippines and thus affect the health of the reef. It was assumed that with an extensive herbivorous fish population, it would reduce the algae cover and thus allow for more coral to grow. However, the study found that while there was a significant correlation between the seasons, with an increase in fish during the wet season and an increase in algae cover during the dry season, there was no significant correlation suggesting that the presence of (the whole of) herbivorous fish was affecting algae cover. It can thus be concluded that at this stage without further research on other factors/requirements facilitating a potential benthic shift increasing coral cover, one cannot suggest the promulgation of additional legislation to reduce overall commercial fishing.

While the results indicate that as a whole group, herbivorous fish have no significant impact on the algae cover, there are certain species and genera as well as the browser niche group within the herbivory fish group that may have some impact on the algae cover in the Dauin research area, i.e., by removing algae, baring the substrate for coral polyp attachment and thus coral growth. Only few species were found to have any commercial value and mostly for local subsistence fishing. However, sample sizes were too small to assign any significance to these findings, and thus conclude whether this should be subject to future regulation.

The follow-on research as indicated above may apart from a greater focus on some specific research areas with significant algae cover, also focus on the other hand in more details the feeding patterns of certain species of damsel, surgeon, and parrot fish as well as all of the angelfish genus. With the results of that research there may be possible legislation required to protect these particular fish species.

6. Recommendations

There were several issues identified during the study that may have had an impact on the study's implementation or its outcomes. Following a short description of these issues, recommendations are made to address those issues.

Recommendation 1: **More data over a larger time frame**. The current limitation was that there was only two years' worth of data. This is understandable as IMR was founded two years ago and as such has only been collecting data for two years but are currently collecting their third round of data. Additional data to be collected for at least another three years would possibly provide a better indication of trends in fish diversity and composition.

Recommendation 2: **Collect data within a closer time frame at more sites at the same time.** As an expansion of the first recommendation above, surveys were carried out across 19 weeks, with only one site being surveyed each week. This may have caused variations within the results due to different conditions throughout a season and each site; the temperatures, rainfall, and sea conditions at the beginning of the dry season may still be comparable with the conditions of the late wet season and could have been different from the middle or the end of the dry season. A recommendation would be to do surveys within a closer time frame, perhaps every day or every other day, where seasonal conditions between sites are more homogonous. In addition, it would be recommended that surveys are being done at 4-5 sites each week. This would also allow for multiple replicant surveys to be completed during each seasonal period. IMR may want to engage more (local) researchers and volunteers to intensify this work.

Recommendation 3: **Collect more focused data.** Elaborating on the two recommendations above, it was found during this study that only a number of species/genera and the browser niche of herbivorous fish were significantly impacting the algae cover. So, to establish a more accurate picture of this impact it is recommended that while still the total volume of fish is counted at each site, more detailed analysis is done with those specific fish species; for example using *in situ* monitoring, see recommendation below. This will eventually also allow for a more specific catch legislation to be developed. Similarly, there were specific sites identified that had most algae cover (all were within MPAs) and may there for more useful to more detailed research on the changes in algae cover in relation to the specific fish species identified.

Recommendation 4: **(Temporary) fixed site video**. IMR is currently only looking at chance data collection and processing, i.e., collecting data during dives when transects are covered. If resources were available, one could consider expanding to a number of in situ experiments, using (temporary) fixed site video installations, which would allow for a more in-depth focusing on the interactions between identified herbivorous fish species and their direct impact on the algae environment. These remotely placed underwater systems would be aimed at patches of algae, either natural growing or introduced in a controlled setting. The videos may be used to observe grazing, browsing, and scraping feeding behavior of herbivorous fish.

Recommendations 5: **Engage with local fishermen and collect relevant economic fisheries data.** There is currently no continued connection with the local fisherman. Research into this has already been done by another research fellow at IMR. However, only a single round of data was collected on number and composition of fish caught locally, and how their fishing practices are impacting the local reefs [12]. It may be possible that this data is already being collected by local government institutions as part of local government legislation on a more regular basis, in which case a collaborative effort may be pursued. Periodic monitoring, using the same methodology as used by the previous research fellow, on a biannual basis is recommended.

[12] For overview of the results of fishing community survey, see 2020 IMR Outlook report, Waters et al. (2020).

Bibliography

Abesamis, R. A., & Russ, G. R. (2010). Patterns of recruitment of coral reef fishes in a monsoonal environment. *Coral Reefs*, *29*(4), 911–921. https://doi.org/10.1007/s00338-010-0653-y

AmbiWeb GmbH. (n.d.). *DUMAGUETE CLIMATE (Philippines)*. Retrieved May 23, 2021, from https://en.climate-data.org/asia/philippines/negros-oriental/dumaguete-4989/

Anticamara, J. A., Go, K. T. B., Ongsyping, S. S., Valdecañas, F. A. T., & Madrid, R. G. S. (2015). National Patterns of Philippine Reef Fish Diversity and Its Implications on the Current Municipal-Level Management. *Science Diliman*, *27*(1), 1–47.

Apdillah, D., Pratomo, A., Azizah, D., Nugraha, A. H., & Febrianto, T. (2020). Potency, status and carrying capacity of coral reef ecosystem for suistainable marine ecotourism development; A case study of small islands in Kepulauan Riau-Indonesia. *IOP Conference Series: Earth and Environmental Science*, *584*(1). https://doi.org/10.1088/1755-1315/584/1/012007

ARC Center of Excellence in Coral Reef Studies. (2013). Community power "can rescue failing fish stocks." *Phys Org*, *April*, 1–2. https://phys.org/news/2013-04-power-fish-stocks.html

Asian Development Bank. (2014). *State of the Coral Triangle : Philippines.* Asian Development Bank.

Arin, T., White, A., & Vogt, H. (2000). Philippine coral reefs under threat: The economic losses caused by reef destruction. *Marine Pollution Bulletin*, *40*(7), 598–605. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed5&NEWS=N&AN=2000245250

Australian Institute of Marine Science. (2021). Long-Term Monitoring Program Annual Summary Report of Coral Reef Condition 2020/2021. In *Annual Summary Report of Coral Reef Condition*.

Bakus, G. J. (1966). Some Relationships of Fishes to Benthic Organisms on Coral Reefs. *Nature Publishing Group*, *210*, 280–284. https://doi.org/https://doi.org/10.1038/210280a0

Bayley, D. T. I., Purvis, A., Nellas, A. C., Arias, M., & Koldewey, H. J. (2020). Measuring the long-term success of small-scale marine protected areas in a Philippine reef fishery. *Coral Reefs*, *39*(6), 1591–1604. https://doi.org/10.1007/s00338-020-01987-7

Bellwood, D. R. (1988). Seasonal changes in the size and composition of the fish yield from reefs around Apo Island, Central Philippines, with notes on methods of yield estimation. *Journal of Fish Biology*, *32*(6), 881–893. https://doi.org/10.1111/j.1095-8649.1988.tb05431.x

Bianchessi, A. (2012a). *A Case Study of the Municipality of Dauin , Negros Oriental , Philippines : A Global Bright Spot for Marine Conservation*. *May 2012*.

Bianchessi, A. (2012b). *A Case Study of the Municipality of Dauin , Negros Oriental , Philippines : A Global Bright Spot for Marine Conservation*. *May 2012*.

Burkepile, D. E., & Hay, M. E. (2008). Herbivore species richness and feeding complementarity affect community structure and function on a coral reef. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(42), 16201–16206. https://doi.org/10.1073/pnas.0801946105

Dell, C. L. A., Longo, G. O., Burkepile, D. E., & Manfrino, C. (2020). Few Herbivore Species Consume Dominant Macroalgae on a Caribbean Coral Reef. *Frontiers in Marine Science*, *7*(August), 1–12. https://doi.org/10.3389/fmars.2020.00676

Descombes, P., Wisz, M. S., Leprieur, F., Parravicini, V., Heine, C., Olsen, S. M., Swingedouw, D., Kulbicki, M., Mouillot, D., & Pellissier, L. (2015). Forecasted coral reef decline in marine biodiversity hotspots under climate change. *Global Change Biology*, *21*(7), 2479–2487. https://doi.org/10.1111/gcb.12868

Díaz-Pérez, L., Rodríguez-Zaragoza, F. A., Ortiz, M., Cupul-Magaña, A. L., Carriquiry, J. D., Ríos-Jara, E., Rodríguez-Troncoso, A. P., & del Carmen García-Rivas, M. (2016). Coral reef health indices versus the biological, ecological and functional diversity of fish and coral assemblages in the Caribbean sea. *PLoS ONE*, *11*(8), 1–19. https://doi.org/10.1371/journal.pone.0161812

Echem, R. T., & Metillo, E. (2011). Spatial and temporal patterns of the macrobenthic algae community structure in selected intertidal zones of Iligan Bay , Northern Mindanao , Philippines. *Philippine Scientist*, *48*(April), 68–84.

Edwards, C. B., Friedlander, A. M., Green, A. G., Hardt, M. J., Sala, E., Sweatman, H. P., Williams, I. D., Zgliczynski, B., Sandin, S. A., & Smith, J. E. (2013). Global assessment of the status of coral reef herbivorous fishes: Evidence for fishing effects. *Proceedings of the Royal Society B: Biological Sciences*, *281*(1774), 7–11. https://doi.org/10.1098/rspb.2013.1835

FAO. (2020). The State of World Fisheries and Aquaculture 2020. In *The State of World Fisheries and Aquaculture 2020*. https://doi.org/10.4060/ca9229en

Foale, S., Adhuri, D., Aliño, P., Allison, E. H., Andrew, N., Cohen, P., Evans, L., Fabinyi, M., Fidelman, P., Gregory, C., Stacey, N., Tanzer, J., & Weeratunge, N. (2013). Food security and the Coral Triangle Initiative. *Marine Policy*, *38*, 174–183. https://doi.org/10.1016/j.marpol.2012.05.033

Froese, R., & Pauly, D. (2020). *FishBase, The Global Database of Fishes*. https://www.fishbase.se/search.php

Gomez, E. D., Aliño, P. M., Yap, H. T., & Licuanan, W. Y. (1994). A review of the status of Philippine reefs. *Marine Pollution Bulletin*, *29*(1–3), 62–68. https://doi.org/10.1016/0025-326X(94)90427-8

Gonzalez-Bernat. (2019). *Why these algae-eating fish may be corals' greatest allies*. https://aida-americas.org/en/blog/why-these-algae-eating-fish-may-be-corals-greatest-allies

Green, A. L., & Bellwood, D. R. (2009). Monitoring Functional Groups of Herbivorous Reef Fishes as Indicators of Coral Reef Resilience A practical guide for coral reef managers in the Asia Pacifi c Region. In *Science* (Issue 7). http://cmsdata.iucn.org/downloads/resilience_herbivorous_monitoring.pdf

Green, S. J., White, A. T., Flores, J. O., Carreon, M., & Sia, A. (2003). *Philippine Fisheries in Crisis : A Framework for Management*.

Hofstede, R. (1998). *Feeding ecology of the angelfish species Pomacanthus asfur and Pomacanthus*. University of Groningen, the Netherlands.

Hughes, T. P., Rodrigues, M. J., Bellwood, D. R., Ceccarelli, D., Hoegh-Guldberg, O., McCook, L., Moltschaniwskyj, N., Pratchett, M. S., Steneck, R. S., & Willis, B. (2007). Phase Shifts, Herbivory, and the Resilience of Coral Reefs to Climate Change. *Current Biology*, *17*(4), 360–365. https://doi.org/10.1016/j.cub.2006.12.049

Institute for Marine Research. (n.d.). Retrieved October 13, 2021, from https://institutemarineresearch.org/

Jonker, M., Johns, K., & Osborne, K. (2008). *Surveys of benthic reef communities using underwater digital photography and counts of juvenile corals. Long-term monitoring of the Great Barrier Reef. Standard Operating Procedure 10/ 2008*. *April 2021*, 85. https://doi.org/10.25845/jjzj-0v14

Kohler, K. E., & Gill, S. M. (2006). Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. *Computers and Geosciences*, *32*(9), 1259–1269. https://doi.org/10.1016/j.cageo.2005.11.009

Kohno, H., Kato, M., & Taki, Y. (1999). Seasonal occurrence and abundance of larval and juvenile fishes in a Philippine surf zone. *Mer*, *36*(3), 101–109.

Kuffner, I. B., Walters, L. J., Becerro, M. A., Paul, V. J., Ritson-Williams, R., & Beach, K. S. (2006). Inhibition of coral recruitment by macroalgae and cyanobacteria. *Marine Ecology Progress Series*, *323*, 107–117. https://doi.org/10.3354/meps323107

Lester, S. E., Halpern, B. S., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B. I., Gaines, S. D., Airamé, S., & Warner, R. R. (2009). Biological effects within no-take marine reserves: A global synthesis. *Marine Ecology Progress Series*, *384*(June 2014), 33–46. https://doi.org/10.3354/meps08029

Lewis, S. M. (1986). The Role of Herbivorous Fishes in the Organization of a Caribbean Reef Community. *Ecological Monographs*, *56*(3), 183–200. https://doi.org/10.2307/2937073

Licuanan, W. Y., & Gomez, E. D. (2000). *Philippine coral reefs: Status and the role of the academe to improve their management*. *2*(October).

McManus, J. W., Meñez, L. A. B., Kesner-Reyes, K. N., Vergara, S. G., & Ablan, M. C. (2000). Coral reef fishing and coral-algal phase shifts: Implications for global reef status. *ICES Journal of Marine Science*, *57*(3), 572–578. https://doi.org/10.1006/jmsc.2000.0720

Muyot, F., Mutia, M. T., Manejar, A. J., Guirhem, G., & Muñez, M. (2019). Status of Ornamental Fish Industry in the Philippines: Prospects for Development. *The Philippine Journal of Fisheries*, *26*(2), 82–97. https://doi.org/10.31398/tpjf/26.2.2019a0011

Nañola, C. L., Aliño, P. M., & Carpenter, K. E. (2011). Exploitation-related reef fish species richness depletion in the epicenter of marine biodiversity. *Environmental Biology of Fishes*, *90*(4), 405–420. https://doi.org/10.1007/s10641-010-9750-6

Narsico, J., Tanedo, M. C., Candelaria, E., Diaz, L., Villanueva, R., Torres, A., & Sinsona, M. (2015). Assessing coral to algal phase shifts in Marcos and Magsaysay reefs Pangasinan, Philippines. *Conference: Biodiversity, Ecology and Conservation of Marine Ecosystems (BECoME 2015)*. https://www.researchgate.net/publication/291335678_Assessing_coral_to_algal_phase_shifts_in_Marcos_and_Magsaysay_reefs_Pangasinan_Philippines

Paddack, M. J., Cowen, R. K., & Sponaugle, S. (2006). Grazing pressure of herbivorous coral reef fishes on low coral-cover reefs. *Coral Reefs*, *25*(3), 461–472. https://doi.org/10.1007/s00338-006-0112-y

Paderanga, O. (2020). *The trophic structure of the fish community at Dauin , Negros Oriental*. *February*, 0–12.

Pandolfi, J. M., Bradbury, R. H., Sala, E., Hughes, T. P., Bjorndal, K. A., Cooke, R. G., McArdle, D., McClenachan, L., Newman, M. J. H., Paredes, G., Warner, R. R., & Jackson, J. B. C. (2003). Global trajectories of the long-term decline of coral reef ecosystems. *Science*, *301*(5635), 955–958. https://doi.org/10.1126/science.1085706

Panga, F. M., Anticamara, J. A., Quibilan, M. C. C., Atrigenio, M. P., & Aliño, P. M. (2021). Through the Boundaries: Environmental Factors Affecting Reef Benthic Cover in Marine Protected Areas in the Philippines. *Frontiers in Marine Science*, *8*(August), 1–12. https://doi.org/10.3389/fmars.2021.702071

Parola, A. (2020). *Misguided Ban on Fishing of Surgeonfish, Damselfish, Rabbitfish, and Parrotfish defeated in Philippines*. https://reefs.com/2020/06/12/misguided-ban-on-fishing-of-surgeonfish-damselfish-rabbitfish-and-parrotfish-defeated-in-philippines/

Plecher, H. (2020). *Total Population of the Philippines*. Statista. https://www.statista.com/statistics/578726/total-population-of-philippines/

Polunin, N. V. C., Harmelin-Vivien, M., & Galzin, R. (1995). Contrasts in algal food processing among five herbivorous coral-reef fishes. *Journal of Fish Biology*, *47*, 455–465.

Puk, L. D., Ferse, S. C. A., & Wild, C. (2016). Patterns and trends in coral reef macroalgae browsing: a review of browsing herbivorous fishes of the Indo-Pacific. *Reviews in Fish Biology and Fisheries*, *26*(1), 53–70. https://doi.org/10.1007/s11160-015-9412-z

Rohrer, J. (2017). *Effectiveness of locally managed Marine Protected Areas in the Visayas, Negros Oriental Province, Philippines*. 60. https://www.marineconservationphilippines.org/wp-content/uploads/2018/02/effectiveness-of-locally-managed-marine-protected-areas-j-rohrer-2017.pdf

Roth, F., Saalmann, F., Thomson, T., Coker, D. J., Villalobos, R., Jones, B. H., Wild, C., & Carvalho, S. (2018). Coral reef degradation affects the potential for reef recovery after disturbance. *Marine Environmental Research*, *142*(September), 48–58. https://doi.org/10.1016/j.marenvres.2018.09.022

Smith, J. (2017). *Herbivorous coral reef fish responses to local and global stressors*. 1–138.

Suh, D., & Pomeroy, R. (2020). Projected Economic Impact of Climate Change on Marine Capture Fisheries in the Philippines. *Frontiers in Marine Science*, *7*(April), 1–14. https://doi.org/10.3389/fmars.2020.00232

The World Bank. (2018). Making Growth Work for the Poor. In *Making Growth Work for the Poor*. https://doi.org/10.1596/29960

Veron, J., Devantier, L., Turak, E., Green, A., Kininmonth, S., Stafford-Smith, M., & Peterson, N. (2011). The Coral Triangle. *Coral Reefs: An Ecosystem in Transition*, *01*(January 2014), 47–55. https://doi.org/10.1007/978-94-007-0114-4

Vroom, P. S., Page, K. N., Page, J. C., Kenyon, B., & Russel E. (2013). Numerous reports suggest that reefs must be dominated by corals to be healthy, but many thriving reefs depend more on algae. *The Scientific Research Society*, *6*(5), 430–437.

Waters, C., & Brand, J. (2020). *2020 OUTLOOK REPORT*. https://institutemarineresearch.org/wp-content/themes/imr/PDFs/2019OutlookReport.pdf

Waters, C., Brand, J., & Manrique, R. (2019). *2019 Outlook Report*. https://institutemarineresearch.org/wp-content/themes/imr/PDFs/2019OutlookReport.pdf

Williams, I. D., White, D. J., Sparks, R. T., Lino, K. C., Zamzow, J. P., Kelly, E. L. A., & Ramey, H. L. (2016). Responses of herbivorous fishes and benthos to 6 years of protection at the Kahekili Herbivore fisheries management area, Maui. *PLoS ONE*, *11*(7), 1–20. https://doi.org/10.1371/journal.pone.0159100

Wilson, S. K., Fulton, C. J., Depczynski, M., Holmes, T. H., Noble, M. M., Radford, B., & Tinkler, P. (2014). Seasonal changes in habitat structure underpin shifts in macroalgae-associated tropical fish communities. *Marine Biology*, *161*(11), 2597–2607. https://doi.org/10.1007/s00227-014-2531-6

Zamani, N. P., & Madduppa, H. H. (2011). *A Standard Criteria for Assesing the Health of Coral Reefs : Implication for Management and Conservation*. *1*(2), 137–146.

Appendices

i. Table of Fish Species Frequency

Fish Species	Frequency
Abudefduf vaigiensis	1052
Acanthurus auranticavus	33
Acanthurus bariene	1
Acanthurus leucocheilus	8
Acanthurus maculiceps	1
Acanthurus nigricauda	1
Acanthurus nigrofuscus	24
Acanthurus pyroferus	44
Aeoliscus strigatus	22
Aluterus scriptus	1
Amanses scopas	9
Amblycirrhitus bimacula	1
Amblyglyphidodon aureus	33
Amblyglyphidodon curacao	79
Amblyglyphidodon leucogaster	324
Amphiprion clarkii	125
Amphiprion frenatus	46
Amphiprion ocellaris	24
Amphiprion percula	2
Amphiprion perideraion	62
Amphiprion sandaracinos	2
Anampses melanurus	8
Anampses meleagrides	3
Apogon angustatus	4
Arothron nigropunctatus	10
Arothron reticularis	1
Arothron stellatus	2
Aulostomus chinensis	2
Balistapus undulatus	206
Balistoides viridescens	2
Bodianus axillaris	1
Bodianus dictynna	29
Bodianus mesothorax	35
Caesio caerulaurea	2
Caesio lunaris	114
Caesio teres	19
Cantherhines pardalis	11
Canthigaster compressa	1
Canthigaster papua	12
Canthigaster valentini	47
Carangoides plagiotaenia	5
Caranx melampygus	1
Centropyge bicolor	12
Centropyge nox	1
Centropyge tibicen	36
Centropyge vroliki	358
Cephalopholis argus	35
Cephalopholis boenak	3
Cephalopholis microprion	6

Cephalopholis miniata	3
Cephalopholis sonnerati	1
Cephalopholis urodeta	35
Chaetodon adiergastos	14
Chaetodon auriga	3
Chaetodon baronessa	192
Chaetodon citrinellus	1
Chaetodon kleinii	201
Chaetodon lineolatus	1
Chaetodon lunula	12
Chaetodon lunulatus	52
Chaetodon melannotus	1
Chaetodon ocellicaudus	7
Chaetodon octofasciatus	4
Chaetodon oxycephalus	3
Chaetodon punctatofasciatus	11
Chaetodon rafflesii	14
Chaetodon selene	1
Chaetodon trifascialis	1
Chaetodon unimaculatus	1
Chaetodon vagabundus	37
Chaetodontoplus mesoleucus	7
Cheilinus chlorourus	9
Cheilinus fasciatus	17
Cheilinus oxycephalus	4
Cheilinus trilobatus	11
Cheilio inermis	27
Cheilodipterus artus	9
Cheilodipterus intermedius	57

Cheilodipterus isostigmus	156
Cheilodipterus macrodon	30
Cheilodipterus nigrotaeniatus	11
Cheilodipterus singapurensis	1
Chlorurus bleekeri	40
Chlorurus bowersi	2
Chlorurus capistratoides	2
Choerodon anchorago	1
Chromis agilis	8
Chromis amboinensis	310
Chromis atripectoralis	6
Chromis caudalis	9
Chromis cinerascens	1
Chromis margaritifer	84
Chromis retrofasciata	3694
Chromis scotochiloptera	206
Chromis ternatensis	10407
Chromis viridis	3079
Chromis weberi	318
Chromis xanthochira	22
Chromis xanthura	54
Chrysiptera bleekeri	3
Chrysiptera rollandi	28
Chrysiptera springeri	38
Chrysiptera talboti	474
Cirrhilabrus lubbocki	3
Cirrhilabrus ryukyuensis	1607
Cirrhitichthys aprinus	1
Cirrhitichthys falco	4

Coradion altivelis	1
Coris batuensis	28
Coris dorsomacula	6
Coris gaimard	42
Coris pictoides	1
Dascyllus aruanus	1026
Dascyllus reticulatus	4095
Dascyllus trimaculatus	877
Diploprion bifasciatum	1
Diproctacanthus xanthurus	20
Dischistodus melanotus	1
Echeneis naucrates	2
Epibulus brevis	24
Epinephelus bleekeri	2
Epinephelus fuscoguttatus	3
Epinephelus merra	30
Epinephelus ongus	7
Fistularia commersonii	5
Forcipiger flavissimus	6
Genicanthus lamarck	2
Gobiodon prolixus	1
Gomphosus varius	12
Gracila albomarginata	1
Gymnothorax thyrsoideus	2
Halichoeres binotopsis	1
Halichoeres biocellatus	1
Halichoeres chlorocephalus	2
Halichoeres chrysus	250
Halichoeres hartzfeldii	9

Halichoeres hortulanus	69
Halichoeres kneri	2
Halichoeres leucurus	22
Halichoeres marginatus	1
Halichoeres melanurus	33
Halichoeres nebulosus	1
Halichoeres papilionaceus	1
Halichoeres podostigma	12
Halichoeres prosopeion	20
Halichoeres richmondi	18
Halichoeres scapularis	99
Hemigymnus fasciatus	17
Hemigymnus melapterus	21
Heniochus chrysostomus	1
Heniochus varius	62
Heteroconger hassi	94
Hipposcarus longiceps	1
Hologymnosus annulatus	2
Hologymnosus doliatus	4
Labrichthys unilineatus	220
Labroides bicolor	5
Labroides dimidiatus	207
Labroides pectoralis	1
Lethrinus amboinensis	1
Lethrinus atkinsoni	2
Lethrinus erythracanthus	1
Lethrinus semicinctus	4
Lutjanus argentimaculatus	20
Lutjanus biguttatus	593

Lutjanus decussatus	43
Lutjanus ehrenbergii	216
Lutjanus fulviflamma	2
Lutjanus fulvus	36
Lutjanus lemniscatus	1
Lutjanus monostigma	11
Lutjanus quinquelineatus	1
Lutjanus rivulatus	2
Lutjanus rufolineatus	67
Lutjanus russellii	5
Lutjanus vitta	30
Lutjanus xanthopinnis	16
Macolor macularis	19
Macolor niger	2
Macropharyngodon meleagris	1
Macropharyngodon negrosensis	43
Macropharyngodon ornatus	1
Meiacanthus atrodorsalis	8
Meiacanthus grammistes	16
Melichthys vidua	31
Monotaxis grandoculis	2
Monotaxis heterodon	3
Mulloidichthys flavolineatus	165
Mulloidichthys vanicolensis	35
Myripristis amaena	92
Myripristis botche	68
Myripristis kuntee	368
Myripristis murdjan	47
Naso lituratus	13

Naso unicornis	16
Neoglyphidodon melas	10
Neoglyphidodon nigroris	14
Neoglyphidodon thoracotaeniatus	18
Neoniphon sammara	14
Neopomacentrus azysron	1
Neopomacentrus filamentosus	1
Novaculichthys taeniourus	13
Odonus niger	3
Ostorhinchus angustatus	4
Ostorhinchus aureus	489
Ostorhinchus cavitensis	2
Ostorhinchus chrysopomus	2
Ostorhinchus chrysotaenia	5
Ostorhinchus compressus	33
Ostorhinchus hartzfeldii	1
Ostorhinchus holotaenia	90
Ostorhinchus jenkinsi	4
Ostorhinchus luteus	3
Ostorhinchus moluccensis	5
Ostorhinchus multilineatus	39
Ostorhinchus nigrofasciatus	6
Ostorhinchus sealei	9
Ostorhinchus wassinki	29
Ostracion cubicus	4
Ostracion solorensis	10
Oxycheilinus bimaculatus	9
Oxycheilinus celebicus	4
Oxycheilinus digramma	4

Oxycheilinus digrammus	6
Oxycheilinus orientalis	2
Oxycheilinus unifasciatus	7
Oxymonacanthus longirostris	4
Parapercis clathrata	94
Parapercis cylindrica	10
Parapercis multiplicata	1
Parapercis nebulosa	2
Parapercis tetracantha	55
Parapercis xanthozona	2
Parupeneus barberinoides	1
Parupeneus barberinus	96
Parupeneus ciliatus	1
Parupeneus crassilabris	34
Parupeneus cyclostomus	19
Parupeneus multifasciatus	377
Parupeneus pleurostigma	6
Pempheris vanicolensis	186
Pervagor aspricaudus	1
Plagiotremus laudandus	4
Plagiotremus rhinorhynchos	4
Plagiotremus tapeinosoma	3
Platax boersii	3
Platax teira	4
Plectorhinchus chaetodonoides	5
Plectorhinchus picus	1
Plectorhinchus polytaenia	12
Plectorhinchus vittatus	2
Plectroglyphidodon lacrymatus	14

Plectropomus laevis	3
Plotosus lineatus	925
Pomacanthus imperator	3
Pomacentrus alexanderae	147
Pomacentrus amboinensis	2218
Pomacentrus armillatus	35
Pomacentrus auriventris	5
Pomacentrus bankanensis	3
Pomacentrus brachialis	5748
Pomacentrus chrysurus	7
Pomacentrus coelestis	2516
Pomacentrus geminospilus	2
Pomacentrus lepidogenys	164
Pomacentrus moluccensis	6841
Pomacentrus nigromanus	1
Pomacentrus opisthostigma	46
Pomacentrus pavo	567
Pomacentrus philippinus	4
Pomacentrus stigma	55
Pomacentrus tripunctatus	5
Pomacentrus vaiuli	2
Priacanthus blochii	1
Pristiapogon fraenatus	3
Pseudanthias huchtii	2470
Pseudanthias squamipinnis	2
Pseudanthias tuka	255
Pseudocheilinus evanidus	19
Pseudocheilinus hexataenia	100
Ptereleotris evides	3

Pterocaesio chrysozona	1
Pterocaesio marri	912
Pterocaesio pisang	454
Pterocaesio tessellata	595
Pterocaesio tile	595
Pygoplites diacanthus	65
Rhinomuraena quaesita	1
Sargocentron rubrum	2
Saurida gracilis	5
Saurida nebulosa	23
Scarus dimidiatus	45
Scarus flavipectoralis	1
Scarus forsteni	4
Scarus frenatus	1
Scarus ghobban	1
Scarus hypselopterus	5
Scarus niger	23
Scarus oviceps	2
Scarus psittacus	64
Scarus rivulatus	11
Scarus rubroviolaceus	2
Scarus schlegeli	1
Scarus spinus	6
Scarus tricolor	40
Scolopsis affinis	5
Scolopsis bilineata	148
Scolopsis ciliata	212
Scolopsis trilineata	3

Seriola dumerili	2
Siganus corallinus	2
Siganus guttatus	75
Siganus margaritiferus	11
Siganus puellus	1
Siganus punctatissimus	1
Siganus unimaculatus	1
Siganus virgatus	36
Sphyraena flavicauda	434
Stethojulis bandanensis	10
Stethojulis interrupta	42
Stethojulis strigiventer	2
Sufflamen bursa	5
Sufflamen chrysopterum	26
Synodus jaculum	1
Synodus variegatus	2
Taeniamia melasma	1
Taeniura lymma	2
Thalassoma amblycephalum	2
Thalassoma hardwicke	35
Thalassoma jansenii	1
Thalassoma lunare	979
Upeneus tragula	11
Valenciennea sexguttata	2
Wetmorella albofasciata	1
Zanclus cornutus	91
Zebrasoma scopas	447

ii. Table of Fish Genus

Genus	Frequency
Abudefduf	1052
Acanthurus	112
Aeoliscus	22
Aluterus	1
Amanses	9
Amblycirrhitus	1
Amblyglyphidodon	436
Amphiprion	261
Anampses	11
Apogon	4
Arothron	13
Aulostomus	2
Balistapus	206
Balistoides	2
Bodianus	65
Caesio	135
Cantherhines	11
Canthigaster	60
Carangoides	5
Caranx	1
Centropyge	407
Cephalopholis	83
Chaetodon	556
Chaetodontoplus	7
Cheilinus	41
Cheilio	27
Cheilodipterus	264
Chlorurus	44
Choerodon	1
Chromis	18198
Chrysiptera	543
Cirrhilabrus	1610
Cirrhitichthys	5
Coradion	1
Coris	77
Dascyllus	5998
Diploprion	1
Diproctacanthus	20
Dischistodus	1
Echeneis	2
Epibulus	24
Epinephelus	42
Fistularia	5
Forcipiger	6
Genicanthus	2
Gobiodon	1
Gomphosus	12
Gracila	1
Gymnothorax	2
Halichoeres	541
Hemigymnus	38
Heniochus	63
Heteroconger	94
Hipposcarus	1
Hologymnosus	6
Labrichthys	220
Labroides	213
Lethrinus	8
Lutjanus	1043
Macolor	21
Macropharyngodon	45
Meiacanthus	24
Melichthys	31
Monotaxis	5
Mulloidichthys	200
Myripristis	575
Naso	29
Neoglyphidodon	42
Neoniphon	14
Neopomacentrus	2
Novaculichthys	13
Odonus	3
Ostorhinchus	721
Ostracion	14
Oxycheilinus	32
Oxymonacanthus	4
Parapercis	164
Parupeneus	534
Pempheris	186
Pervagor	1
Plagiotremus	11
Platax	7
Plectorhinchus	20

Plectroglyphidodon	14
Plectropomus	3
Plotosus	925
Pomacanthus	3
Pomacentrus	18366
Priacanthus	1
Pristiapogon	3
Pseudanthias	2727
Pseudocheilinus	119
Ptereleotris	3
Pterocaesio	2557

Pygoplites	65
Rhinomuraena	1
Sargocentron	2
Saurida	28
Scarus	206
Scolopsis	368
Seriola	2
Siganus	127
Sphyraena	434
Stethojulis	54
Sufflamen	31

Synodus	3
Taeniamia	1
Taeniura	2
Thalassoma	1017
Upeneus	11
Valenciennea	2
Wetmorella	1
Zanclus	91
Zebrasoma	447

iii. Table of Herbivorous Fish

Herbivorous Fish	Frequency
Abudefduf vaigiensis	1052
Acanthurus auranticavus	33
Acanthurus bariene	1
Acanthurus leucocheilus	8
Acanthurus maculiceps	1
Acanthurus nigricauda	1
Acanthurus nigrofuscus	24
Acanthurus pyroferus	44
Aluterus scriptus	1
Amblyglyphidodon aureus	33
Amblyglyphidodon curacao	79
Amphiprion clarkii	125
Amphiprion frenatus	46
Amphiprion ocellaris	24
Amphiprion percula	2
Amphiprion perideraion	62
Amphiprion sandaracinos	2
Centropyge bicolor	12
Centropyge nox	1
Centropyge tibicen	36
Centropyge vroliki	358
Chlorurus bleekeri	40
Chlorurus bowersi	2
Chlorurus capistratoides	2
Chrysiptera bleekeri	3
Chrysiptera rollandi	28
Chrysiptera springeri	38
Chrysiptera talboti	474
Dascyllus aruanus	1026
Dascyllus reticulatus	4095
Dascyllus trimaculatus	877
Dischistodus melanotus	1
Hipposcarus longiceps	1
Naso lituratus	13
Naso unicornis	16
Neoglyphidodon melas	10
Neoglyphidodon nigroris	14
Ostracion cubicus	4
Ostracion solorensis	10
Platax boersii	3
Platax teira	4
Plectroglyphidodon lacrymatus	14
Pomacanthus imperator	3
Pomacentrus alexanderae	147
Pomacentrus amboinensis	2218
Pomacentrus armillatus	35
Pomacentrus auriventris	5
Pomacentrus bankanensis	3
Pomacentrus brachialis	5748
Pomacentrus chrysurus	7
Pomacentrus coelestis	2516
Pomacentrus geminospilus	2
Pomacentrus lepidogenys	164
Pomacentrus moluccensis	6841
Pomacentrus nigromanus	1
Pomacentrus opisthostigma	46
Pomacentrus pavo	567
Pomacentrus philippinus	4
Pomacentrus stigma	55
Pomacentrus tripunctatus	5
Pomacentrus vaiuli	2
Scarus dimidiatus	45
Scarus flavipectoralis	1
Scarus forsteni	4
Scarus frenatus	1
Scarus ghobban	1
Scarus hypselopterus	5
Scarus niger	23
Scarus oviceps	2
Scarus psittacus	64
Scarus rivulatus	11
Scarus rubroviolaceus	2
Scarus schlegeli	1
Scarus spinus	6
Scarus tricolor	40
Siganus corallinus	2
Siganus guttatus	75
Siganus margaritiferus	11
Siganus puellus	1
Siganus punctatissimus	1
Siganus unimaculatus	1
Siganus virgatus	36
Zebrasoma scopas	447

iv. Table of Total fish per Location

Location	Frequency	Status
Bulak	3729	NON-MPA
Bulak (10m)	2125	MPA
Bulak (5m)	3503	MPA
Lipayo	2745	MPA
Lipayo (10m)	3077	MPA
Lipayo (5m)	3178	MPA
Masaplod Norte (10m)	3713	MPA
Masaplod Norte (5m)	2473	MPA
Masaplod Sur (10m/M)	1760	MPA
Masaplod Sur (10m/N)	2194	NON-MPA
Masaplod Sur (5m/M)	2168	MPA
Masaplod Sur (5m/N)	2271	NON-MPA
Mayoong Tubig (10m)	6178	MPA
Mayoong Tubig (5m)	2531	MPA
Poblacion District I (10m)	4379	MPA
Poblacion District I (5m)	3874	MPA
Poblacion District II (10m)	6035	MPA
Poblacion District II (5m)	4144	MPA
Sahara	2852	MPA

v. Table of Benthic Composition per Location

Location	Coral	Algae	Hexacorals	Octocorals	Bivalves	Hydroids	Sponges	Seagrass	Other	Abiotic	Dead.Corals	Unknown	Tape	Status
Bulak	26.38	6.30	0.38	0.35	0.00	0.27	3.68	10.38	0.70	49.70	1.82	0.03	0.00	NON-MPA
Bulak (10m)	2.15	5.73	0.77	0.18	0.00	1.85	2.03	0.00	1.52	85.55	0.13	0.05	0.00	MPA
Bulak (5m)	7.80	7.78	0.82	1.35	0.00	4.12	5.38	0.00	2.67	69.63	0.45	0.00	0.40	MPA
Lipayo	10.15	7.59	0.02	0.66	0.00	0.36	2.31	0.00	0.63	74.13	3.65	0.02	0.00	MPA
Lipayo (10m)	34.56	9.09	0.03	0.13	0.03	0.04	5.17	0.00	3.55	28.29	18.94	0.15	7.76	MPA
Lipayo (5m)	22.24	9.69	0.42	0.23	0.00	0.02	2.79	4.27	0.71	49.12	10.42	0.10	9.36	MPA
Masaplod Norte (10m)	9.00	13.77	0.65	2.77	0.07	2.89	13.75	0.00	2.11	46.51	8.13	0.35	0.23	MPA
Masaplod Norte (5m)	2.16	20.02	0.37	0.60	0.02	0.41	6.85	0.00	0.34	43.45	25.74	0.03	0.14	MPA
Masaplod Sur (10m/M)	41.82	15.55	0.72	5.92	0.00	0.12	8.49	0.00	7.70	13.12	5.55	0.52	0.03	MPA
Masaplod Sur (10m/N)	21.41	12.35	0.05	4.92	0.00	0.05	10.74	2.17	5.65	36.92	5.63	0.10	0.02	NON-MPA
Masaplod Sur (5m/M)	21.48	10.64	0.22	0.67	0.02	0.07	0.77	0.00	1.47	43.76	20.88	0.02	0.05	MPA
Masaplod Sur (5m/N)	11.64	5.76	0.05	1.66	0.00	0.03	2.33	22.85	2.13	46.45	7.10	0.00	0.00	NON-MPA
Mayoong Tubig (10m)	12.54	15.39	0.69	1.02	0.00	0.15	7.44	0.22	5.10	47.33	9.95	0.17	0.13	MPA
Mayoong Tubig (5m)	10.86	26.04	0.08	0.55	0.00	0.15	4.04	0.42	2.51	37.76	17.59	0.00	0.02	MPA
Poblacion District I (10m)	38.36	10.88	0.62	0.95	0.00	0.00	2.41	0.00	0.49	42.37	3.91	0.02	0.23	MPA
Poblacion District I (5m)	39.62	20.53	0.68	0.41	0.03	0.18	2.72	0.00	0.32	30.61	4.88	0.02	0.02	MPA
Poblacion District II (10m)	43.37	14.86	0.03	0.65	0.03	3.42	4.59	0.00	1.02	29.11	2.75	0.15	0.40	MPA
Poblacion District II (5m)	30.95	12.23	0.40	1.33	0.02	0.68	2.20	0.69	0.99	47.04	3.40	0.07	0.21	MPA
Sahara	10.62	4.68	0.17	0.05	0.00	0.40	5.55	0.10	0.45	77.07	0.83	0.08	0.00	MPA

vi. Number of Individuals per Niche Group

Niche Group	Frequency
Browsers	36
Grazers/detritivores	1093
Scrapers/small excavators	251

vii. Species count per Niche Group

Full	Niche Group	Commercially Important	Frequency
Acanthurus auranticavus	Grazers/detritivores	Commercial	33
Acanthurus bariene	Grazers/detritivores	Commercial	1
Acanthurus leucocheilus	Grazers/detritivores	No	8
Acanthurus maculiceps	Grazers/detritivores	Commercial	1
Acanthurus nigricauda	Grazers/detritivores	No	1
Acanthurus nigrofuscus	Grazers/detritivores	Commercial	24
Acanthurus pyroferus	Grazers/detritivores	Commercial	44
Centropyge bicolor	Grazers/detritivores	Subsistence fisheries	12
Centropyge nox	Grazers/detritivores	No	1
Centropyge tibicen	Grazers/detritivores	No	36
Centropyge vroliki	Grazers/detritivores	Minor	358
Chlorurus bleekeri	Scrapers/small excavators	Commercial	40
Chlorurus bowersi	Scrapers/small excavators	No	2
Chlorurus capistratoides	Scrapers/small excavators	No	2
Hipposcarus longiceps	Scrapers/small excavators	No	1
Naso lituratus	Browsers	Commercial	13
Naso unicornis	Browsers	Commercial	16
Platax boersii	Browsers	No	3
Platax teira	Browsers	No	4
Scarus dimidiatus	Scrapers/small excavators	No	45
Scarus flavipectoralis	Scrapers/small excavators	No	1
Scarus forsteni	Scrapers/small excavators	No	4
Scarus frenatus	Scrapers/small excavators	No	1
Scarus ghobban	Scrapers/small excavators	Commercial	1
Scarus hypselopterus	Scrapers/small excavators	No	5
Scarus niger	Scrapers/small excavators	No	23
Scarus oviceps	Scrapers/small excavators	No	2

Scarus psittacus	Scrapers/small excavators	No	64
Scarus rivulatus	Scrapers/small excavators	No	11
Scarus rubroviolaceus	Scrapers/small excavators	No	2
Scarus schlegeli	Scrapers/small excavators	No	1
Scarus spinus	Scrapers/small excavators	No	6
Scarus tricolor	Scrapers/small excavators	Commercial	40
Siganus corallinus	Grazers/detritivores	Commercial	2
Siganus guttatus	Grazers/detritivores	Commercial	75
Siganus margaritiferus	Grazers/detritivores	No	11
Siganus puellus	Grazers/detritivores	Commercial	1
Siganus punctatissimus	Grazers/detritivores	Commercial	1
Siganus unimaculatus	Grazers/detritivores	No	1
Siganus virgatus	Grazers/detritivores	Commercial	36
Zebrasoma scopas	Grazers/detritivores	No	447

viii. Tukey's Post Hoc For Season (Total and Herbivorous fish Only)

Locaiton Matrix (Herbivorous Fish only)	p.adj
Dry:Bulak (5m)-Dry:Bulak	0.004043
Dry:Lipayo (10m)-Dry:Bulak	1.91E-05
Wet:Masaplod Norte (5m)-Dry:Bulak	4.14E-13
Dry:Sahara-Dry:Bulak	2.67E-13
Wet:Sahara-Dry:Bulak	5.63E-06
Dry:Bulak (5m)-Wet:Bulak	1.07E-05
Dry:Lipayo (10m)-Wet:Bulak	4.95E-08
Wet:Masaplod Norte (5m)-Wet:Bulak	4.71E-13
Dry:Sahara-Wet:Bulak	3.77E-13
Wet:Sahara-Wet:Bulak	2.26E-09
Wet:Masaplod Norte (5m)-Dry:Bulak (10m)	3.60E-08
Dry:Sahara-Dry:Bulak (10m)	1.96E-09
Dry:Bulak (5m)-Wet:Bulak (10m)	0.019521
Dry:Lipayo (10m)-Wet:Bulak (10m)	0.000101
Wet:Masaplod Norte (5m)-Wet:Bulak (10m)	4.91E-13
Dry:Sahara-Wet:Bulak (10m)	2.66E-13
Wet:Sahara-Wet:Bulak (10m)	2.82E-05
Wet:Bulak (5m)-Dry:Bulak (5m)	0.000201
Wet:Lipayo-Dry:Bulak (5m)	0.000834
Wet:Lipayo (10m)-Dry:Bulak (5m)	0.002418
Wet:Lipayo (5m)-Dry:Bulak (5m)	0.010172
Wet:Masaplod Norte (5m)-Dry:Bulak (5m)	0.00096
Wet:Masaplod Sur (10m/N)-Dry:Bulak (5m)	7.47E-06
Wet:Masaplod Sur (5m/M)-Dry:Bulak (5m)	3.62E-08
Dry:Masaplod Sur (5m/N)-Dry:Bulak (5m)	0.002133
Wet:Masaplod Sur (5m/N)-Dry:Bulak (5m)	1.26E-05
Dry:Mayoong Tubig (10m)-Dry:Bulak (5m)	0.020114

Location Matrix (Total Fish Population)	p.adj
Dry:Lipayo (10m)-Dry:Bulak	0.018219
Dry:Masaplod Norte (10m)-Dry:Bulak	1.08E-12
Wet:Masaplod Norte (10m)-Dry:Bulak	0.000898
Dry:Lipayo (10m)-Wet:Bulak	0.000383
Dry:Masaplod Norte (10m)-Wet:Bulak	3.21E-13
Wet:Masaplod Norte (10m)-Wet:Bulak	3.11E-06
Dry:Masaplod Norte (10m)-Dry:Bulak (10m)	9.50E-10
Dry:Masaplod Norte (10m)-Wet:Bulak (10m)	3.54E-05
Dry:Masaplod Norte (10m)-Dry:Bulak (5m)	2.01E-10
Wet:Masaplod Norte (10m)-Dry:Bulak (5m)	0.047247
Dry:Lipayo (10m)-Wet:Bulak (5m)	0.02916
Dry:Masaplod Norte (10m)-Wet:Bulak (5m)	4.04E-13
Wet:Masaplod Norte (10m)-Wet:Bulak (5m)	0.000908
Dry:Masaplod Norte (10m)-Dry:Lipayo	1.48E-06
Dry:Lipayo (10m)-Wet:Lipayo	0.000953
Dry:Masaplod Norte (10m)-Wet:Lipayo	2.52E-13
Wet:Masaplod Norte (10m)-Wet:Lipayo	1.59E-05
Wet:Lipayo (5m)-Dry:Lipayo (10m)	0.004536
Dry:Masaplod Norte (10m)-Dry:Lipayo (10m)	0.001819
Wet:Masaplod Sur (10m/M)-Dry:Lipayo (10m)	0.02324
Dry:Masaplod Sur (10m/N)-Dry:Lipayo (10m)	0.041039
Wet:Masaplod Sur (5m/M)-Dry:Lipayo (10m)	0.003393
Dry:Masaplod Sur (5m/N)-Dry:Lipayo (10m)	0.014358
Wet:Masaplod Sur (5m/N)-Dry:Lipayo (10m)	0.009074
Wet:Mayoong Tubig (10m)-Dry:Lipayo (10m)	5.66E-06
Wet:Mayoong Tubig (5m)-Dry:Lipayo (10m)	0.014049
Wet:Poblacion District I (10m)-Dry:Lipayo (10m)	4.27E-05

Wet:Mayoong Tubig (10m)-Dry:Bulak (5m)	5.40E-07
Dry:Mayoong Tubig (5m)-Dry:Bulak (5m)	0.013987
Wet:Mayoong Tubig (5m)-Dry:Bulak (5m)	7.88E-07
Dry:Poblacion District I (5m)-Dry:Bulak (5m)	6.06E-08
Wet:Poblacion District I (5m)-Dry:Bulak (5m)	0.019846
Dry:Poblacion District II (10m)-Dry:Bulak (5m)	0.000647
Wet:Poblacion District II (10m)-Dry:Bulak (5m)	0.000337
Dry:Poblacion District II (5m)-Dry:Bulak (5m)	1.80E-06
Wet:Poblacion District II (5m)-Dry:Bulak (5m)	0.005238
Dry:Sahara-Dry:Bulak (5m)	0.000201
Dry:Lipayo (10m)-Wet:Bulak (5m)	1.05E-06
Wet:Masaplod Norte (5m)-Wet:Bulak (5m)	2.69E-13
Dry:Sahara-Wet:Bulak (5m)	3.39E-13
Wet:Sahara-Wet:Bulak (5m)	2.29E-08
Wet:Masaplod Norte (5m)-Dry:Lipayo	3.56E-05
Wet:Masaplod Sur (10m/N)-Dry:Lipayo	0.044636
Wet:Masaplod Sur (5m/M)-Dry:Lipayo	0.007609
Dry:Poblacion District I (5m)-Dry:Lipayo	0.021787
Dry:Sahara-Dry:Lipayo	7.50E-06
Dry:Lipayo (10m)-Wet:Lipayo	3.54E-06
Wet:Masaplod Norte (5m)-Wet:Lipayo	5.05E-13
Dry:Sahara-Wet:Lipayo	3.90E-13
Wet:Sahara-Wet:Lipayo	3.45E-07
Wet:Lipayo (10m)-Dry:Lipayo (10m)	1.13E-05
Dry:Lipayo (5m)-Dry:Lipayo (10m)	0.025047
Wet:Lipayo (5m)-Dry:Lipayo (10m)	4.65E-05
Dry:Masaplod Sur (10m/M)-Dry:Lipayo (10m)	0.002591
Wet:Masaplod Sur (10m/M)-Dry:Lipayo (10m)	0.000753

Dry:Poblacion District I (5m)-Dry:Lipayo (10m)	0.000497
Wet:Poblacion District I (5m)-Dry:Lipayo (10m)	0.002263
Dry:Poblacion District II (10m)-Dry:Lipayo (10m)	0.000296
Wet:Poblacion District II (10m)-Dry:Lipayo (10m)	1.56E-06
Dry:Poblacion District II (5m)-Dry:Lipayo (10m)	0.00379
Wet:Poblacion District II (5m)-Dry:Lipayo (10m)	0.000185
Dry:Masaplod Norte (10m)-Wet:Lipayo (10m)	4.98E-09
Dry:Masaplod Norte (10m)-Dry:Lipayo (5m)	2.55E-08
Dry:Masaplod Norte (10m)-Wet:Lipayo (5m)	2.93E-13
Wet:Masaplod Norte (10m)-Wet:Lipayo (5m)	9.12E-05
Wet:Masaplod Norte (10m)-Dry:Masaplod Norte (10m)	0.021479
Dry:Masaplod Norte (5m)-Dry:Masaplod Norte (10m)	1.44E-10
Wet:Masaplod Norte (5m)-Dry:Masaplod Norte (10m)	8.49E-06
Dry:Masaplod Sur (10m/M)-Dry:Masaplod Norte (10m)	2.88E-06
Wet:Masaplod Sur (10m/M)-Dry:Masaplod Norte (10m)	1.42E-11
Dry:Masaplod Sur (10m/N)-Dry:Masaplod Norte (10m)	3.25E-12
Wet:Masaplod Sur (10m/N)-Dry:Masaplod Norte (10m)	1.01E-09
Dry:Masaplod Sur (5m/M)-Dry:Masaplod Norte (10m)	3.90E-09
Wet:Masaplod Sur (5m/M)-Dry:Masaplod Norte (10m)	3.86E-13
Dry:Masaplod Sur (5m/N)-Dry:Masaplod Norte (10m)	1.38E-12
Wet:Masaplod Sur (5m/N)-Dry:Masaplod Norte (10m)	6.87E-13
Dry:Mayoong Tubig (10m)-Dry:Masaplod Norte (10m)	1.49E-11
Wet:Mayoong Tubig (10m)-Dry:Masaplod Norte (10m)	3.71E-13
Dry:Mayoong Tubig (5m)-Dry:Masaplod Norte (10m)	4.82E-08
Wet:Mayoong Tubig (5m)-Dry:Masaplod Norte (10m)	5.53E-13
Dry:Poblacion District I (10m)-Dry:Masaplod Norte (10m)	1.18E-11
Wet:Poblacion District I (10m)-Dry:Masaplod Norte (10m)	2.87E-13
Dry:Poblacion District I (5m)-Dry:Masaplod Norte (10m)	4.23E-13

Dry:Masaplod Sur (10m/N)-Dry:Lipayo (10m)	0.001195
Wet:Masaplod Sur (10m/N)-Dry:Lipayo (10m)	3.25E-08
Dry:Masaplod Sur (5m/M)-Dry:Lipayo (10m)	0.001349
Wet:Masaplod Sur (5m/M)-Dry:Lipayo (10m)	3.35E-10
Dry:Masaplod Sur (5m/N)-Dry:Lipayo (10m)	9.27E-06
Wet:Masaplod Sur (5m/N)-Dry:Lipayo (10m)	6.22E-08
Dry:Mayoong Tubig (10m)-Dry:Lipayo (10m)	9.93E-05
Wet:Mayoong Tubig (10m)-Dry:Lipayo (10m)	6.96E-09
Dry:Mayoong Tubig (5m)-Dry:Lipayo (10m)	6.96E-05
Wet:Mayoong Tubig (5m)-Dry:Lipayo (10m)	6.08E-09
Wet:Poblacion District I (10m)-Dry:Lipayo (10m)	0.000536
Dry:Poblacion District I (5m)-Dry:Lipayo (10m)	7.66E-10
Wet:Poblacion District I (5m)-Dry:Lipayo (10m)	9.57E-05
Dry:Poblacion District II (10m)-Dry:Lipayo (10m)	2.77E-06
Wet:Poblacion District II (10m)-Dry:Lipayo (10m)	1.57E-06
Dry:Poblacion District II (5m)-Dry:Lipayo (10m)	1.25E-08
Wet:Poblacion District II (5m)-Dry:Lipayo (10m)	2.43E-05
Wet:Masaplod Norte (5m)-Wet:Lipayo (10m)	4.00E-13
Dry:Sahara-Wet:Lipayo (10m)	2.63E-13
Wet:Sahara-Wet:Lipayo (10m)	3.54E-06
Wet:Masaplod Norte (5m)-Dry:Lipayo (5m)	2.37E-09
Dry:Sahara-Dry:Lipayo (5m)	7.73E-11

Wet:Poblacion District I (5m)-Dry:Masaplod Norte (10m)	2.65E-13
Dry:Poblacion District II (10m)-Dry:Masaplod Norte (10m)	3.44E-13
Wet:Poblacion District II (10m)-Dry:Masaplod Norte (10m)	3.61E-13
Dry:Poblacion District II (5m)-Dry:Masaplod Norte (10m)	3.62E-13
Wet:Poblacion District II (5m)-Dry:Masaplod Norte (10m)	4.59E-13
Dry:Sahara-Dry:Masaplod Norte (10m)	2.51E-05
Wet:Sahara-Dry:Masaplod Norte (10m)	2.37E-08
Dry:Masaplod Norte (5m)-Wet:Masaplod Norte (10m)	0.016499
Wet:Masaplod Sur (10m/M)-Wet:Masaplod Norte (10m)	0.001749
Dry:Masaplod Sur (10m/N)-Wet:Masaplod Norte (10m)	0.002483
Wet:Masaplod Sur (10m/N)-Wet:Masaplod Norte (10m)	0.02901
Wet:Masaplod Sur (5m/M)-Wet:Masaplod Norte (10m)	0.00011
Dry:Masaplod Sur (5m/N)-Wet:Masaplod Norte (10m)	0.000753
Wet:Masaplod Sur (5m/N)-Wet:Masaplod Norte (10m)	0.000401
Dry:Mayoong Tubig (10m)-Wet:Masaplod Norte (10m)	0.005252
Wet:Mayoong Tubig (10m)-Wet:Masaplod Norte (10m)	7.24E-09
Wet:Mayoong Tubig (5m)-Wet:Masaplod Norte (10m)	0.00056
Dry:Poblacion District I (10m)-Wet:Masaplod Norte (10m)	0.007352
Wet:Poblacion District I (10m)-Wet:Masaplod Norte (10m)	1.63E-07
Dry:Poblacion District I (5m)-Wet:Masaplod Norte (10m)	6.09E-06
Wet:Poblacion District I (5m)-Wet:Masaplod Norte (10m)	3.80E-05
Dry:Poblacion District II (10m)-Wet:Masaplod Norte (10m)	2.72E-06

Wet:Sahara-Dry:Lipayo (5m)	0.022485
Wet:Masaplod Norte (5m)-Wet:Lipayo (5m)	2.99E-13
Dry:Sahara-Wet:Lipayo (5m)	2.94E-13
Wet:Sahara-Wet:Lipayo (5m)	5.64E-06
Wet:Masaplod Norte (5m)-Dry:Masaplod Norte (10m)	3.98E-07
Wet:Masaplod Sur (5m/M)-Dry:Masaplod Norte (10m)	0.033681
Dry:Sahara-Dry:Masaplod Norte (10m)	3.47E-08
Wet:Masaplod Norte (5m)-Wet:Masaplod Norte (10m)	9.03E-08
Dry:Sahara-Wet:Masaplod Norte (10m)	7.50E-09
Wet:Masaplod Norte (5m)-Dry:Masaplod Norte (5m)	1.84E-07
Dry:Sahara-Dry:Masaplod Norte (5m)	1.73E-08
Dry:Masaplod Sur (10m/M)-Wet:Masaplod Norte (5m)	2.56E-09
Wet:Masaplod Sur (10m/M)-Wet:Masaplod Norte (5m)	1.09E-10
Dry:Masaplod Sur (10m/N)-Wet:Masaplod Norte (5m)	1.36E-12
Wet:Masaplod Sur (10m/N)-Wet:Masaplod Norte (5m)	2.91E-13
Dry:Masaplod Sur (5m/M)-Wet:Masaplod Norte (5m)	1.35E-11
Wet:Masaplod Sur (5m/M)-Wet:Masaplod Norte (5m)	3.34E-13
Dry:Masaplod Sur (5m/N)-Wet:Masaplod Norte (5m)	3.16E-13
Wet:Masaplod Sur (5m/N)-Wet:Masaplod Norte (5m)	4.11E-13
Dry:Mayoong Tubig (10m)-Wet:Masaplod Norte (5m)	3.83E-13
Wet:Mayoong Tubig (10m)-Wet:Masaplod Norte (5m)	3.46E-13
Dry:Mayoong Tubig (5m)-Wet:Masaplod Norte (5m)	4.39E-13
Wet:Mayoong Tubig (5m)-Wet:Masaplod Norte (5m)	3.52E-13
Dry:Poblacion District I (10m)-Wet:Masaplod Norte (5m)	1.91E-06
Wet:Poblacion District I (10m)-Wet:Masaplod Norte (5m)	1.93E-12
Wet:Poblacion District II (10m)-Wet:Masaplod Norte (10m)	2.21E-09
Dry:Poblacion District II (5m)-Wet:Masaplod Norte (10m)	0.00011
Wet:Poblacion District II (5m)-Wet:Masaplod Norte (10m)	1.12E-06

Dry:Poblacion District I (5m)-Wet:Masaplod Norte (5m)	3.61E-13
Wet:Poblacion District I (5m)-Wet:Masaplod Norte (5m)	3.40E-13
Dry:Poblacion District II (10m)-Wet:Masaplod Norte (5m)	4.60E-13
Wet:Poblacion District II (10m)-Wet:Masaplod Norte (5m)	3.42E-13
Dry:Poblacion District II (5m)-Wet:Masaplod Norte (5m)	3.19E-13
Wet:Poblacion District II (5m)-Wet:Masaplod Norte (5m)	4.66E-13
Dry:Sahara-Dry:Masaplod Sur (10m/M)	3.69E-10
Wet:Sahara-Dry:Masaplod Sur (10m/M)	0.002788
Dry:Sahara-Wet:Masaplod Sur (10m/M)	7.95E-12
Wet:Sahara-Wet:Masaplod Sur (10m/M)	0.000609
Dry:Sahara-Dry:Masaplod Sur (10m/N)	3.14E-13
Wet:Sahara-Dry:Masaplod Sur (10m/N)	0.000397
Dry:Sahara-Wet:Masaplod Sur (10m/N)	3.05E-13
Wet:Sahara-Wet:Masaplod Sur (10m/N)	2.19E-09
Dry:Sahara-Dry:Masaplod Sur (5m/M)	6.53E-13
Wet:Sahara-Dry:Masaplod Sur (5m/M)	0.000735
Dry:Sahara-Wet:Masaplod Sur (5m/M)	0
Wet:Sahara-Wet:Masaplod Sur (5m/M)	2.30E-12
Dry:Sahara-Dry:Masaplod Sur (5m/N)	3.80E-13
Wet:Sahara-Dry:Masaplod Sur (5m/N)	1.71E-06
Dry:Sahara-Wet:Masaplod Sur (5m/N)	3.53E-13
Wet:Sahara-Wet:Masaplod Sur (5m/N)	1.97E-09
Dry:Sahara-Dry:Mayoong Tubig (10m)	4.43E-13
Wet:Sahara-Dry:Mayoong Tubig (10m)	2.00E-05
Dry:Sahara-Wet:Mayoong Tubig (10m)	0
Wet:Sahara-Wet:Mayoong Tubig (10m)	1.34E-11
Dry:Sahara-Dry:Mayoong Tubig (5m)	2.62E-13

Wet:Sahara-Dry:Mayoong Tubig (5m)	1.84E-05
Dry:Sahara-Wet:Mayoong Tubig (5m)	0
Wet:Sahara-Wet:Mayoong Tubig (5m)	4.55E-11
Dry:Sahara-Dry:Poblacion District I (10m)	3.49E-07
Dry:Sahara-Wet:Poblacion District I (10m)	3.65E-13
Wet:Sahara-Wet:Poblacion District I (10m)	0.000217
Dry:Sahara-Dry:Poblacion District I (5m)	0
Wet:Sahara-Dry:Poblacion District I (5m)	2.29E-12
Dry:Sahara-Wet:Poblacion District I (5m)	3.48E-13
Wet:Sahara-Wet:Poblacion District I (5m)	1.44E-05
Dry:Sahara-Dry:Poblacion District II (10m)	3.33E-13
Wet:Sahara-Dry:Poblacion District II (10m)	2.25E-07
Dry:Sahara-Wet:Poblacion District II (10m)	3.39E-13
Wet:Sahara-Wet:Poblacion District II (10m)	6.19E-08
Dry:Sahara-Dry:Poblacion District II (5m)	6.75E-14
Wet:Sahara-Dry:Poblacion District II (5m)	1.21E-10
Dry:Sahara-Wet:Poblacion District II (5m)	3.68E-13
Wet:Sahara-Wet:Poblacion District II (5m)	1.28E-06

ix. Tukey's Post Hoc for Benthic Cover

Location Matrix	p.adj
Wet:Masaplod Norte (10m)-Dry:Bulak	0.044872
Dry:Masaplod Norte (5m)-Dry:Bulak	1.26E-08
Wet:Masaplod Norte (5m)-Dry:Bulak	6.49E-05
Dry:Masaplod Sur (10m/M)-Dry:Bulak	1.03E-07
Dry:Mayoong Tubig (10m)-Dry:Bulak	0.005126
Wet:Mayoong Tubig (10m)-Dry:Bulak	0.002035
Dry:Mayoong Tubig (5m)-Dry:Bulak	1.23E-07
Wet:Mayoong Tubig (5m)-Dry:Bulak	1.26E-08
Wet:Poblacion District I (10m)-Dry:Bulak	0.002789
Dry:Poblacion District I (5m)-Dry:Bulak	1.27E-08
Wet:Poblacion District I (5m)-Dry:Bulak	7.38E-07
Dry:Poblacion District II (10m)-Dry:Bulak	5.62E-08
Dry:Poblacion District II (5m)-Dry:Bulak	0.000214
Dry:Masaplod Norte (5m)-Wet:Bulak	1.27E-08
Wet:Masaplod Norte (5m)-Wet:Bulak	0.001545
Dry:Masaplod Sur (10m/M)-Wet:Bulak	4.32E-06
Wet:Mayoong Tubig (10m)-Wet:Bulak	0.027518
Dry:Mayoong Tubig (5m)-Wet:Bulak	5.12E-06
Wet:Mayoong Tubig (5m)-Wet:Bulak	1.26E-08
Wet:Poblacion District I (10m)-Wet:Bulak	0.035504
Dry:Poblacion District I (5m)-Wet:Bulak	1.32E-08
Wet:Poblacion District I (5m)-Wet:Bulak	2.82E-05
Dry:Poblacion District II (10m)-Wet:Bulak	2.23E-06
Dry:Poblacion District II (5m)-Wet:Bulak	0.004254
Dry:Lipayo (5m)-Dry:Bulak (10m)	0.023751
Dry:Masaplod Norte (10m)-Dry:Bulak (10m)	0.004061
Wet:Masaplod Norte (10m)-Dry:Bulak (10m)	0.001719

Dry:Masaplod Norte (5m)-Dry:Bulak (10m)	1.26E-08
Wet:Masaplod Norte (5m)-Dry:Bulak (10m)	6.28E-07
Dry:Masaplod Sur (10m/M)-Dry:Bulak (10m)	1.30E-08
Dry:Masaplod Sur (10m/N)-Dry:Bulak (10m)	0.045727
Wet:Masaplod Sur (10m/N)-Dry:Bulak (10m)	0.03462
Dry:Mayoong Tubig (10m)-Dry:Bulak (10m)	0.000113
Wet:Mayoong Tubig (10m)-Dry:Bulak (10m)	3.65E-05
Dry:Mayoong Tubig (5m)-Dry:Bulak (10m)	1.31E-08
Wet:Mayoong Tubig (5m)-Dry:Bulak (10m)	1.26E-08
Wet:Poblacion District I (10m)-Dry:Bulak (10m)	5.33E-05
Dry:Poblacion District I (5m)-Dry:Bulak (10m)	1.26E-08
Wet:Poblacion District I (5m)-Dry:Bulak (10m)	1.66E-08
Dry:Poblacion District II (10m)-Dry:Bulak (10m)	1.28E-08
Dry:Poblacion District II (5m)-Dry:Bulak (10m)	2.52E-06
Dry:Masaplod Norte (5m)-Wet:Bulak (10m)	1.29E-08
Wet:Masaplod Norte (5m)-Wet:Bulak (10m)	0.005147
Dry:Masaplod Sur (10m/M)-Wet:Bulak (10m)	1.98E-05
Dry:Mayoong Tubig (5m)-Wet:Bulak (10m)	2.32E-05
Wet:Mayoong Tubig (5m)-Wet:Bulak (10m)	1.26E-08
Dry:Poblacion District I (5m)-Wet:Bulak (10m)	1.63E-08
Wet:Poblacion District I (5m)-Wet:Bulak (10m)	0.000118
Dry:Poblacion District II (10m)-Wet:Bulak (10m)	1.05E-05
Dry:Poblacion District II (5m)-Wet:Bulak (10m)	0.013027
Dry:Masaplod Norte (5m)-Dry:Bulak (5m)	6.08E-08
Dry:Masaplod Sur (10m/M)-Dry:Bulak (5m)	0.001134
Dry:Mayoong Tubig (5m)-Dry:Bulak (5m)	0.001286
Wet:Mayoong Tubig (5m)-Dry:Bulak (5m)	1.26E-08
Dry:Poblacion District I (5m)-Dry:Bulak (5m)	6.47E-07

Wet:Poblacion District I (5m)-Dry:Bulak (5m)	0.00504
Dry:Poblacion District II (10m)-Dry:Bulak (5m)	0.000664
Dry:Masaplod Norte (5m)-Wet:Bulak (5m)	1.27E-08
Wet:Masaplod Norte (5m)-Wet:Bulak (5m)	0.000385
Dry:Masaplod Sur (10m/M)-Wet:Bulak (5m)	7.88E-07
Dry:Mayoong Tubig (10m)-Wet:Bulak (5m)	0.020476
Wet:Mayoong Tubig (10m)-Wet:Bulak (5m)	0.008973
Dry:Mayoong Tubig (5m)-Wet:Bulak (5m)	9.45E-07
Wet:Mayoong Tubig (5m)-Wet:Bulak (5m)	1.26E-08
Wet:Poblacion District I (10m)-Wet:Bulak (5m)	0.011921
Dry:Poblacion District I (5m)-Wet:Bulak (5m)	1.27E-08
Wet:Poblacion District I (5m)-Wet:Bulak (5m)	5.59E-06
Dry:Poblacion District II (10m)-Wet:Bulak (5m)	4.00E-07
Dry:Poblacion District II (5m)-Wet:Bulak (5m)	0.001155
Dry:Masaplod Norte (5m)-Dry:Lipayo	1.27E-08
Wet:Masaplod Norte (5m)-Dry:Lipayo	0.001178
Dry:Masaplod Sur (10m/M)-Dry:Lipayo	2.99E-06
Dry:Mayoong Tubig (10m)-Dry:Lipayo	0.047859
Wet:Mayoong Tubig (10m)-Dry:Lipayo	0.022497
Dry:Mayoong Tubig (5m)-Dry:Lipayo	3.56E-06
Wet:Mayoong Tubig (5m)-Dry:Lipayo	1.26E-08
Wet:Poblacion District I (10m)-Dry:Lipayo	0.02923
Dry:Poblacion District I (5m)-Dry:Lipayo	1.30E-08
Wet:Poblacion District I (5m)-Dry:Lipayo	2.01E-05
Dry:Poblacion District II (10m)-Dry:Lipayo	1.53E-06
Dry:Poblacion District II (5m)-Dry:Lipayo	0.00332
Dry:Masaplod Norte (5m)-Wet:Lipayo	1.54E-08
Wet:Masaplod Norte (5m)-Wet:Lipayo	0.022495
Dry:Masaplod Sur (10m/M)-Wet:Lipayo	0.000138

Dry:Mayoong Tubig (5m)-Wet:Lipayo	0.00016
Wet:Mayoong Tubig (5m)-Wet:Lipayo	1.26E-08
Dry:Poblacion District I (5m)-Wet:Lipayo	5.50E-08
Wet:Poblacion District I (5m)-Wet:Lipayo	0.000726
Dry:Poblacion District II (10m)-Wet:Lipayo	7.67E-05
Dry:Masaplod Norte (5m)-Dry:Lipayo (10m)	1.33E-08
Wet:Masaplod Norte (5m)-Dry:Lipayo (10m)	0.010151
Dry:Masaplod Sur (10m/M)-Dry:Lipayo (10m)	4.78E-05
Dry:Mayoong Tubig (5m)-Dry:Lipayo (10m)	5.57E-05
Wet:Mayoong Tubig (5m)-Dry:Lipayo (10m)	1.26E-08
Dry:Poblacion District I (5m)-Dry:Lipayo (10m)	2.37E-08
Wet:Poblacion District I (5m)-Dry:Lipayo (10m)	0.00027
Dry:Poblacion District II (10m)-Dry:Lipayo (10m)	2.59E-05
Dry:Poblacion District II (5m)-Dry:Lipayo (10m)	0.024346
Dry:Masaplod Norte (5m)-Wet:Lipayo (10m)	1.29E-06
Dry:Masaplod Sur (10m/M)-Wet:Lipayo (10m)	0.011114
Dry:Mayoong Tubig (5m)-Wet:Lipayo (10m)	0.012315
Wet:Mayoong Tubig (5m)-Wet:Lipayo (10m)	1.26E-08
Dry:Poblacion District I (5m)-Wet:Lipayo (10m)	1.38E-05
Wet:Poblacion District I (5m)-Wet:Lipayo (10m)	0.039116
Dry:Poblacion District II (10m)-Wet:Lipayo (10m)	0.007
Dry:Masaplod Norte (5m)-Dry:Lipayo (5m)	0.000609
Wet:Mayoong Tubig (5m)-Dry:Lipayo (5m)	1.26E-08
Dry:Poblacion District I (5m)-Dry:Lipayo (5m)	0.004028
Dry:Masaplod Norte (5m)-Wet:Lipayo (5m)	1.27E-08
Wet:Masaplod Norte (5m)-Wet:Lipayo (5m)	0.000917
Dry:Masaplod Sur (10m/M)-Wet:Lipayo (5m)	2.26E-06
Dry:Mayoong Tubig (10m)-Wet:Lipayo (5m)	0.039184
Wet:Mayoong Tubig (10m)-Wet:Lipayo (5m)	0.018151

Dry:Mayoong Tubig (5m)-Wet:Lipayo (5m)	2.70E-06
Wet:Mayoong Tubig (5m)-Wet:Lipayo (5m)	1.26E-08
Wet:Poblacion District I (10m)-Wet:Lipayo (5m)	0.023691
Dry:Poblacion District I (5m)-Wet:Lipayo (5m)	1.29E-08
Wet:Poblacion District I (5m)-Wet:Lipayo (5m)	1.53E-05
Dry:Poblacion District II (10m)-Wet:Lipayo (5m)	1.16E-06
Dry:Poblacion District II (5m)-Wet:Lipayo (5m)	0.00261
Dry:Masaplod Norte (5m)-Dry:Masaplod Norte (10m)	0.004061
Wet:Mayoong Tubig (5m)-Dry:Masaplod Norte (10m)	1.26E-08
Dry:Poblacion District I (5m)-Dry:Masaplod Norte (10m)	0.021798
Dry:Sahara-Dry:Masaplod Norte (10m)	0.014075
Wet:Sahara-Dry:Masaplod Norte (10m)	0.021564
Dry:Masaplod Norte (5m)-Wet:Masaplod Norte (10m)	0.009152
Wet:Masaplod Sur (5m/N)-Wet:Masaplod Norte (10m)	0.044872
Wet:Mayoong Tubig (5m)-Wet:Masaplod Norte (10m)	1.26E-08
Dry:Poblacion District I (5m)-Wet:Masaplod Norte (10m)	0.043958
Dry:Sahara-Wet:Masaplod Norte (10m)	0.006422
Wet:Sahara-Wet:Masaplod Norte (10m)	0.010134
Wet:Masaplod Sur (10m/M)-Dry:Masaplod Norte (5m)	5.03E-05
Dry:Masaplod Sur (10m/N)-Dry:Masaplod Norte (5m)	0.000221
Wet:Masaplod Sur (10m/N)-Dry:Masaplod Norte (5m)	0.000328
Dry:Masaplod Sur (5m/M)-Dry:Masaplod Norte (5m)	0.000188
Wet:Masaplod Sur (5m/M)-Dry:Masaplod Norte (5m)	4.95E-08
Dry:Masaplod Sur (5m/N)-Dry:Masaplod Norte (5m)	1.26E-08
Wet:Masaplod Sur (5m/N)-Dry:Masaplod Norte (5m)	1.26E-08
Wet:Mayoong Tubig (5m)-Dry:Masaplod Norte (5m)	0.006691
Dry:Poblacion District I (10m)-Dry:Masaplod Norte (5m)	1.27E-08
Wet:Poblacion District II (10m)-Dry:Masaplod Norte (5m)	6.34E-07
Wet:Poblacion District II (5m)-Dry:Masaplod Norte (5m)	1.32E-08

Dry:Sahara-Dry:Masaplod Norte (5m)	1.26E-08
Wet:Sahara-Dry:Masaplod Norte (5m)	1.26E-08
Dry:Masaplod Sur (5m/N)-Wet:Masaplod Norte (5m)	0.000133
Wet:Masaplod Sur (5m/N)-Wet:Masaplod Norte (5m)	6.49E-05
Wet:Mayoong Tubig (5m)-Wet:Masaplod Norte (5m)	1.28E-08
Dry:Poblacion District I (10m)-Wet:Masaplod Norte (5m)	0.000335
Wet:Poblacion District II (5m)-Wet:Masaplod Norte (5m)	0.009391
Dry:Sahara-Wet:Masaplod Norte (5m)	3.78E-06
Wet:Sahara-Wet:Masaplod Norte (5m)	7.19E-06
Wet:Masaplod Sur (5m/M)-Dry:Masaplod Sur (10m/M)	0.000936
Dry:Masaplod Sur (5m/N)-Dry:Masaplod Sur (10m/M)	2.31E-07
Wet:Masaplod Sur (5m/N)-Dry:Masaplod Sur (10m/M)	1.03E-07
Wet:Mayoong Tubig (5m)-Dry:Masaplod Sur (10m/M)	6.15E-07
Dry:Poblacion District I (10m)-Dry:Masaplod Sur (10m/M)	6.67E-07
Wet:Poblacion District II (10m)-Dry:Masaplod Sur (10m/M)	0.00684
Wet:Poblacion District II (5m)-Dry:Masaplod Sur (10m/M)	4.32E-05
Dry:Sahara-Dry:Masaplod Sur (10m/M)	1.58E-08
Wet:Sahara-Dry:Masaplod Sur (10m/M)	1.93E-08
Wet:Mayoong Tubig (5m)-Wet:Masaplod Sur (10m/M)	1.26E-08
Dry:Poblacion District I (5m)-Wet:Masaplod Sur (10m/M)	0.000417
Wet:Mayoong Tubig (5m)-Dry:Masaplod Sur (10m/N)	1.26E-08
Dry:Poblacion District I (5m)-Dry:Masaplod Sur (10m/N)	0.001617
Wet:Mayoong Tubig (5m)-Wet:Masaplod Sur (10m/N)	1.26E-08
Dry:Poblacion District I (5m)-Wet:Masaplod Sur (10m/N)	0.002317
Wet:Mayoong Tubig (5m)-Dry:Masaplod Sur (5m/M)	1.26E-08
Dry:Poblacion District I (5m)-Dry:Masaplod Sur (5m/M)	0.001387
Dry:Mayoong Tubig (5m)-Wet:Masaplod Sur (5m/M)	0.001063
Wet:Mayoong Tubig (5m)-Wet:Masaplod Sur (5m/M)	1.26E-08
Dry:Poblacion District I (5m)-Wet:Masaplod Sur (5m/M)	5.06E-07

Wet:Poblacion District I (5m)-Wet:Masaplod Sur (5m/M)	0.004228
Dry:Poblacion District II (10m)-Wet:Masaplod Sur (5m/M)	0.000545
Dry:Mayoong Tubig (10m)-Dry:Masaplod Sur (5m/N)	0.008954
Wet:Mayoong Tubig (10m)-Dry:Masaplod Sur (5m/N)	0.003699
Dry:Mayoong Tubig (5m)-Dry:Masaplod Sur (5m/N)	2.77E-07
Wet:Mayoong Tubig (5m)-Dry:Masaplod Sur (5m/N)	1.26E-08
Wet:Poblacion District I (10m)-Dry:Masaplod Sur (5m/N)	0.005006
Dry:Poblacion District I (5m)-Dry:Masaplod Sur (5m/N)	1.27E-08
Wet:Poblacion District I (5m)-Dry:Masaplod Sur (5m/N)	1.68E-06
Dry:Poblacion District II (10m)-Dry:Masaplod Sur (5m/N)	1.20E-07
Dry:Poblacion District II (5m)-Dry:Masaplod Sur (5m/N)	0.000423
Dry:Mayoong Tubig (10m)-Wet:Masaplod Sur (5m/N)	0.005126
Wet:Mayoong Tubig (10m)-Wet:Masaplod Sur (5m/N)	0.002035
Dry:Mayoong Tubig (5m)-Wet:Masaplod Sur (5m/N)	1.23E-07
Wet:Mayoong Tubig (5m)-Wet:Masaplod Sur (5m/N)	1.26E-08
Wet:Poblacion District I (10m)-Wet:Masaplod Sur (5m/N)	0.002789
Dry:Poblacion District I (5m)-Wet:Masaplod Sur (5m/N)	1.27E-08
Wet:Poblacion District I (5m)-Wet:Masaplod Sur (5m/N)	7.38E-07
Dry:Poblacion District II (10m)-Wet:Masaplod Sur (5m/N)	5.62E-08
Dry:Poblacion District II (5m)-Wet:Masaplod Sur (5m/N)	0.000214
Wet:Mayoong Tubig (5m)-Dry:Mayoong Tubig (10m)	1.26E-08
Dry:Poblacion District I (10m)-Dry:Mayoong Tubig (10m)	0.018413
Dry:Sahara-Dry:Mayoong Tubig (10m)	0.000509
Wet:Sahara-Dry:Mayoong Tubig (10m)	0.000866
Wet:Mayoong Tubig (5m)-Wet:Mayoong Tubig (10m)	1.27E-08
Dry:Poblacion District I (10m)-Wet:Mayoong Tubig (10m)	0.008002
Dry:Sahara-Wet:Mayoong Tubig (10m)	0.000177
Wet:Sahara-Wet:Mayoong Tubig (10m)	0.00031
Wet:Mayoong Tubig (5m)-Dry:Mayoong Tubig (5m)	6.18E-07

Dry:Poblacion District I (10m)-Dry:Mayoong Tubig (5m)	8.00E-07
Wet:Poblacion District II (10m)-Dry:Mayoong Tubig (5m)	0.00762
Wet:Poblacion District II (5m)-Dry:Mayoong Tubig (5m)	5.03E-05
Dry:Sahara-Dry:Mayoong Tubig (5m)	1.66E-08
Wet:Sahara-Dry:Mayoong Tubig (5m)	2.09E-08
Dry:Poblacion District I (10m)-Wet:Mayoong Tubig (5m)	1.26E-08
Wet:Poblacion District I (10m)-Wet:Mayoong Tubig (5m)	1.27E-08
Dry:Poblacion District I (5m)-Wet:Mayoong Tubig (5m)	0.000957
Wet:Poblacion District I (5m)-Wet:Mayoong Tubig (5m)	8.69E-08
Dry:Poblacion District II (10m)-Wet:Mayoong Tubig (5m)	1.21E-06
Wet:Poblacion District II (10m)-Wet:Mayoong Tubig (5m)	1.26E-08
Dry:Poblacion District II (5m)-Wet:Mayoong Tubig (5m)	1.27E-08
Wet:Poblacion District II (5m)-Wet:Mayoong Tubig (5m)	1.26E-08
Dry:Sahara-Wet:Mayoong Tubig (5m)	1.26E-08
Wet:Sahara-Wet:Mayoong Tubig (5m)	1.26E-08
Wet:Poblacion District I (10m)-Dry:Poblacion District I (10m)	0.010658
Dry:Poblacion District I (5m)-Dry:Poblacion District I (10m)	1.27E-08
Wet:Poblacion District I (5m)-Dry:Poblacion District I (10m)	4.76E-06
Dry:Poblacion District II (10m)-Dry:Poblacion District I (10m)	3.39E-07
Dry:Poblacion District II (5m)-Dry:Poblacion District I (10m)	0.001012
Dry:Sahara-Wet:Poblacion District I (10m)	0.000253
Wet:Sahara-Wet:Poblacion District I (10m)	0.000439
Wet:Poblacion District II (10m)-Dry:Poblacion District I (5m)	7.05E-06
Wet:Poblacion District II (5m)-Dry:Poblacion District I (5m)	2.24E-08
Dry:Sahara-Dry:Poblacion District I (5m)	1.26E-08
Wet:Sahara-Dry:Poblacion District I (5m)	1.26E-08

Wet:Poblacion District II (10m)-Wet:Poblacion District I (5m)	0.025474
Wet:Poblacion District II (5m)-Wet:Poblacion District I (5m)	0.000245
Dry:Sahara-Wet:Poblacion District I (5m)	4.21E-08
Wet:Sahara-Wet:Poblacion District I (5m)	7.32E-08
Wet:Poblacion District II (10m)-Dry:Poblacion District II (10m)	0.004233

Wet:Poblacion District II (5m)-Dry:Poblacion District II (10m)	2.33E-05
Dry:Sahara-Dry:Poblacion District II (10m)	1.41E-08
Wet:Sahara-Dry:Poblacion District II (10m)	1.57E-08
Wet:Poblacion District II (5m)-Dry:Poblacion District II (5m)	0.022668
Dry:Sahara-Dry:Poblacion District II (5m)	1.42E-05
Wet:Sahara-Dry:Poblacion District II (5m)	2.63E-05