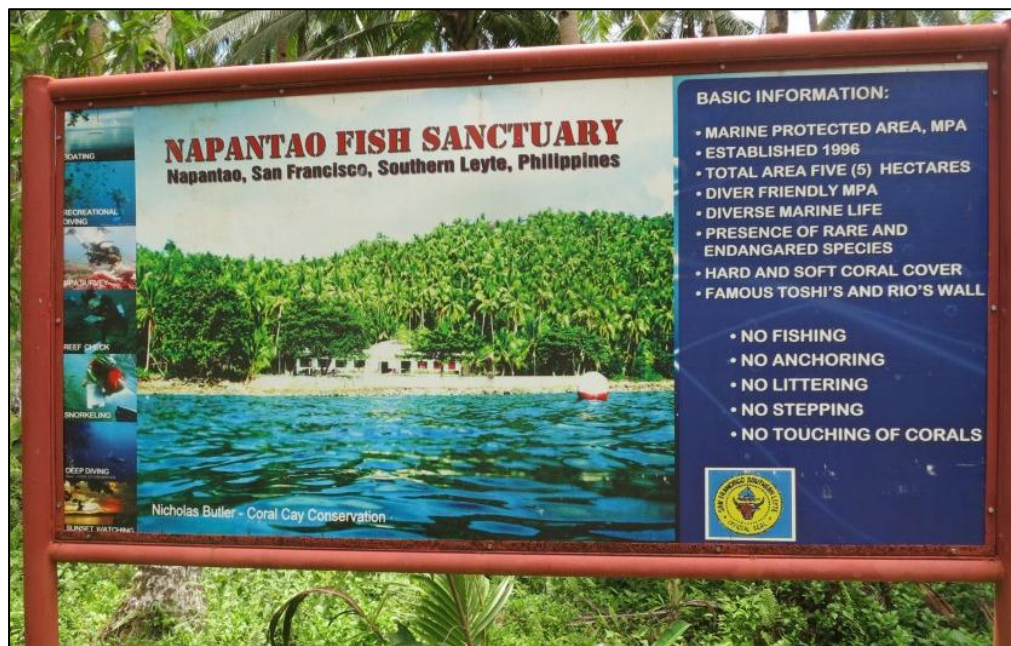


Do Marine Protected Areas (MPAs) have an impact on coral reef health in Sogod Bay, The Philippines?



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Abstract

Over the last five years Marine Protected Areas (MPA) have been significantly criticized by coastal communities with regard to them being poorly managed and consequently having a negative impact on coral reef health. Through researching the use of abundance and diversity data on specific coral, invertebrate and fish species this project has analysed trends both inside and outside an MPA at two sites within Sogod Bay, the Philippines. Data from baseline surveys was statistically analysed to test whether the MPA had an effect on marine life and specifically whether it generated a healthier coral community. Results from this study indicated that there are differences present between inside and outside the MPA but to gain a greater understanding of the variances there needs to be continued research into further essential coral reef conservation as well as a higher degree of education available to local people to ensure clarity regarding the usefulness of the schemes to enable long term sustainable management.

Chapter 1: Introduction

1.0 What are coral reefs?

Coral reefs are lime ecosystems comprised from an assemblage of millions of minute anemone-like animals called 'polyps', each with a series of tentacles which host the microalgae zooxanthellae (Wood 2007). The organisms are linked in a mutualistic relationship, the zooxanthellae using the polyp as a habitat but in return generating food for the coral through photosynthesis and surrounding carbohydrates (Sorokin 1993).

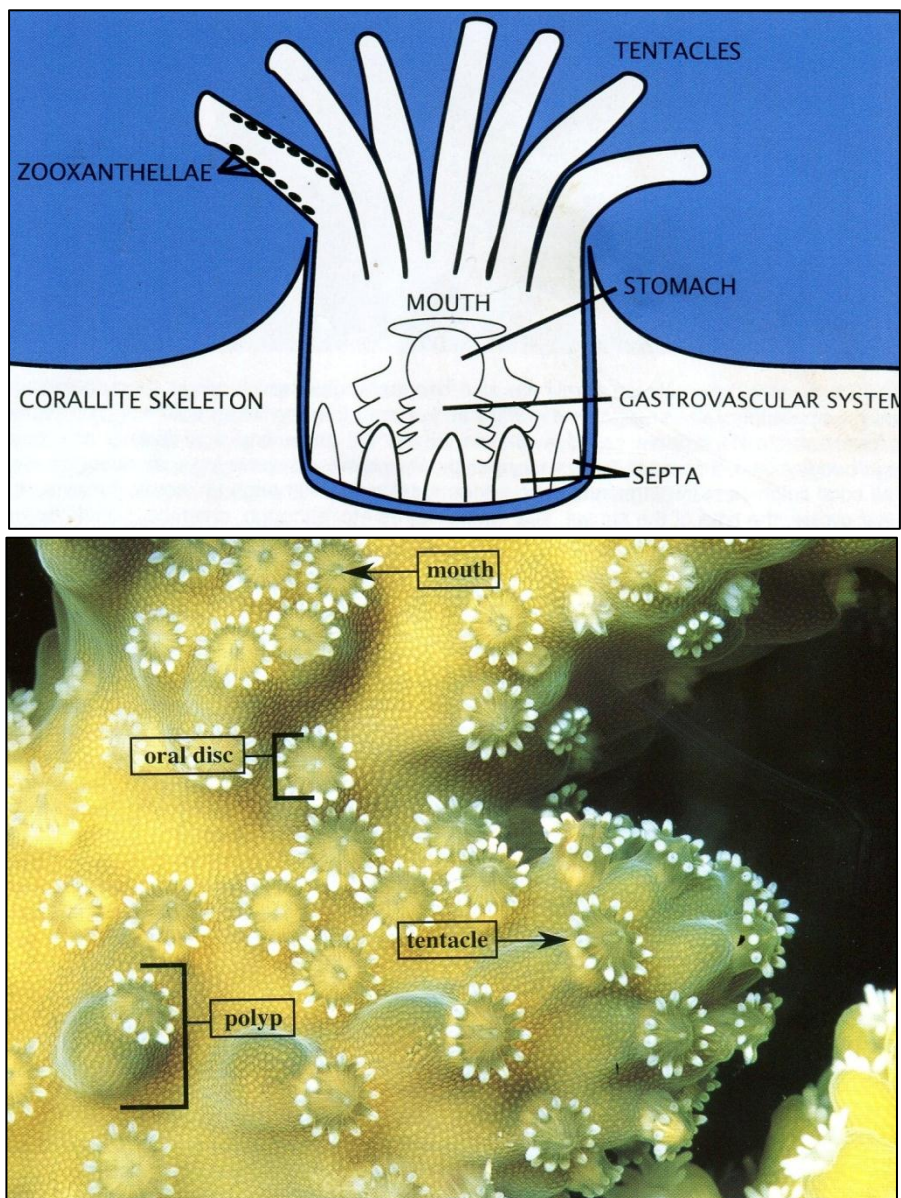


Figure 1 (Top): A diagram of the structure of an individual polyp

Source: Wood (2007)

Figure 2 (Bottom): Individual polyps on a branching hard coral species

Source: Carpenter (1997)

Coral growth is restricted up to depths of 50 metres and sea water temperatures of between 20-28 degrees (Groom n.d) and a small change in water temperature can have lethal consequences on the corals including its ability to reproduce (Dubinsky 1990).

Individual polyp growth can be fairly rapid however, as an overall structure coral reefs take several hundreds of years to form which is why at present there is great concern over the degradation of reefs because recovery rates are extremely slow within these fundamental ecosystems (Wood and Johannes 1975).

1.1 The history of coral reef formation:

Coral reef formation is historically varied and diverse with global ecosystems developing from calcareous algae millions of years ago within the Precambrian era. Many reef structures died out with the onset of oscillating glaciations due to increased ice mass and reduced sea level, but by the Triassic period reefs became abundant again with the development of many modern day coral families, especially around the tropical coasts (Sorokin 1993). At the time of the Palaeogene-Eocene transition greater marine organisms began to populate the reef structures contributing to the mass of carbonaceous material, this growth continued into the Pleistocene with only minimal disruptions from fluctuating environmental conditions. Modern day coral colonies fully emerged within the Holocene which now make up a small layer of the many meters of ancient corals (Sorokin 1993).

1.2 The study of coral reefs:

Ideas surrounding coral reef formation and morphology were first coined by the great Charles Darwin in 1842; he suggested three main types of reef structure each being linked together through their formation; them being fringing reefs, barrier reefs and atoll reefs (Darwin 1842). He suggested that fringing reefs form around islands and if exposed to tectonic activity and subsidence then they can develop into a barrier reef. If this coral was then further subjected to enhanced vertical movement of the sea, land change and heightened coral growth then the barrier reef could evolve into an atoll (Sorokin 1993). Since 1842 Darwin's ideas have since been reviewed however, the principle theories of growth and evolution of coral reefs still remain valid (Sorokin 1993).

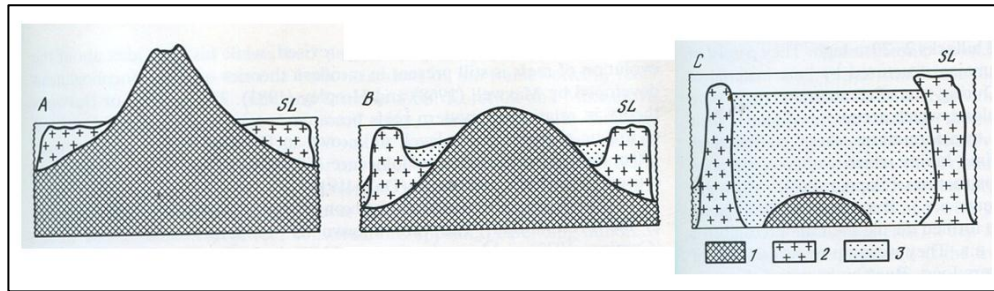


Figure 3: A diagram representing the three stages in coral formation coined by Darwin.

A. Fringing Reef

B. Barrier Reef

C. Atoll Reef

(1. Basic rocks, 2. Consolidated biogenic carbonate rocks, 3. Unconsolidated carbonate rocks)

Source: Sorokin (1993)

After Darwin, studies surrounding coral ecology continued with the likes of Adelbert von Chamisso and Charles Lyell at the end of the 18th century, furthermore expeditions including Sir Maurice Yonge in 1923 to the Great Barrier Reef, led to major developments within coral understanding which has now proved fundamental to present conservation of these imperative ecosystems (Sorokin 1993).

1.3 Coral reefs within the Philippines:

Within the 18,000 km of Philippine coastline there is an estimated 27,000km² area of coral reef providing the most substantial and sustainable source of subsistence for the Filipino people. They offer many important benefits through their goods and services and it is estimated they provide almost US\$ 1 billion annually to the Filipino economy (White et al 2000).



Figure 4 (Left): A map of The Philippines

Source: Google Maps (2013)

Figure 5 (Bottom): A map of The Philippines in relation to other countries in Asia

Source: Google Maps (2013)



1.4 Threats to coral reefs within the Philippines:

It has been estimated that globally over 75% of coral reefs have been degraded by human activity (Groom, n.d), and within the Philippines less than 5% of them are considered in 'excellent condition' (White et al 2000). Natural pressures including increased populations of Crown of Thorn starfish (COT) and diseases such as Ulcerative White Spot disease (Kaczmarzky and Richardson 2010) both target the hard coral species causing large scale degradation. The threats are often accentuated by human pressures such as globally induced climate change, destructive fishing practices and increased sediment loads. Additional activities surrounding tourism have negative impacts on the coral life for instance exploitation, increased pollution and damage caused from anchor use (Carpenter et al 1992).

1.5 Protection of coral reefs within the Philippines:

Since the early 1980's ample determination has led to the establishment of approximately 400 MPAs, or Marine Sanctuaries within the Philippines, however, it has been made evident that approximately 80% of these are not being managed properly, being labelled 'paper parks' (Bonham et al 2008) due to the current challenging socio-political and environmental context of the country (Christie et al 2002), problems stemming from weak institutions, lack of financial and human resources, growing populations and poverty, external issues which endanger the MPAs ecology (McClanahan 1999).

MPAs have generated much financial controversy because the views of many people are that they are unnecessary due to their slow yielding results. Through the collaborative work with the British non-governmental organisation (NGO) Coral Cay Conservation (CCC), this project will conduct research into whether two MPAs within Sogod Bay, Southern Leyte, Philippines, are having a positive effect on marine life and whether the economic cost can be justified. CCC works in partnership with the government and local communities to set up and manage MPA's to reduce the impacts of threats to the coral and help sustain the biological diversity; therefore, through abundance and diversity data from specific marine species one will draw conclusions on the impact of protected areas on the reef within the bay.

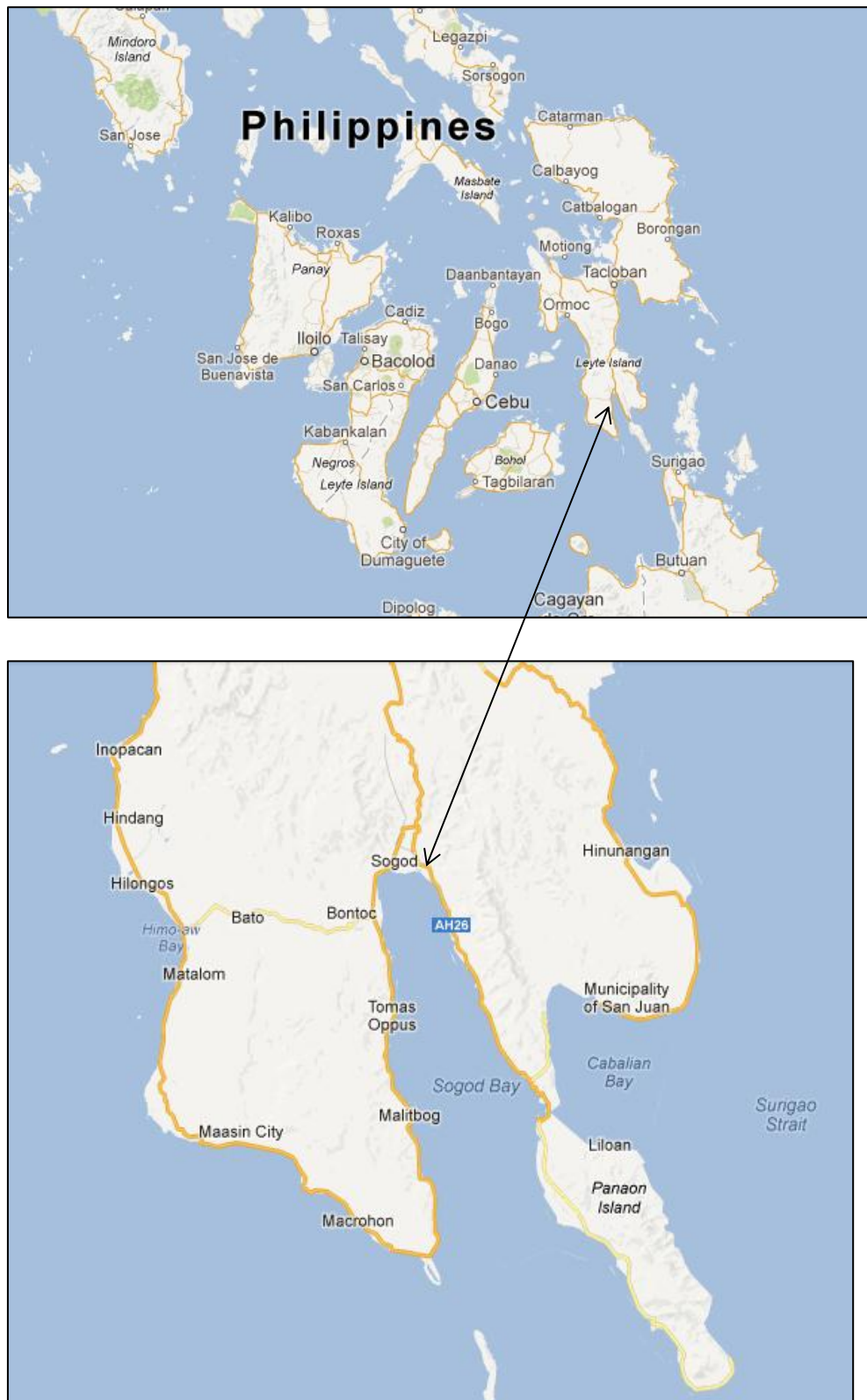


Figure 6 (Above): A map of Southern Leyte

Source: Google Maps (2013)

Figure 7 (Bottom): A map of Sogod Bay in relation to Southern Leyte, the Philippines

Source: Google Maps (2013)

Aims:

- To test whether coral, invertebrate and fish diversity and abundance differs inside compared to outside an MPA at two different locations within Sogod Bay, The Philippines.
- To test whether the coral reef health is healthier inside an MPA compared to outside.

Research Questions:

- Is there a difference in coral, invertebrate and fish diversity and abundance inside compared to outside an MPA at the locations of Buenavista and Napantao in Sogod Bay?
- Are there differences in abundance and diversity of species between Buenavista and Napantao, and if so what is possibly causing these differences?
- What is a healthy coral reef and could possible differences in coral, invertebrate and fish species mean that one part of the reef is healthier than another part?
- What are some of the problems associated with MPAs and is Sogod Bay affected by these?

Hypothesis:

- **Experimental:** The influences of MPAs in Sogod Bay create significant differences in marine species diversity and abundance inside compared to outside the marine protected area.
- **Null:** The influences of MPAs in Sogod Bay do not create significant differences in marine species diversity and abundance inside compared to outside the marine protected area.

Chapter 2: Literature Review

1.0 The value of coral reefs:

Coral reefs are one of the most diverse habitats on earth and as marine environments they are so biologically rich that more fish species can be found within the 0.2% of ocean cover they provide than in any other marine or freshwater habitat. They contain 25% of all marine species and are renowned for their high productivity and biological diversity (World Meteorological Organization 2010).

Coral reefs have been coined ‘the rain forest of the sea’ (Rinkevich 2008:1821) due to the sheer amount of biological productivity they exhibit as well as the primary foundations they support for a huge ecosystem (Rinkevich 2008). They are estimated to provide benefits in the value of around US\$ 30 billion each year through goods and services and therefore are an ecosystem that many people heavily depend on (World Meteorological Organization 2010).

1.1 The locations of coral reefs:

Although coral reefs are distributed all around the world the majority of the greatest primary productive and bio-diverse are located within South East Asia with a total area of approximately 53%; the remaining reefs can be found in the Pacific (19%), the Atlantic (15%) and the Red Sea (9%) (Sorokin 1993).

Reefs located within the Indo-Australian region, 120° to 170°E, are renowned for being the most taxonomically diverse and ecologically resilient (Bellwood and Hughes 2001) and within this region the Indo-Malay-Philippines Archipelago (IMPA), seen in figure 8, is considered as the area of highest marine biodiversity due to the geography and geology of its

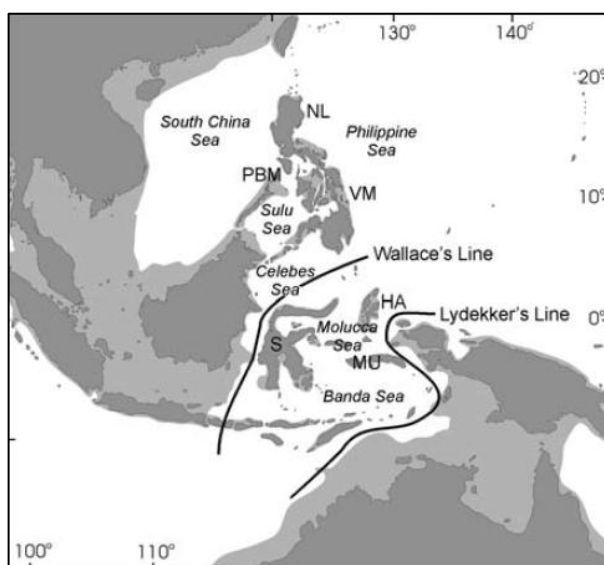


Figure 8: The Indo-Malay-Philippines Archipelago.
Source: Carpenter and Springer (2005)

origin.

1.2 Reasons behind the IMPA's diversity:

This diversity can be explained through the use of four main hypotheses presented by Carpenter and Springer (2005). Firstly, the reefs have undergone a significant degree of overlap in that over time numerous species have collected within this region from different oceans due to the archipelagos high rate of primary productivity that can support abundant marine life. The movement of species into the IMPA is made possible due to the regions ability to accumulate as prevailing currents transport species to the tropical shallow water habitats which then act as core areas of refuge. The processes involved in the IMPA's origin have created vast arrays of biodiversity through the evolution of highly endemic species and the islands are thought to have undergone tectonic activity and isolation which enabled vicariant processes such as allopatric speciation. This led to the development of a succession of marine species which could then only be found within the IMPA, them being highly endemic and range restricted (Carpenter and Springer 2005).

The Philippines are considered the 'area of highest diversity and endemism' within the IMPA (Carpenter and Springer 2005:471). The specific reasoning why this area is more biologically rich than other parts of the IMPA is still not fully understood, however it is thought to be tied into the combination of the theories above. The formation of the Philippines within the Cenozoic period is believed to be highly intricate, deriving from a set of three island systems that enabled concentrated vicariance and speciation. Today, the Filipino reefs are still highly diverse consisting of many marine species, for instance there is believed to be approximately 2,200 fish species alone (Galzin et al 1994), and of the more larger bodied fish fauna 38 are endemic, much greater than the combined regions of Indonesia and Malaysia at just 19 (Carpenter and Springer 2005).

1.3 The benefits provided by coral reefs:

The reefs provide many significant benefits for local Filipino people through the goods and services they offer and one of the most significant is the annual fish harvest with yields of approximately 35t/km²/year (Acala 1988) of which 50% of the populations protein is derived from supporting 1 million small scale fishermen (White et al 2000). The fish harvest not only sustains the local people but is an important source of income.

The reefs are becoming increasingly attractive to foreign tourism through recreational activities such as snorkelling and diving which brings huge opportunities and sizeable

amounts of income with them, for example, at Apo Island alone in the West of the Philippines tourism and recreation brings an estimated US\$ 300,800 per km² per year, a figure which is ever increasing (Constanza et al 1997).

The coral has also provided goods which have attracted the attention of scientists within the medical field researching and creating products from the marine life to fight various diseases and infections such as cancer and Aids (Groom n.d). Furthermore, services including coastal protection from natural disasters are critical for the archipelago (White et al 2000) and they also act as a carbon sink, that in combination with reefs globally, they remove approximately 700 billion kg of carbon a year. This is a vital service which maintains the balance within ecosystems, something more significant now with the impending crisis of global warming (Nybakken 2005).

In addition the reefs provide noteworthy aesthetic and cultural value (Groom n.d).

Coral reef resource products and uses.		
Resource	Role in reef	Product use
<i>Major reef export products of economic importance</i>		
*Stony coral ^a	Primary reef frame builder	Building material, fish tank decoration
*Precious coral ^b	Enhances habitat	Jewelry decoration
Fish ^b	Link in metabolism	Food, aquarium fish
* <i>Tridacna</i> clams ^b	Calcification	Shell collection, food
Top shells, <i>Trochus</i>	Calcification, food chain	Mother-of-pearl
Oysters ^b	Calcification, food chain	Pearls
Various gastropods ^b	Calcification, food chain	Collection, decoration, crafts
*Sea horses ^b	Food chain	Medicine, aquarium use
Lobsters ^b	Scavenger	Gourmet food
Sea cucumbers	Detritus feeder, sand	'Trepang', food
Sponges ^b	Borer	Toiletry
*Sea turtles ^b	Food chain	Shell, oil, meat, eggs
Sea snakes ^b	Food chain	skin, crafts
Misc. invertebrates	Varied	Antibiotics, drugs
*Coral sand	Substrate, beaches	Concrete, building
*Ecosystem	Conservation, genetic diversity	Tourism, aesthetic appeal, natural laboratory
Organism group	Kind	

Figure 9: Some of the products and uses that coral reefs provide.

Source: White et al 2000

1.4 The threats to the coral reefs:

Evidently coral reefs are of significant value to many people, an ecosystem which is heavily coerced and therefore threatened and globally coral reef environments are in severe decline due to pressures from pollution, climate change, overexploitation, invasive species and sedimentation (Bellwood et al 2004). Figure 10 sourced from White et al (2005) shows an example of the impact of overexploitation through the decline in fish per catch since the 1940's from six provinces in the Philippines.

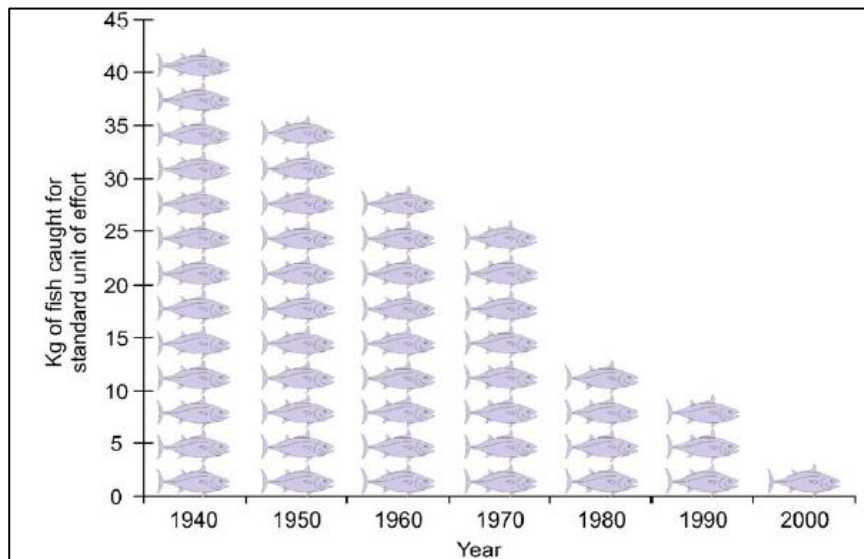


Figure 10: The decline of fish per catch since the 1940's from six provinces in the Philippines.

Source: White et al (2005)

The percentage of global annual coral loss was estimated to be approximately 2% between 1997-2003 (Rinkevich 2008), this habitat devastation continues and therefore this figure is likely to have risen since that time (Jones et al 2004).

Fatalities have been witnessed more significantly in areas such as the Caribbean where coral cover has reduced from 50% to just 10% in less than 30 years (Gardener et al 2003). The Philippines and surrounding areas however are thought to have greater ecological resilience with an efficient ability to recover from disturbance as reflected in a less momentous decline (Roff and Mumby 2012) however; this positive fact should not lead to complacency, essential, substantial action is necessary to ensure no further loss. Major drivers of threat to the Philippines are poverty, lack of control on planning and development along coastal areas,

a rapidly growing population, lack of management expertise and temperamental political views. Overshadowing all of these factors is the absence of an alternative source of income for the local population and a major issue in a poor tropical country where there is minimal development in other industries (White et al 2005). It can be seen therefore that efficient management of these ecosystems is vital and that it is needed to ‘stem the increasing tide of destruction’ to these coastal environments (White et al 2005:949).

1.5 Management of coral reefs:

Ultimately the goal of management is to reduce decline and to sustain goods and services in which people depend enormously on. Continued deterioration of reef environments has attracted the attention of many influential people including scientists and non-governmental organisations (NGO’s), as well as governmental officials and the general public. As the seriousness of the scale of degradation increases and becomes more evident in turn the scale of management has increased especially within the Philippines (Rinkevich 2008).

Integrated coastal management (ICM) has been in place for at least three decades within the Philippines and recently management has become more community based with the devolution of authority to local municipal, city and provisional governments that has led to the development of civic run MPA’s (White et al 2005). The development of more ‘bottom-up’ schemes has advanced significantly with foreign NGOs playing an imperative role and progress has started through a number of steps initially with awareness and growth of the problem and with a national study which led to programs and structures being created which were implemented and then initially evaluated (Sorensen et al 1990). Certain events and new

1932	Fisheries Act gives most management responsibility to central government
1974	First municipal marine reserve around Sumilon Island, Cebu
1976	Commercial fishing limited to areas beyond 7km of the shoreline
1979	Coastal zone management committee with 22 agencies formed
1991	Local government code devolves responsibilities to local governments
1996-2004	Fisheries and aquatic resources management councils authorized
1998	First national coastal Mayors conference held to discuss ICM issues
2003	Philippine sustainable archipelago development framework developed

Figure 11: Eight of the most important events and laws passed in the development of MPA’s in the Philippines.

Source: White et al 2005

laws were passed and some of the most important can be seen in figure 11, along with a number of initiatives that led to the development of more MPA's. The benefits of these include overall improved coral reef health due to a reduction in destructive fishing practices and exploitation leading to increased fish yields and marine life. Revenue is created from charging tourists entrance fees and this money is reinvested into developing additional methods of sustainable management (White et al 2005). Furthermore, this type of organization gives local people involvement and awareness that by using the reefs sustainably it will benefit them in the future through income and food stability (White et al 2005).

The number of MPA's and therefore coral reef protected areas within the Philippines is ever increasing with a recent survey suggesting that there are 439 in place. Figure 12 highlights the location of some of the most significant MPAs in the Philippines, with Figure 13 showing a schematic of a sample MPA.

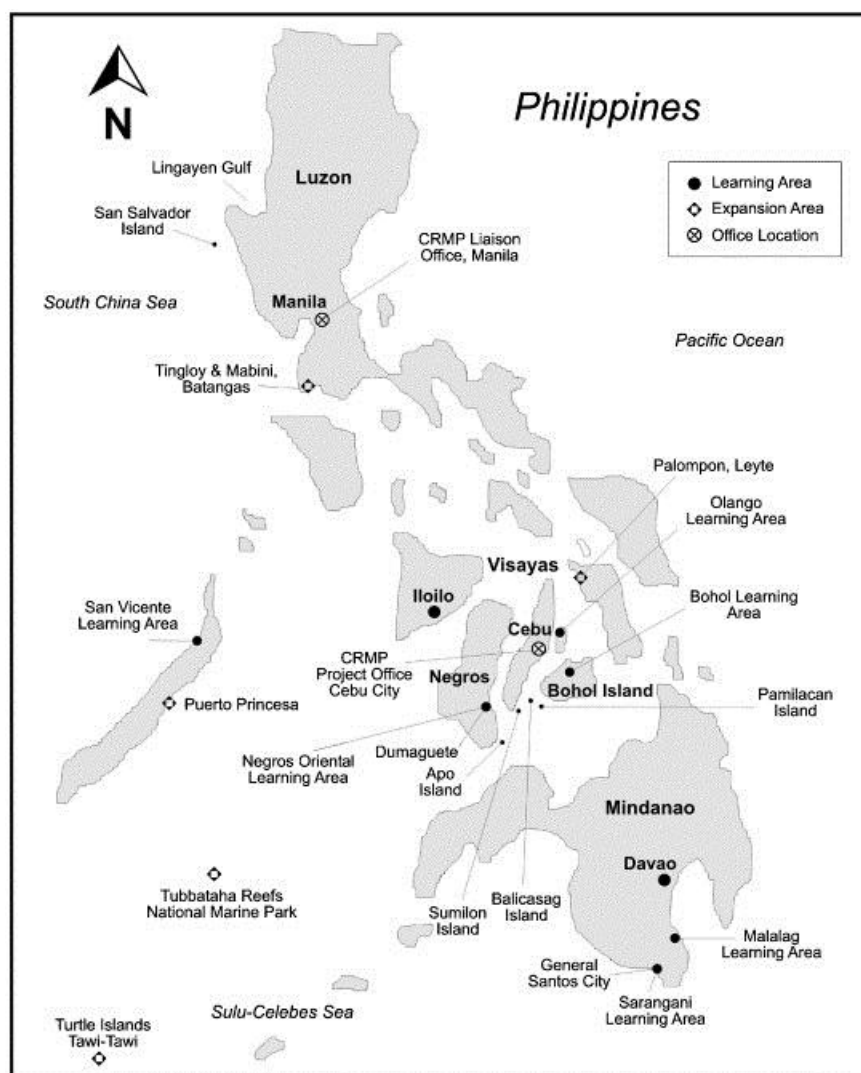


Figure 12: Some of the most significant MPAs within the Philippines

Source: White et al 2005

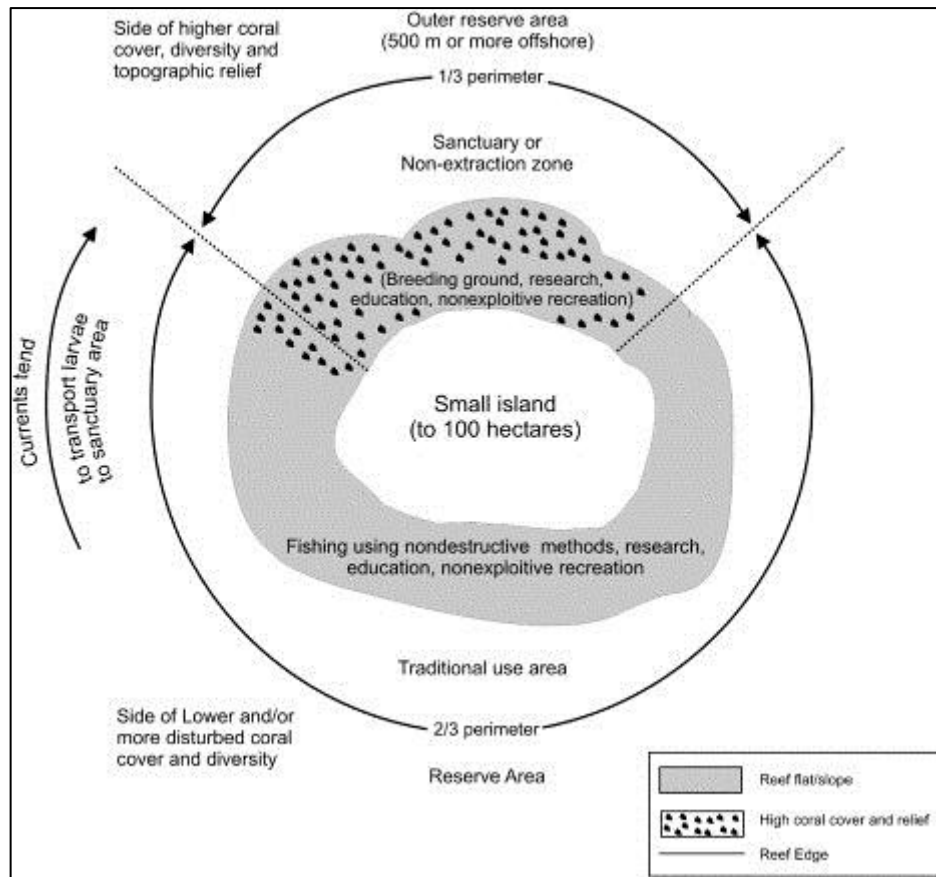


Figure 13: A sample MPA within the Philippines

Source: White et al 2005

However, within the wider literature it has been highlighted that not all of the MPAs are being managed properly and a field survey showing that only 40% were functioning at a sustainable level (White et al 2005). This is thought to be the result of the lack of knowledge and expertise within the local communities on how to manage the reef as well as issues involving expenditure and how to actually apply the management. There is huge debate over whether the coral should continue to be ‘passively’ managed through MPA’s, whereby the reefs are protected and maintained just as they are or whether they should be ‘actively’ managed with processes to actually restore and regenerate the reefs (Rinkevich 2008). Many local governments are currently debating how effective MPAs are and whether their costs can be justified.

With the use of marine abundance data this project will therefore concentrate on the impact of MPA’s on the coral reef at two sites in Sogod Bay, Southern Leyte, The Philippines and

will strive to identify whether coral data from inside the MPA's indicates a healthier reef and if so, allows justifications to be made on the benefits of the protected areas. This work will contribute to the field of conservation of coral reefs indicating where future management may need to be adjusted, for example by taking a more active approach. By using data collected through the NGO CCC this dissertation will highlight the severity of the coral decline presenting and emphasising the need for continued or improved sustainable management. This project is designed to fill in some of the gaps within the wider literature on actual MPA data from the field, testing whether the management schemes implemented currently are sufficient enough to sustain a healthy coral reef and highlighting possible issues that have led to this unsustainability associated with MPA's within the Philippines and ultimately whether these are applicable to Sogod Bay.

Chapter 3: Methodology

1.0 Field locations:

Since 2006, through CCC, trained volunteers have collected semi-quantitative data from inside and outside MPAs on the coral reefs in Sogod Bay, Southern Leyte, The Philippines. The data has been and continues to be collected through baseline surveys at a number of sites within the bay; five of the locations have more abundant data as they have been surveyed to a greater detail, they can be seen in the table 1 below, furthermore figure 14 shows where the individual MPAs are located within the bay highlighted with a red star.

<u>MPA Site</u>	<u>Date of Establishment and Size</u>
Buenavista, Padre Burgos	2005/8 hectares
Lungsodaan, Padre Burgos	2005/4.5 hectares
Santa Paz, San Francisco	1996/300 meters
Santa Sophia, Padre Burgos	2005/4.5 meters
Napantao, San Francisco	200/8/5 hectares

Table 1: MPA Sites

Source: van Bochove et al 2011

For this project, research will be conducted from the comparison of two of the sites at Buenavista and Napantao. The two locations have been selected on their proximity to each other in that they are located adjacent within the bay which offers a good premise for comparison. By contrasting data from inside and outside the MPAs and then comparing with each other it allows one to compare the value of the protected area. If significant differences are present within the results, in that one area is more efficient than the other, one can begin to evaluate why there are variances and what causes them. The sites are located opposite to each other therefore specific processes which act on the different parts of the bay can be evaluated, for instance dissimilar fishing pressures and practices and tourism.

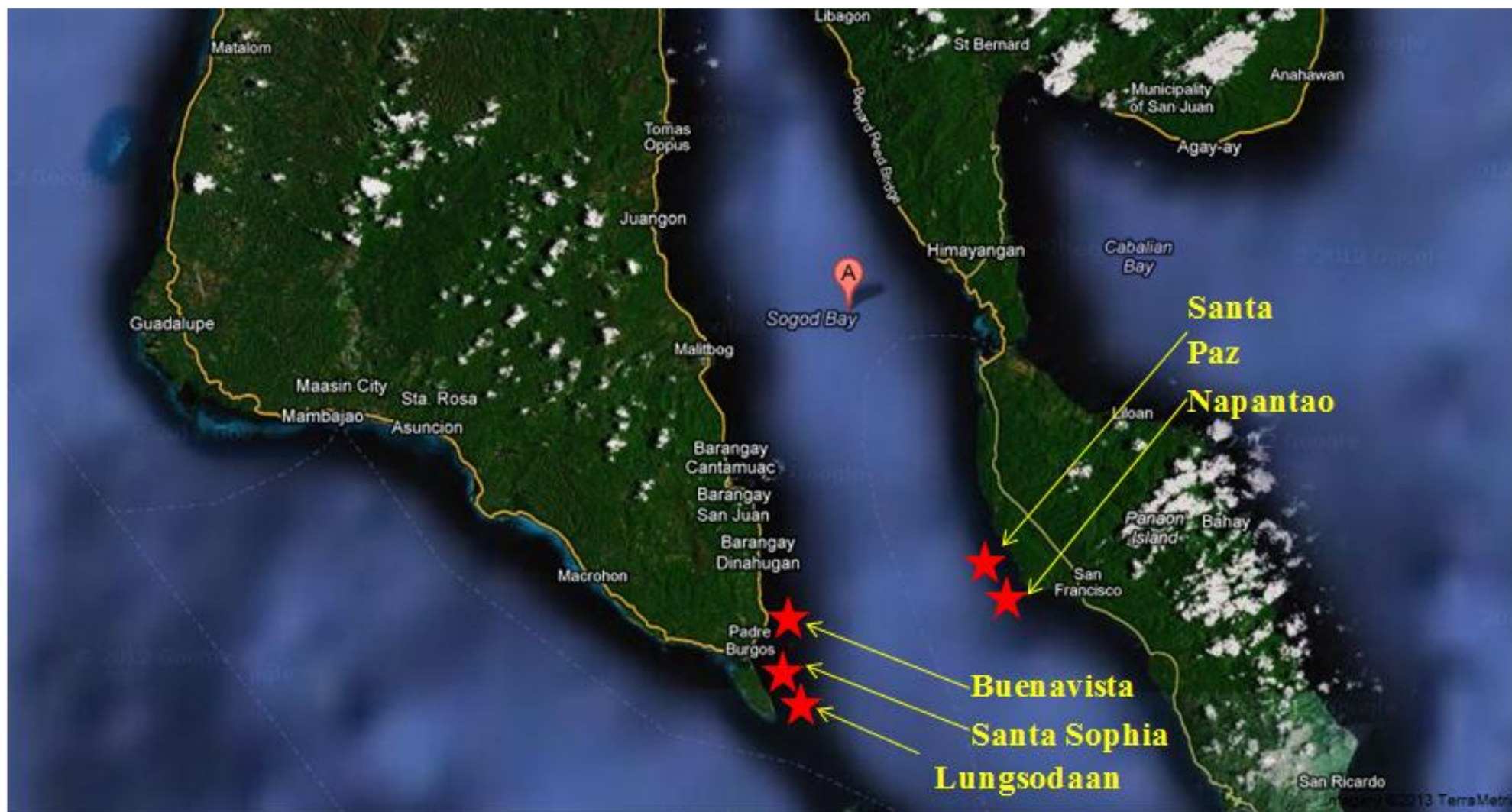


Figure 14: A map of Sogod Bay, Southern Leyte highlighting the key areas of data collection

Source: Google Maps (2013)

1.1 Type of data collected:

The data collected from inside and outside the MPA's focuses on the physical aspects of the reef and the abundance and diversity of hard corals, invertebrate and fish species. By analysing this data it allows one to see possible differences in how species are composed within the different parts of the reef. Studies within the literature have focused on similar ideas, for example Bellwood and Hughes (2001) concentrated on the different processes which shape coral and fish species abundance and configuration across the Indo-Pacific oceans. However a comparison study of marine life between protected and non-protected areas at two nearby sites is not prominent within the literature therefore this study fills in some of the gaps related to coral conservation through the use of MPAs.

Data was collected on the identification of over 100 fish species, 40 corals, 60 invertebrates and 25 marine algae and plants and this marine life is regarded as 'target' species (Wood 2007). They are chosen as a convenient way to assess the overall health and diversity of the reef (Allen and Werner 2002), as it would be impossible to record every species of fish, coral and invertebrate that a volunteer would see on a given dive.

Allen and Werner (2002), who conducted a similar study focusing on just the diversity of coral reef fish, have put forward a number of reasons which apply to this study on why particular fish are chosen as target species to assess the overall reef. They concentrated on six families of fish (Butterflyfish, Angelfish, Damselfish, Wrasse, Parrotfish and Surgeonfish), as they are core species which characterize the fauna of the reef and are taxonomically well documented, fairly well recognised underwater and often use a wide range of habitats in coral rich areas (Allen and Werner 2002). These reasons can generally be extrapolated for why specific marine species were chosen for this study.

1.2 Method of data collection:

For up to two weeks before the surveys begin, volunteers are extensively trained through a marine science skill development programme to allow them to be able to identify the target species; they are tested both through theory and practically in the water to raise them to a standard which is high enough to be able to partake in the surveys.

Equipment needed for the survey includes:

- Surface marker buoy (SMB)

- 50 meter tape
- Fish buoy
- Global Positioning System (GPS)
- Thermometer
- 2 small plastic bottles to collect water for salinity testing
- Compass
- Depth gauge
- Slate and pencil
- SCUBA equipment

At each location surveys were conducted at a depth of 12 metres as this depth zone tends to have the greatest concentration of coral marine life diversity (Allen and Werner 2002). The survey team is made up of four divers, each having specific roles to fulfil, they are listed below:

- Physical Diver (Diver 1)
- Fish Diver (Diver 2)
- Invert Diver (Diver 3)
- Coral Diver (Diver 4)

The dive begins when the team have finished kitting up on board and have entered the water. At the surface diver 1 records the bearing at which the dive is to the shore, the temperature of the water and the salinity, diver 2 holds a fish buoy ready for the end of the dive and diver 3 is holding the SMB. Whilst the divers are waiting to descend and carrying out final checks, a boat marshal on board will note down the transect locations with a GPS and draw a brief sketch of the area observing possible human impacts and influences within the area for example, fishing boats.

When the team is ready, diver 1 will lead the team descending to the required depth whilst carrying out regular ear checks and ensuring that everyone is okay. As soon as the team have found the required depth the survey begins with diver 1 passing the end of the 50 meter line to diver 4 and directing them where to sit, diver 1 then again records depth, temperature and salinity, showing the team the bearing of the direction in which the survey will take place and takes one end of the 50m line from diver 4.

Diver 2 starts to swim along the transect and records all the fish species 2.5m either side of themselves, they are directed by their fins from behind by diver 1 to make sure the correct bearing and depth is maintained. It is important that diver 2 goes first as this allows for the maximum amount of fish to be recorded without them being frightened off by the rest of the team. As diver 2 moves along, diver 1 reels out the 50m line behind them at the same time as recording the impression of the site; the topography, orientation, visibility, current strength and direction, a physical map and other impacts and if there are any changes in habitat this is also recorded and pointed out to other members of the team.

When diver 2 is at the end of the 50m line, diver 1 will signal for them to stop and record the depth. Diver 2 places down the fish buoy to mark the end of the transect and takes the reel from diver 1 who then swims back to diver 3 to collect the SMB whilst signalling to diver 3 and 4 to begin. Diver 3 then swims along the 50m line recording target invertebrate species 2.5m either side of themselves whilst reeling in the tape with diver 4 behind recording target coral species 1m either side of themselves. When diver 3 and 4 have finished, diver 1 will signal the end of the survey taking the SMB from diver 2 and pulling it under the surface to notify to the boat marshal that the survey has finished and the boat will return to pick up the divers whilst the GPS is recorded again.

Diver 1 checks everyone's air and signals a return to the surface, the team ascend slowly taking a 3 minute safety stop at 5m to allow any excess nitrogen to diffuse that may have collected in the blood and when at the surface, diver 1 will again take another shore reference.

Figures 15 and 16 are illustrations of how the baseline surveys are conducted.

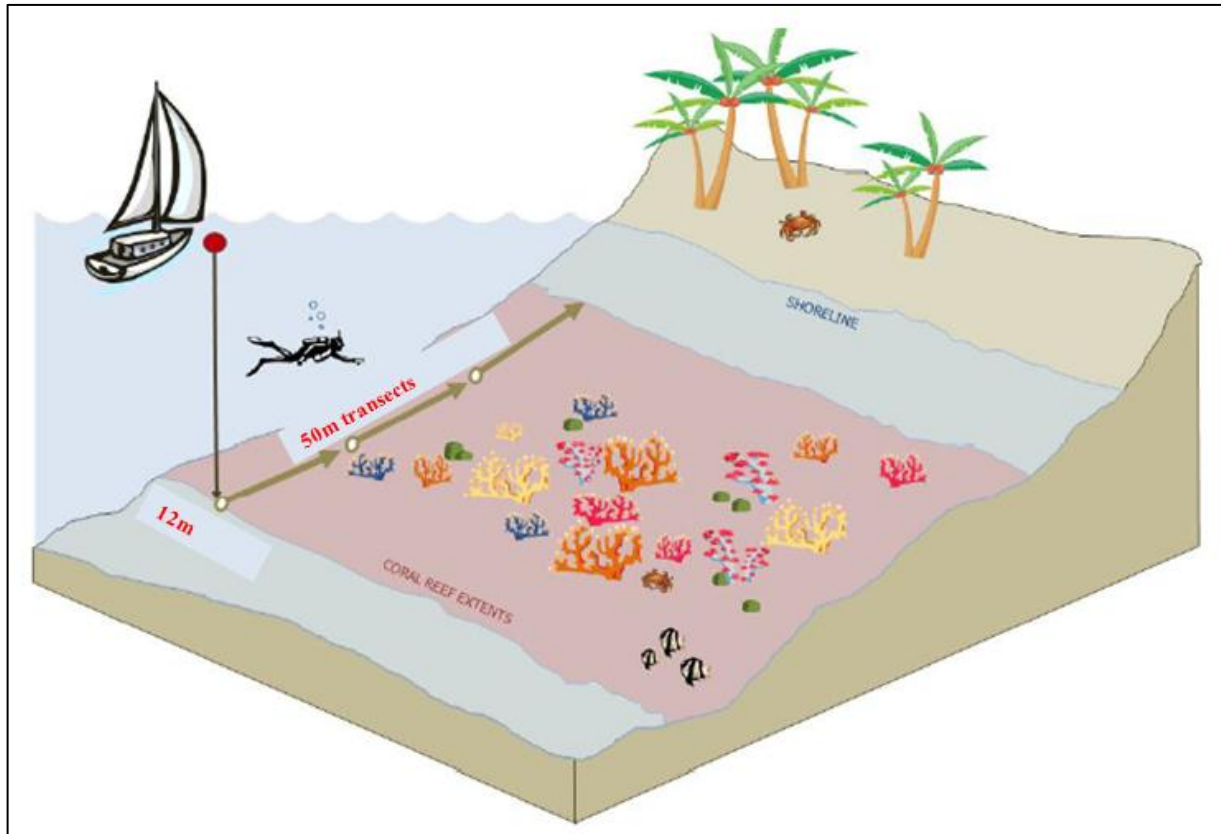


Figure 15: Illustration of CCC baseline survey

Source: van Bochove et al 2011

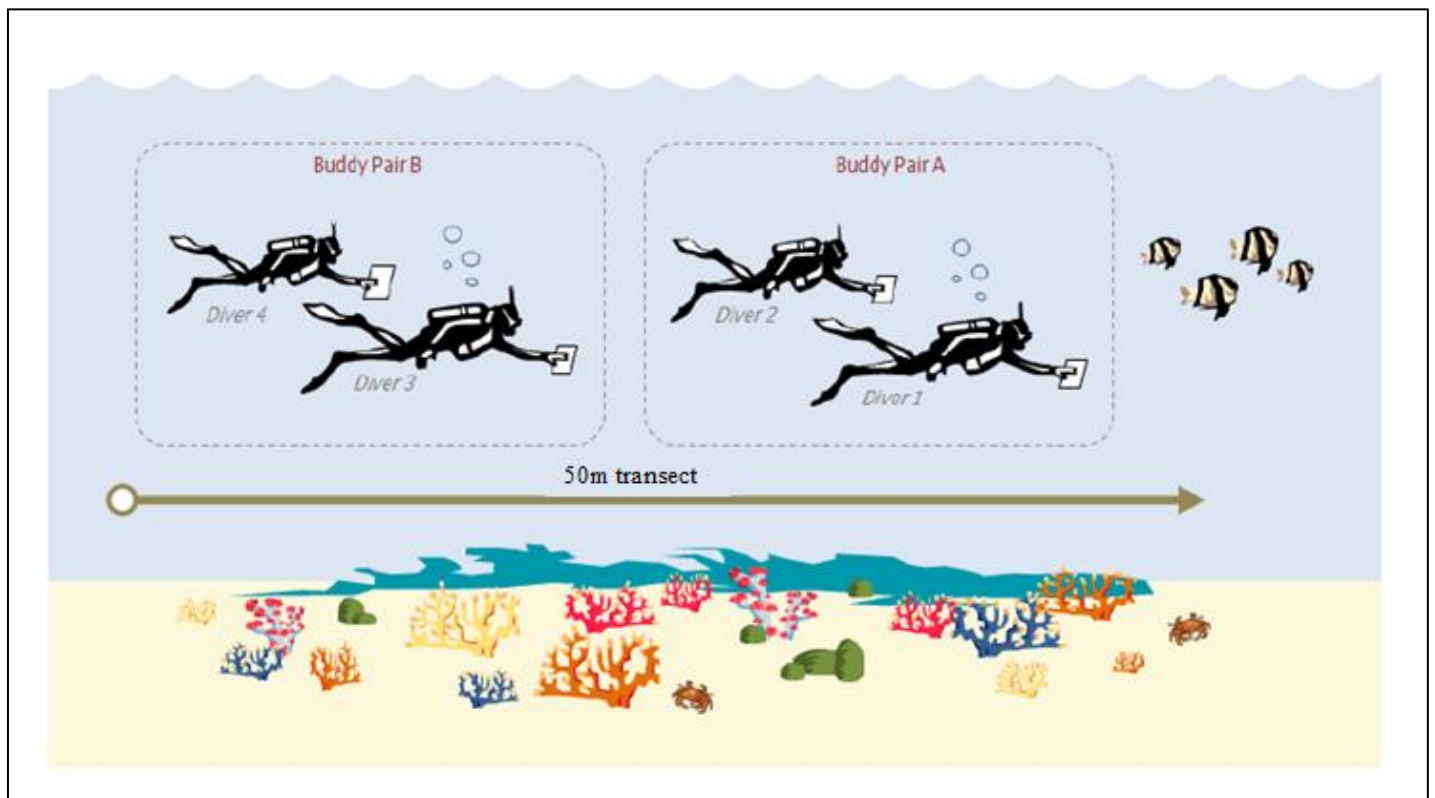


Figure 16: Illustration of CCC baseline survey

Source: van Bochove et al 2011

1.3 Limitations in data collection:

Many studies which have conducted marine surveys use similar SCUBA methods for instance, Christie et al (2002) volunteers collected data on fish richness and abundance and Jones et al (2004) divers used 50m transects along the reef habitat to collect diversity data. However, it is recognised that collecting inclusive and widespread data on coral reef conditions is difficult and that it can be limited due to the amount of useful data that can be collected (McIntyre 2010). Therefore there is a general lack of coherent marine data from the Philippines; furthermore the data which is collected is usually associated with a number of limitations. Surveys being conducted are adding to the collections of data, however as they are conducted year round by many different volunteers the sampling is not carried consistently out by the same set of people (Galzin et al 1994), this may adjust results due to subjectivity as some volunteers may identify the set of target species better than others therefore human error needs to be taken into account. Furthermore as surveys are conducted all year round and all of the results are being compared to each other, it does not take into account possible differences in reef ecology due to different times in the year. There may also be greater abundant data in summer periods when more surveys are conducted due to it being a more popular time for people to volunteer (Allen and Werner 2002).

1.4 Statistical analysis of the data:

Once back at base the team input the marine data onto an Excel spread sheet and from there it will be analysed in a series of graphs to show key fluctuations and trends within the data sets. The software program 'PAST' will then be used to conduct diversity statistics on the data to see whether there are significant differences between inside and outside the MPAs. Table 2 shows the following statistics that will be used:

• Dominance Index	This indicates whether the total number of species observed is dominated by one or two particular species, the higher the values the greater the dominance of a species.
• Shannon H Index	This is an indicator of diversity; higher values suggest higher diversity within the data.

• Evenness Index	This shows how much variation there is within the data, the higher the value of evenness the lower the variation within the data set.
• Fishers Alpha Index	This is a measure again of diversity showing which species are more dominant within a data set. However it takes into account very small observation numbers and reduces this significance so that clear trends can be seen even when observation numbers are low.

Table 2: Diversity statistics

Source: Harper (1999)

1.5 Limitations of diversity statistics:

There is a wealth of different statistical methods which can be used to analyse this sort of data. For instance Allen and Werner (2002) used the program Statview to conduct simple linear regression analyses on their data sets to determine the total diversity of coral reef fish fauna.

However the diversity statistics mentioned above are being used as they test a wide range of aspects which provide insight into whether there are significant differences between coral, invertebrate and fish fauna diversity and abundance.

However, studies within the literature which have also used similar diversity statistics have highlighted possible drawbacks stating that methods looking at species richness; diversity and abundance only tend to focus on the most dominant species within the data set and therefore do not reflect the whole marine ecosystem well (Gillett et al 2012). This unfortunately may lead to misleading assumptions about the reef which could then affect possible management strategies.

Chapter 4: Results

Semi-quantitative data from inside and outside the MPAs at Buenavista and Napantao will be presented through a series of pie charts to clearly depict patterns and trends, this information will then be analysed and compared using diversity statistics. At the end of the results section there will be a visual catalogue presenting various species which have been referred to in this chapter.

1.0 Site 1- Buenavista- Inside the MPA:

Coral:

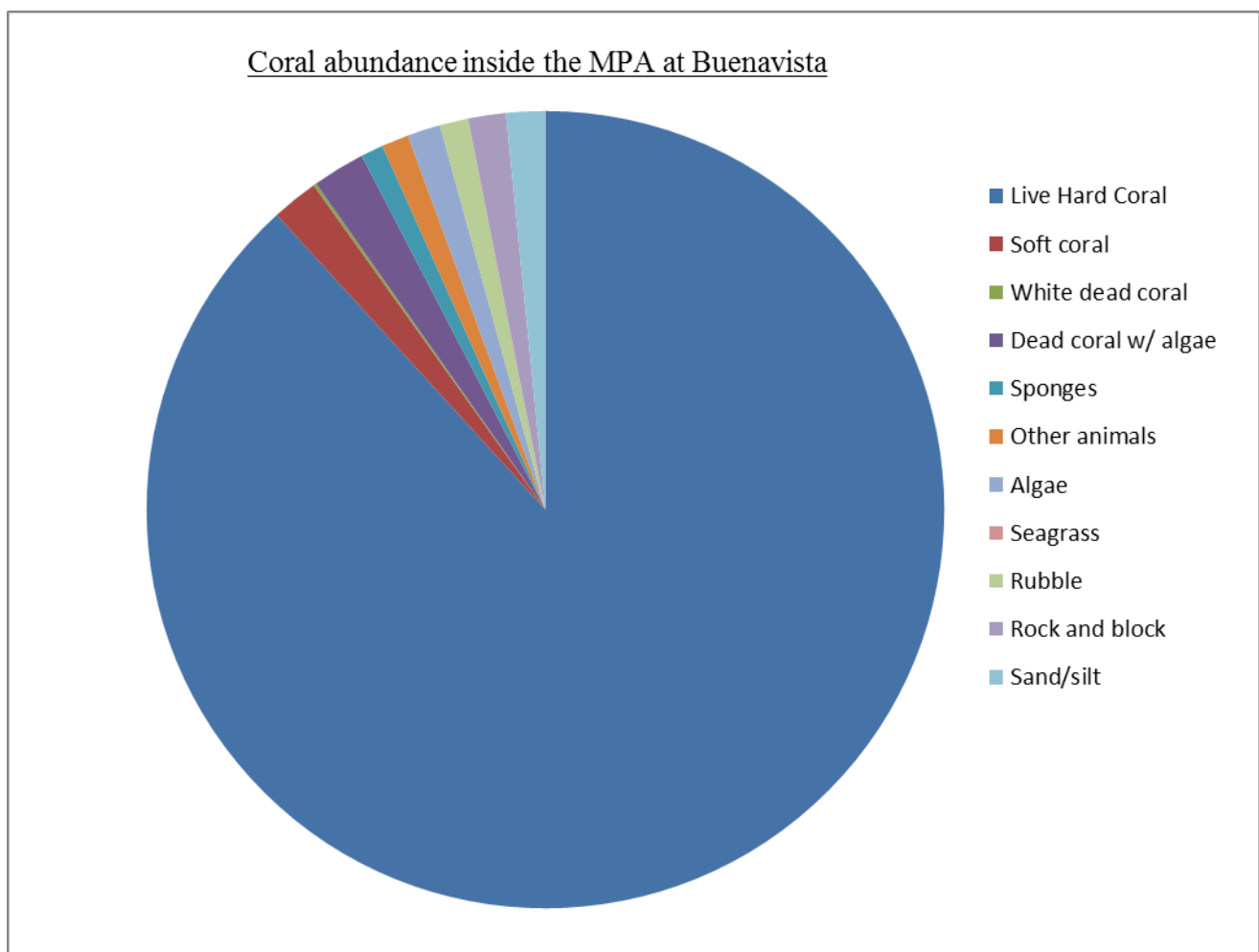


Figure 17: A pie chart to show the abundance of coral inside the MPA at Buenavista.

The chart shows that there is a vast abundance of live hard coral, consisting of approximately 88% of the coral survey. From the ten other components on the reef, each has a similar profusion of either 1 or 2%, and an overall absence of seagrass.

Source: Author

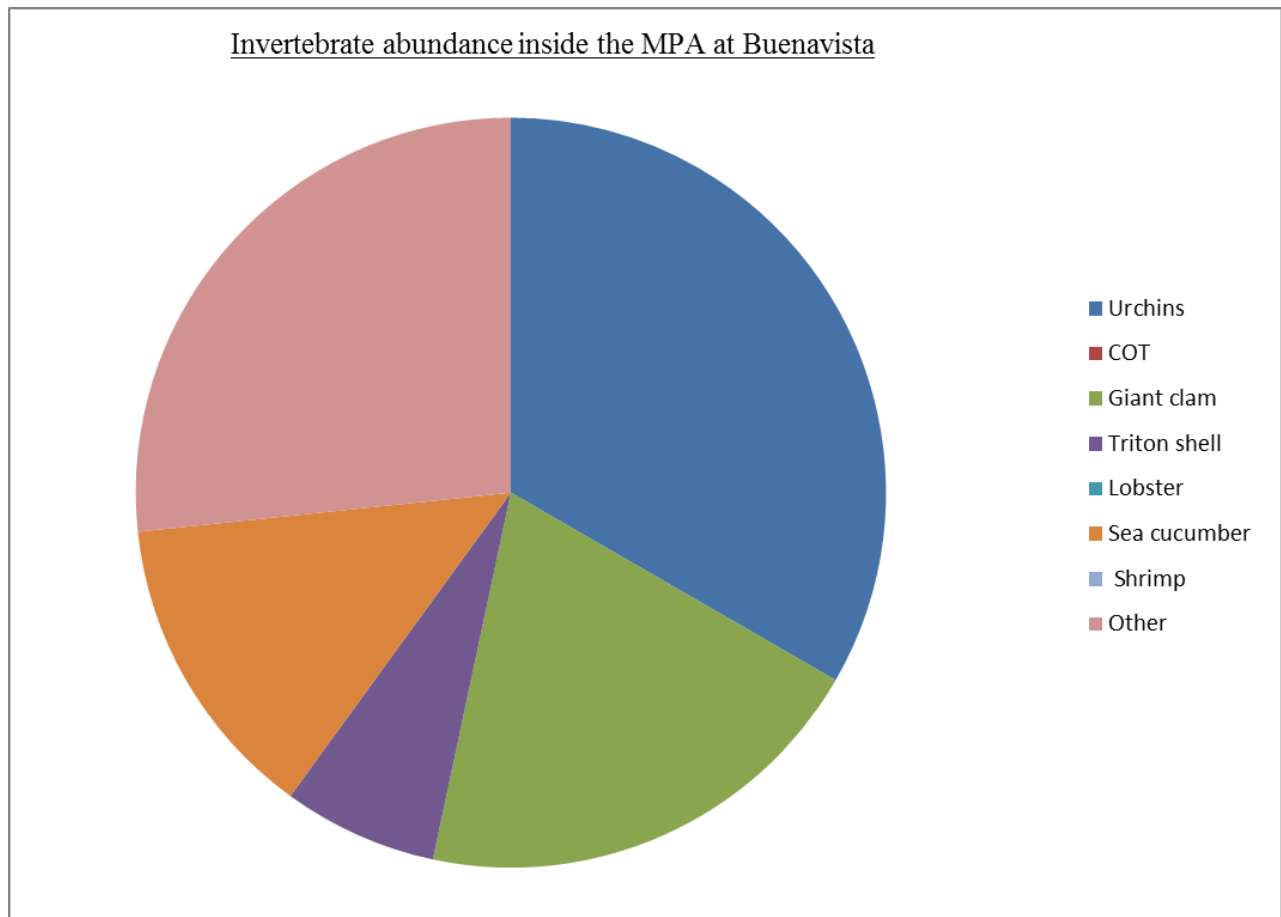
Invertebrate:

Figure 18: A pie chart to show the abundance of invertebrate inside the MPA at Buenavista.

The chart shows that there is a dominance of urchins with an abundance of 33%, behind this the category 'other' is second most abundant with a figure of 27%. Within the MPA there is small presence of giant clam, sea cucumber and triton shells but a complete absence of COTs, lobsters and shrimp.

Source: Author

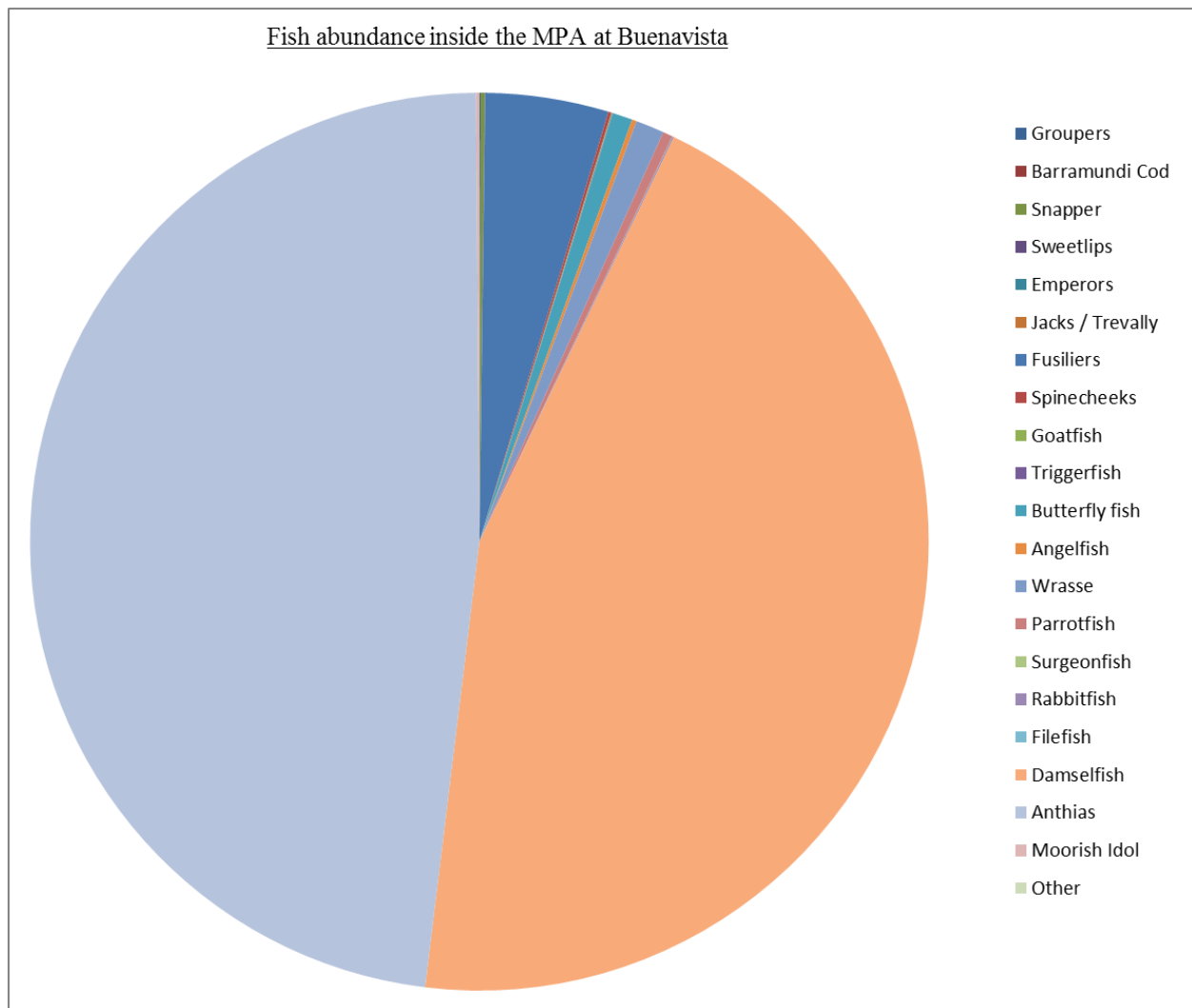
Fish:

Figure 19: A pie chart to show the abundance of fish inside the MPA at Buenavista.

The chart displays that there are three main abundant species of fish which are the Anthias at 48%, Damselfish at 45% and Fusiliers at 4%. The other species of fish are all in small abundances with there being an overall absence of Barramundi cod, Emperors, Jacks, Filefish and Other.

Source: Author

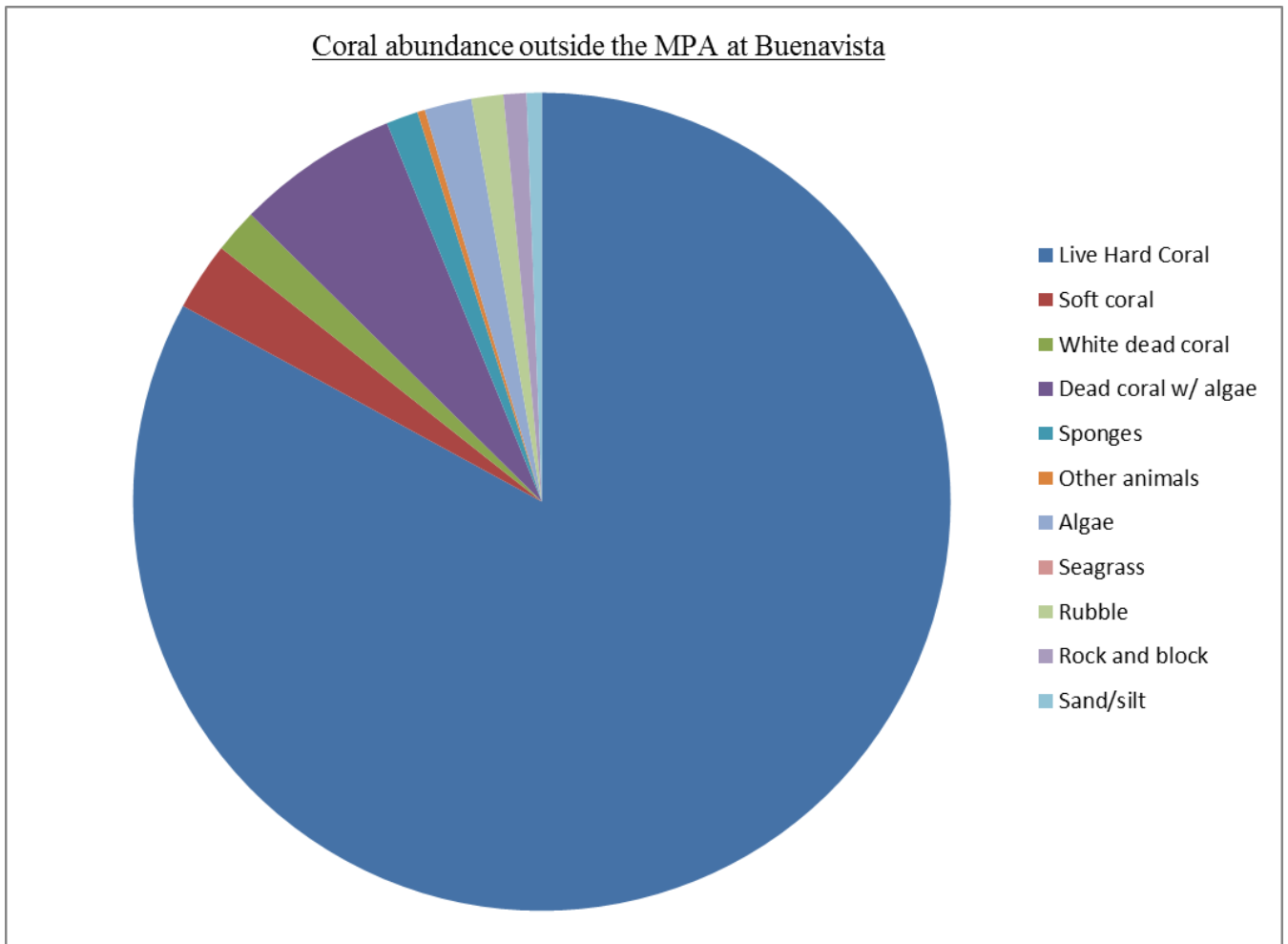
1.1 Site 1- Buenavista- Outside the MPA:**Coral:**

Figure 20: A pie chart to show the abundance of coral outside the MPA at Buenavista.

The chart shows that there is again a huge dominance of live hard coral with an abundance of 83%, with dead coral with algae being the second most abundant at 6%. The other species composing the reef are of similar abundances varying from approximately 3-0.5% and there is again an absence of seagrass.

Source: Author

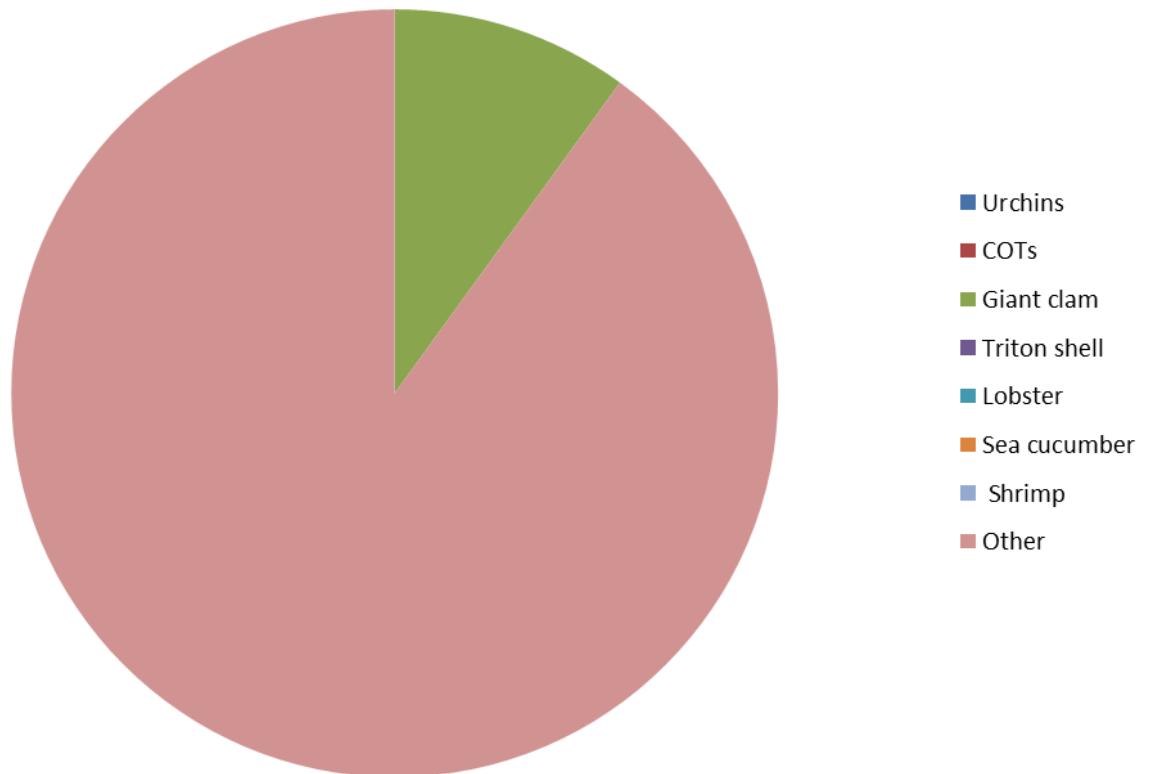
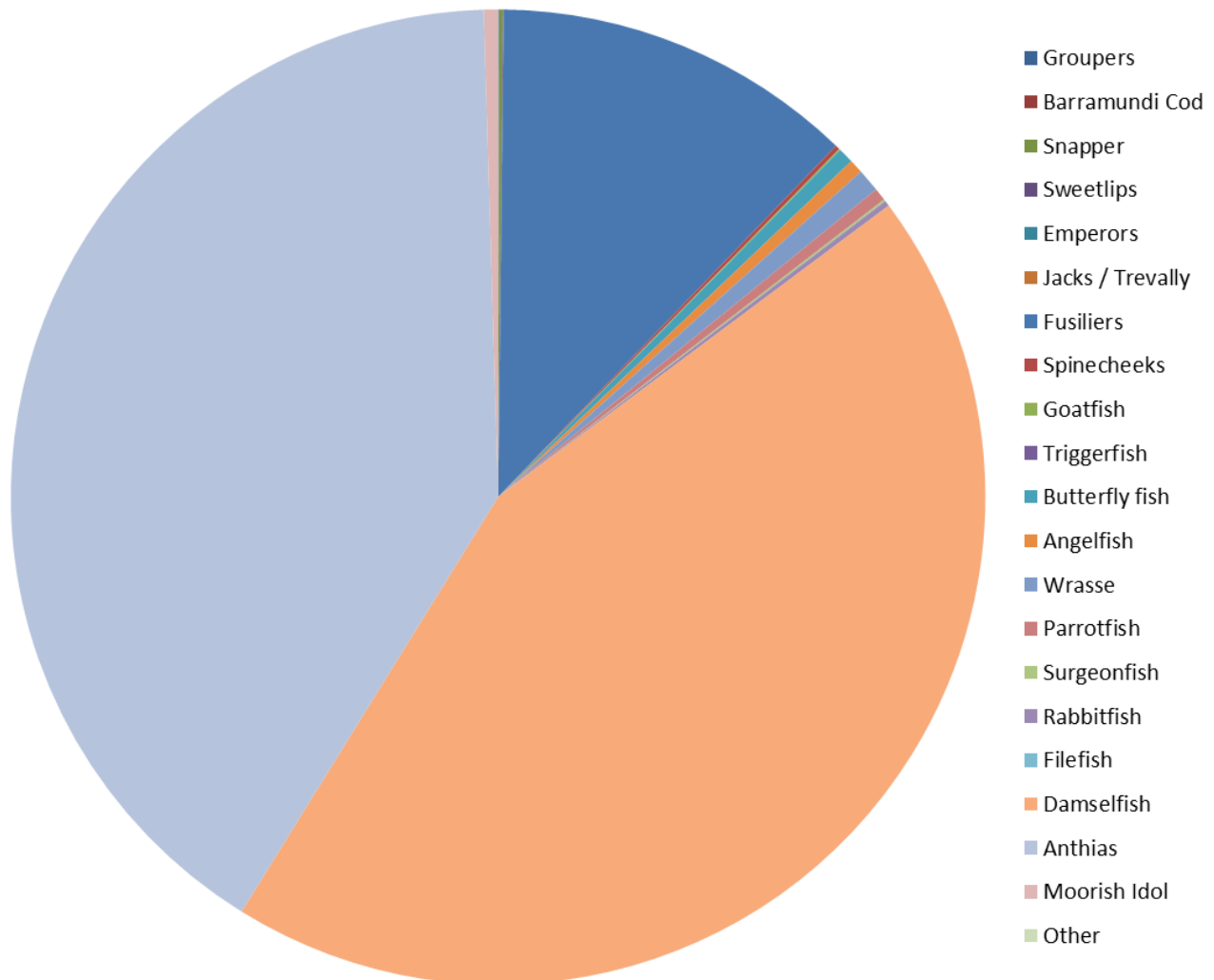
Invertebrate:Invertebrate abundance outside the MPA at Buenavista

Figure 21: A pie chart to show the abundance of invertebrate outside the MPA at Buenavista.

The chart highlights there is a significant abundance of just two species, those being other at 90% and giant clams at 10% and there is a general lack of urchins, COTs, triton shells, lobsters, sea cucumbers and shrimp.

Source: Author

Fish:Fish abundance outside the MPA at Buenavista**Figure 22: A pie chart to show the abundance of fish outside the MPA at Buenavista.**

The chart highlights that there is a dominance of two main species; those being the Damsel fish at 44% and the Anthias at 41% with Fusiliers being the third most abundant category at 12%.

The remaining fish species are all in marginally small quantities with there being a nonappearance of Barramundi cod, Emperors, Jacks, Triggerfish, Filefish and Other

Source: Author

1.2 Site 1- Buenavista- A comparison of Inside and Outside the MPA:**Coral:**

The graphs highlight similar abundance levels of coral components within and outside the MPA, showing the highest quantities in live hard coral content. Inside the MPA shows a slightly higher percentage of total coral cover, whereas outside there appears to be a higher cover of dead coral, soft coral and algae.

Coral Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	10	10	1	1
Individuals	818	828	0	0
Dominance	0.7852	0.7015	0.004	0.002
Shannon H	0.6057	0.7735	0.009	0.01
Evenness e ^H /S	0.1833	0.2167	0.01	0.01
Fisher alpha	1.603	1.6	1	1

Table 3: Diversity statistics for coral inside and outside the MPA at Buenavista

Source: Author

	No Significant Difference (Figure above 0.05)
	Significant Difference (Figure below 0.05)

Table 3 shows that there is the same amount of taxa recorded both inside and outside the MPA, but that there is a higher number of individuals outside. The table shows that there is a significant difference in the dominance of one or two species inside compared to outside, with inside showing a higher figure, possibly due to the higher quantities of live coral cover. The Shannon H value also shows a significant difference, indicating that outside of the MPA there is greater diversity, the evenness value supports this finding as it shows a lower variation in species within the MPA compared to outside. The Fishers alpha value however shows no significant difference between inside and outside the MPA, however, its values do correlate with dominance and Shannon H in that they do show important differences between inside and out therefore, this value could be showing a limitation in the data set in that there are not enough observations made.

Invertebrate:

The graphs depict a clear difference in trends between inside and outside the MPA. Within the MPA there is a far wider variety of species suggesting more diversity whereas outside the MPA the reef life is composed of only two main species, however, both show no sign of COTs.

Invert Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	5	2	0.018	0.022
Individuals	15	10	0	0
Dominance	0.2444	0.82	0.002	0.001
Shannon H	1.49	0.3251	0.002	0.001
Evenness $e^{H/S}$	0.8872	0.6921	0.178	0.209
Fisher alpha	2.626	0.7517	0.101	0.214

Table 4: Diversity statistics for invertebrate inside and outside the MPA at Buenavista

Source: Author

	No Significant Difference (Figure above 0.05)
	Significant Difference (Figure below 0.05)

Table 4 shows a difference in both the number of taxa recorded inside and outside as well as the number of individuals with inside showing the greatest values in both of these. There is a significant difference in dominance with outside showing greater values as it is only made up of two species. The Shannon H value also shows a significant difference with inside having a much higher figure of diversity as it is composed of a wider variety of species. However, the Evenness value shows that there is not a significant difference between inside and outside suggesting that there is minimal variation perhaps linked to the small amount of overall species recorded. The Fishers alpha value also shows no significant difference, again possibly linked by the limitation of small observation numbers as the data is dealing with very small quantities of species.

Fish:

The graphs show patterns and dominances within similar species inside and outside the MPA, with outside being slightly less diverse.

Fish Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	16	15	0.574	0.533
Individuals	9592	10734	0	0
Dominance	0.4328	0.3741	0.001	0.001
Shannon H	1.002	1.162	0.001	0.001
Evenness e^H/S	0.1703	0.2131	0.003	0.001
Fisher alpha	1.873	1.716	0.284	0.258

Table 5: Diversity statistics for fish inside and outside the MPA at Buenavista

Source: Author

	No Significant Difference (Figure above 0.05)
	Significant Difference (Figure below 0.05)

Table 5 shows a higher amount of fish individuals outside the MPA but a greater number of taxa within and there are significant differences in dominance and Evenness values suggesting that inside has a higher dominance by a few species and that there is more of a variation compared to outside. From looking at the graphs, it suggests that inside has a higher diversity; however the Shannon H value indicates otherwise, this could be due to inside only having one more type of taxa than outside and having less overall number of individuals, meaning that statistically it is not more diverse. The Fishers alpha value shows no significant difference even though it correlates with the higher dominance figure, again possibly being linked to limitations of the study.

1.3 Site 2- Napantao- Inside the MPA

Coral:

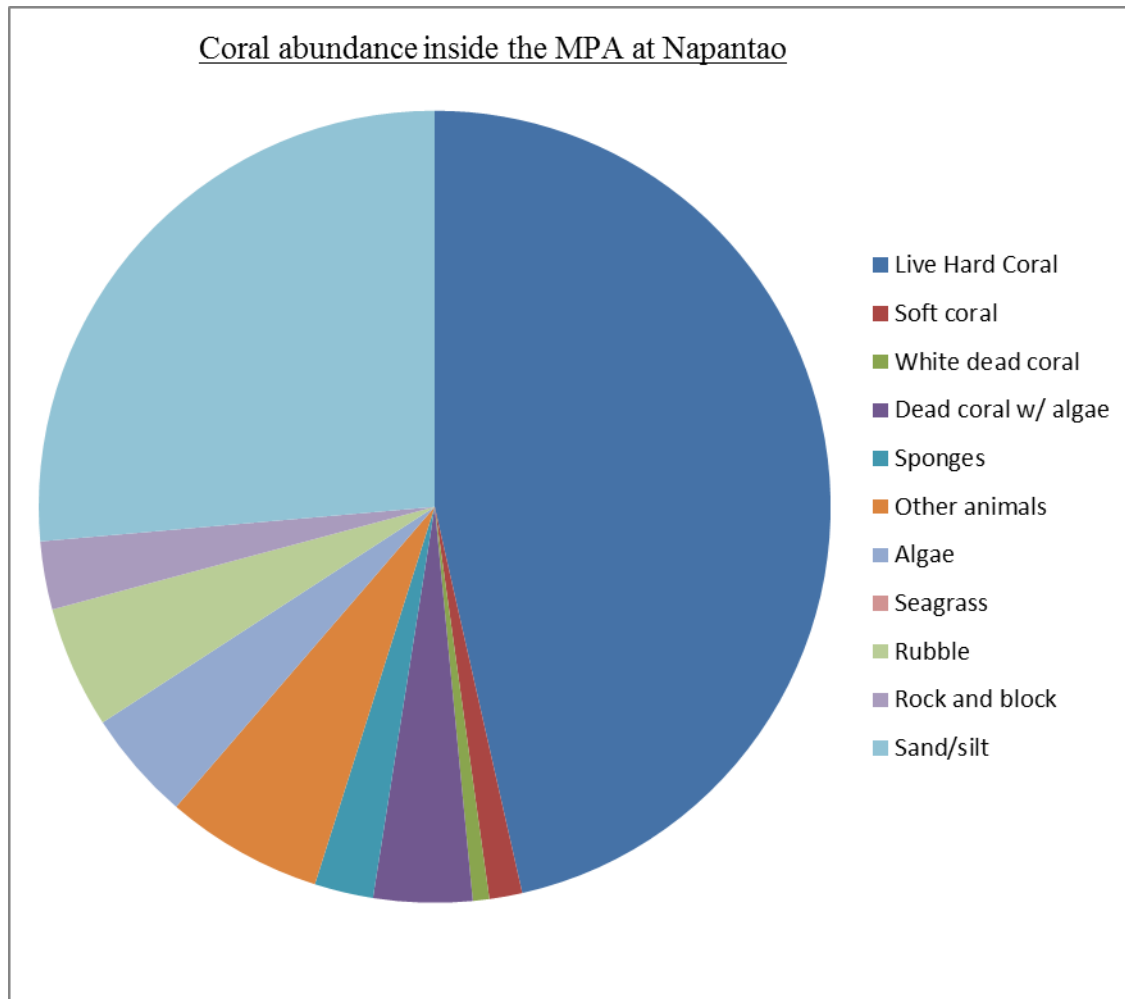


Figure 23: A pie chart to show the abundance of coral inside the MPA at Napantao.

The chart shows that there is a large abundance of live hard coral cover at 46%, closely followed by sand and silts at 26%. There are similar abundances of the other categories, and comparable to Buenavista there is an absence of seagrass.

Source: Author

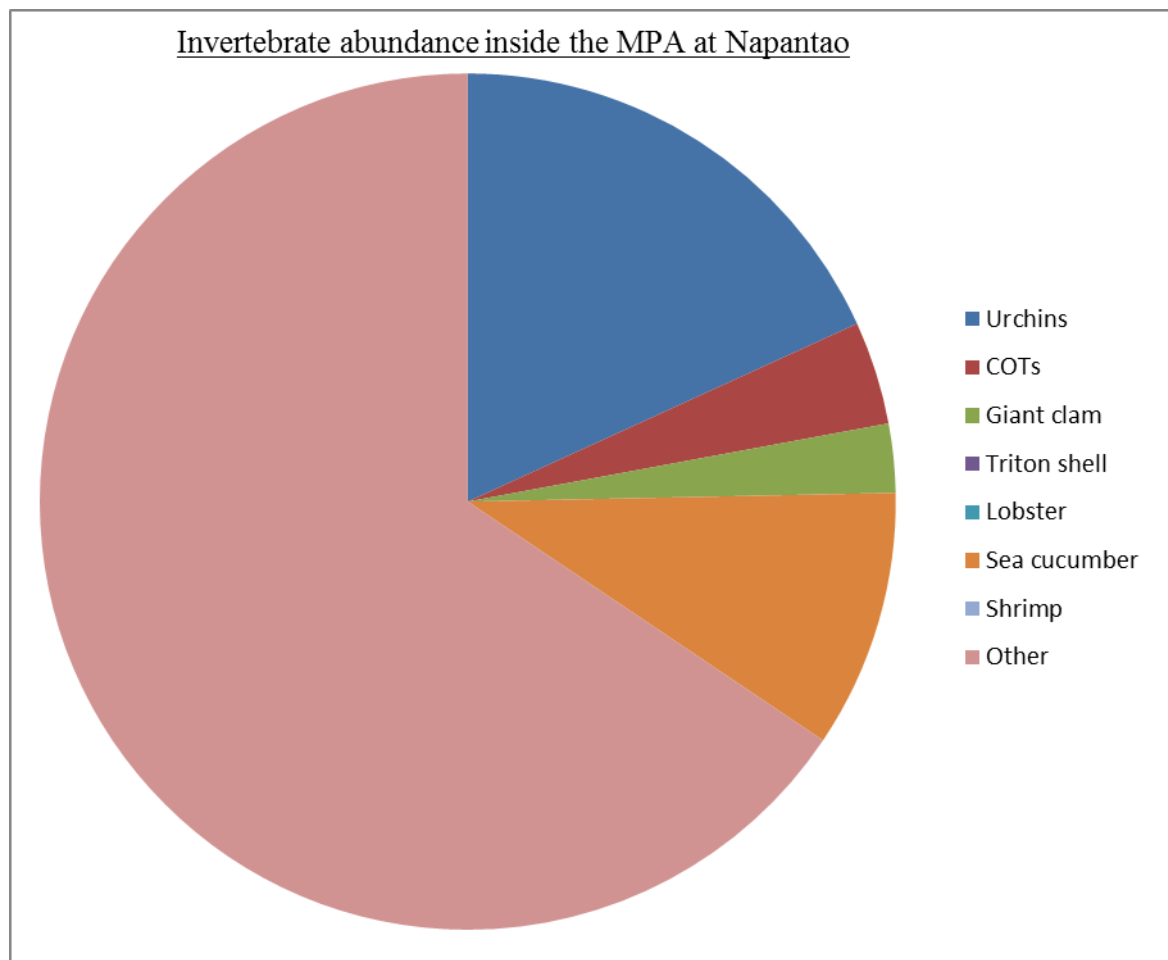
Invertebrate:

Figure 24: A pie chart to show the abundance of invertebrate inside the MPA at Napantao.

The chart shows that there is a huge dominance of ‘other’ species at 66% with urchins second and sea cucumbers the third most abundant. There is an absence of triton shells and lobster, but unlike Buenavista there is a presence of COTs.

Source: Author

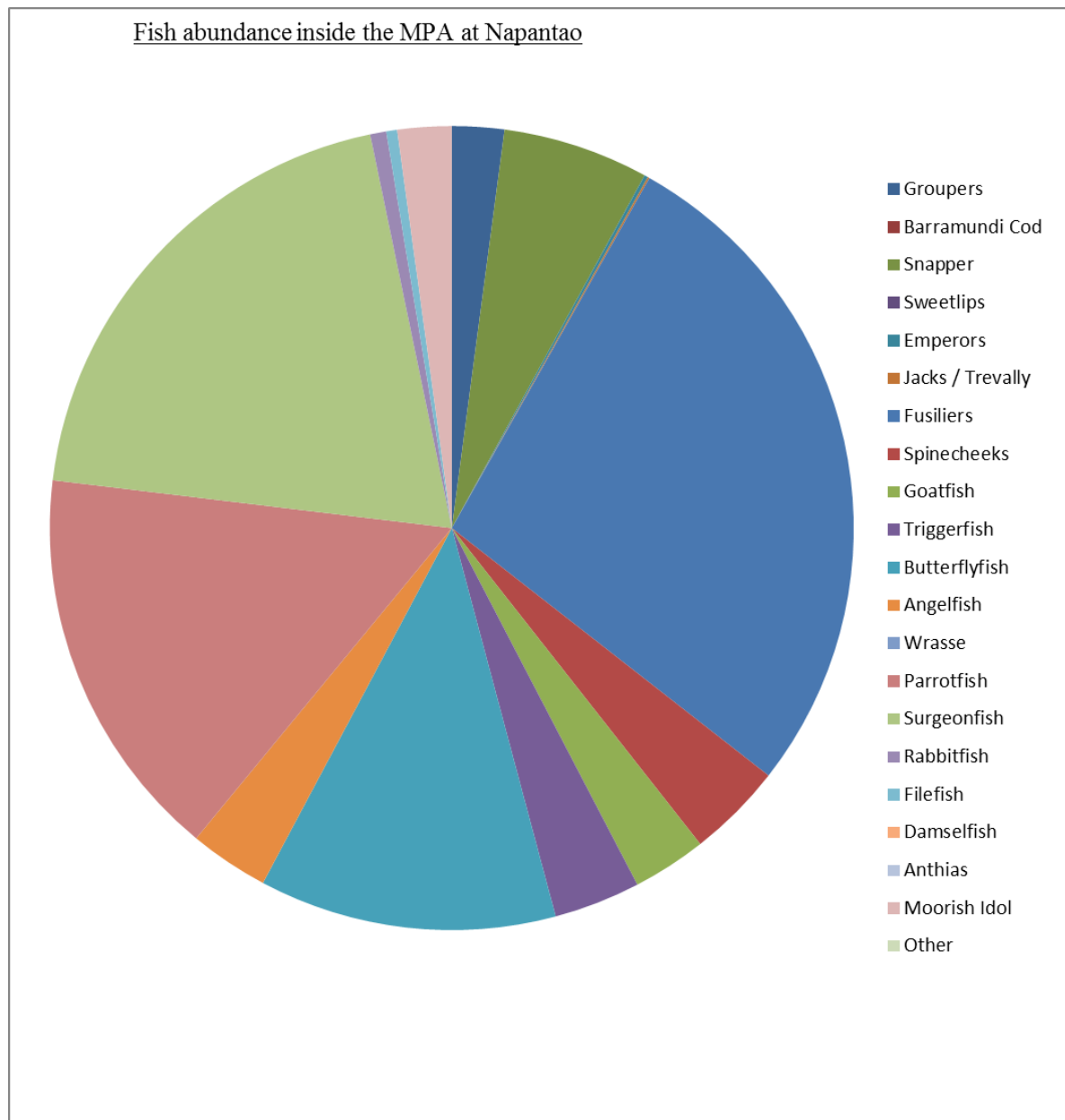
Fish:

Figure 25: A pie chart to show the abundance of fish inside the MPA at Napantao.

The chart displays a wide variety of fish species, the most dominate being Fusiliers (27%), Surgeonfish (20%) and Parrotfish (16%), with the other species all being fairly similar in distributions, however, there is an absence of Barramundi cod, Sweetlips, Wrasse, Damsel fish, Anthias and Other.

Source: Author

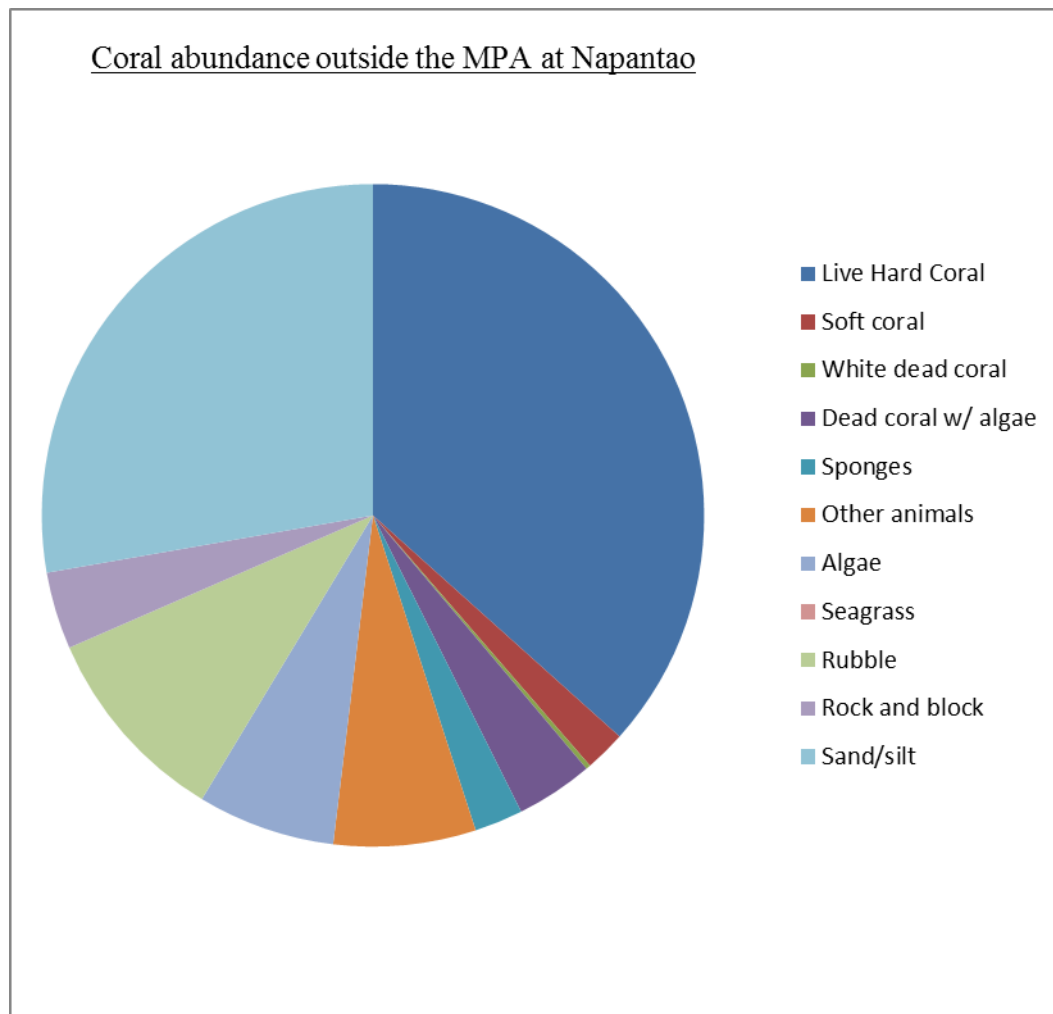
1.4 Site 2- Napantao- Outside the MPA:**Coral:**

Figure 26: A pie chart to show the abundance of coral outside the MPA at Napantao.

The chart shows that there is again a large abundance of live hard coral and sand and silt. There is also a fairly large proportion of algae, rubble and other animals as well as a similar quantity of dead coral with algae at 4% in comparison to inside.

Source: Author

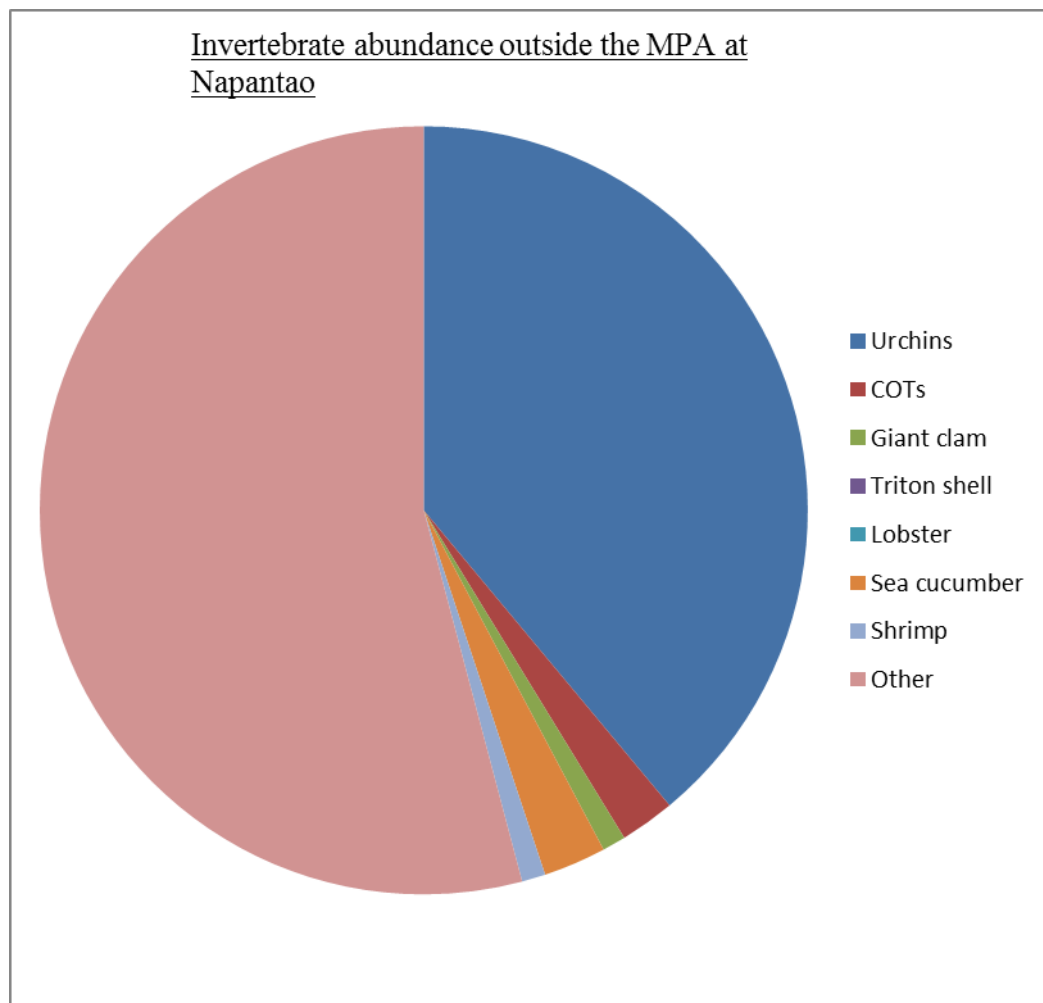
Invertebrate:

Figure 27: A pie chart to show the abundance of invertebrate outside the MPA at Napantao.

The chart shows that the reef is composed primarily of ‘other’ invertebrates and urchins and similar to inside there is a small percentage of COTs. There is an overall absence of triton shells and lobsters, again comparable to inside the MPA.

Source: Author

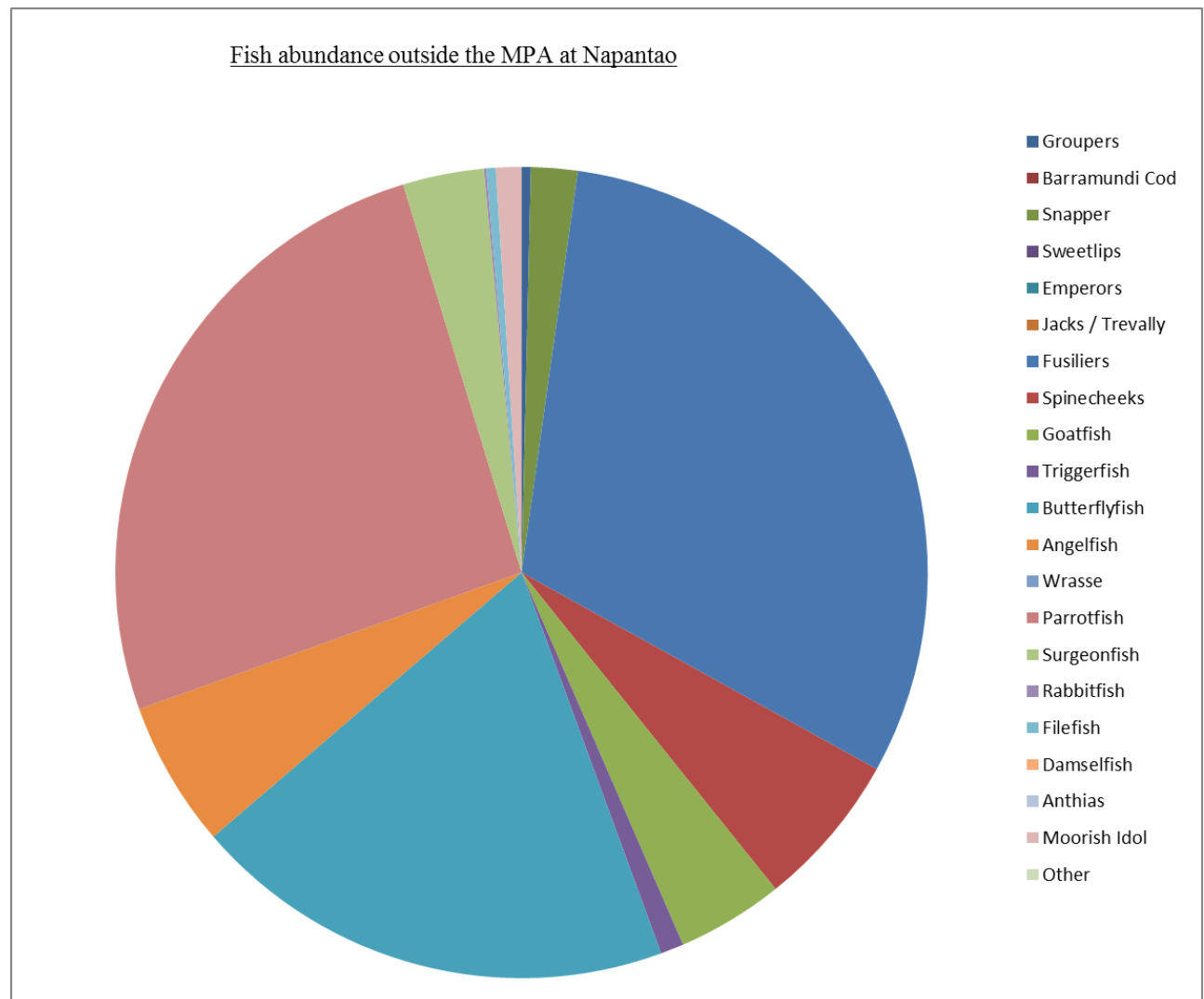
Fish:

Figure 28: A pie chart to show the abundance of fish outside the MPA at Napantao.

The chart shows there is a wide variety of fish species with the most dominant being Fusiliers (31%), Parrotfish (26%) and Butterflyfish (19%). The other species of fish all show similar proportions in abundance however, there is a lack of Barramundi cod, Sweetlips, Wrasse, Damselfish, Anthias and Other.

Source: Author

1.5 Site 2- Napantao- A comparison of Inside and Outside the MPA:**Coral:**

The graphs both show similar percentages of live hard coral but with inside having a slightly larger quantity however outside the MPA data shows that the reef is composed more of sands, silts, rubble and algae.

Coral Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	10	10	1	1
Individuals	1042	1354	0	0
Dominance	0.2973	0.2341	0.001	0.001
Shannon H	1.584	1.745	0.001	0.001
Evenness e^H/S	0.4873	0.5728	0.001	0.001
Fisher alpha	1.533	1.464	1	1

Table 6: Diversity statistics for coral inside and outside the MPA at Napantao

Source: Author

	No Significant Difference (Figure above 0.05)
	Significant Difference (Figure below 0.05)

A table 6 show that there is a greater number of individuals outside of the MPA but compared with inside there is the same number of taxa. The data shows that there is a significant difference in the dominance of corals composing the reef at Napantao displaying a greater dominance of species inside the MPA compared to outside. The Shannon H value also shows a significant difference suggesting that outside the MPA there is greater diversity in the numbers of coral species, hence it is more varied however, the Evenness value suggests otherwise, showing that outside the MPA there is less variety. This inconsistency could be linked to small sample numbers, something that may also be seen with the Fishers alpha as it suggests no significant difference between the samples relating to the dominance and abundance of species.

Invertebrate:

The graphs highlight that outside of the MPA there is a larger percentage of urchins, whereas inside there is a greater percentage of 'other' species. Inside the MPA there are larger percentages of COTs and sea cucumbers but there is an absence of shrimp.

Invert Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	5	6	0.446	0.395
Individuals	154	303	0	0
Dominance	0.4749	0.446	0.42	0.422
Shannon H	1.035	0.9739	0.513	0.488
Evenness e^H/S	0.5629	0.4414	0.069	0.051
Fisher alpha	0.9893	1.06	1	1

Table 7: Diversity statistics for invertebrates inside and outside the MPA at Napantao

Source: Author

	No Significant Difference (Figure above 0.05)
	Significant Difference (Figure below 0.05)

Table 7 shows that there is a greater number of taxa present outside of the MPA as well as a greater number of individuals however, the diversity statistics suggest that there are no significant differences between the data sets involving dominance and diversity of species. This is the first set of data which overall shows no significant differences between inside the MPA and outside.

Fish:

The graphs show similar proportions of the dominant fish species both inside and outside the MPA. There is less of an abundance of Angelfish and Spinecheeks inside the MPA but it does show significantly higher numbers of commercial fish such as Surgeonfish, Snappers and Groupers.

Fish Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	15	13	0.124	0.256
Individuals	1381	1083	0	0
Dominance	0.1629	0.2093	0.001	0.001
Shannon H	2.08	1.824	0.001	0.001
Evenness e^H/S	0.5336	0.4766	0.134	0.258
Fisher alpha	2.352	2.077	0.346	0.46

Table 8: Diversity statistics for invertebrates inside and outside the MPA at Napantao

Source: Author

	No Significant Difference (Figure above 0.05)
	Significant Difference (Figure below 0.05)

Table 8 shows that there is a greater number of taxa and individuals within the MPA compared to outside. The dominance values propose that there is a significant difference suggesting that outside of the MPA there is a greater dominance of one or two particular fish compared to inside, where it is more balanced. The Shannon H value advocates that there is a significant difference in the assortment of fish species, suggesting that there is more diversity inside of the MPA than outside, supported by the fact that there is less of a dominance of just one or two species. The Evenness and Fishers alpha value both suggest no significant differences in the data sets and they do not equate well with the other indicators which may suggest there is a limitation in data collection, in that there was not enough observations made at this specific site.

1.6 Overall comparison of Site 1 and Site 2:

Coral: Overall data from both sites shows the same amount of taxa recorded but a difference in the number of individuals, site 2 having a much larger abundance however generally for diverse ecosystems, both show fairly low levels of coral species.

Invertebrate: Site 2 shows a greater abundance of invertebrate species compared to site 1, but again as with coral, these figures are very low for such an extensive ecosystem.

Fish: Site 1 has a significantly larger amount of fish individuals than site 2; furthermore it shows a greater diversity in the species that are present however, again similar to coral and invertebrate, this is a small amount of fish recorded, possibly linked to small numbers of observations.

Generally the results show that site 1, Buenavista, has more significant differences within the data sets, this may be due to the fact that it has been an established MPA for longer than site 2, Napantao

1.7 Visual catalogue of some of the species mentioned within the results chapter:



Plate 1 (Above left): Volunteers conducting baseline surveys on the reef

Source: Richard Wise

Plate 2 (Above right): Tabulate hard coral colony

Source: Richard Wise

Plate 3 (Left): Crown of Thorn (COT) seastar digesting a hard coral

Source: Wood (2007)

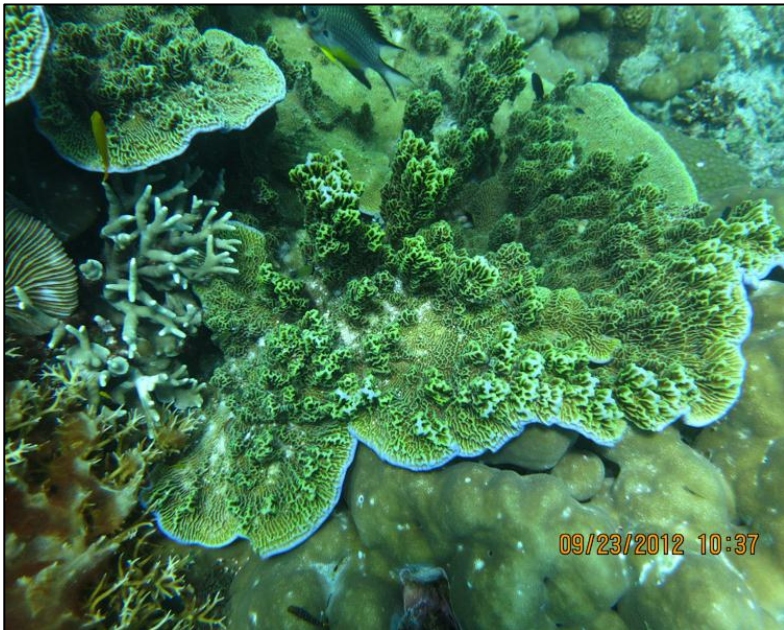


Plate 4 (Above left): A school of Humbug Dascyllus Damsel fish

Source: Jocelyn Sze

Plate 5 (Above right): Short Spine Sea Urchin

Source: Jocelyn Sze

Plate 6 (Left): Encrusting hard coral

Source: Edward Sedaghati



Plate 7 (Above left): A school of 'Blue and Yellow'
Fusilier fish

Source: Carpenter (1997)

Plate 8 (Above right): Soft coral

Source: Edward Sedaghati

Plate 9 (left): A blackspot Snapper fish

Source: Carpenter (1997)



Plate 10 (Above left): An Anemone Damsel fish protecting its anemone

Source: Edward Sedaghati

Plate 11 (Above right): Evidence of coral bleaching

Source: Author

Plate 12 (Left): Marble algae

Source: Jocelyn Sze



Plate 13 (Above left): A Triggerfish grazing the coral

Source: Edward Sedaghati

Plate 14 (Above right): A Picasso Triggerfish

Source: Carpenter (1997)

Plate 15 (Left): An 'Other' invertebrate, a Nudibranch

Source: Jocelyn Sze.

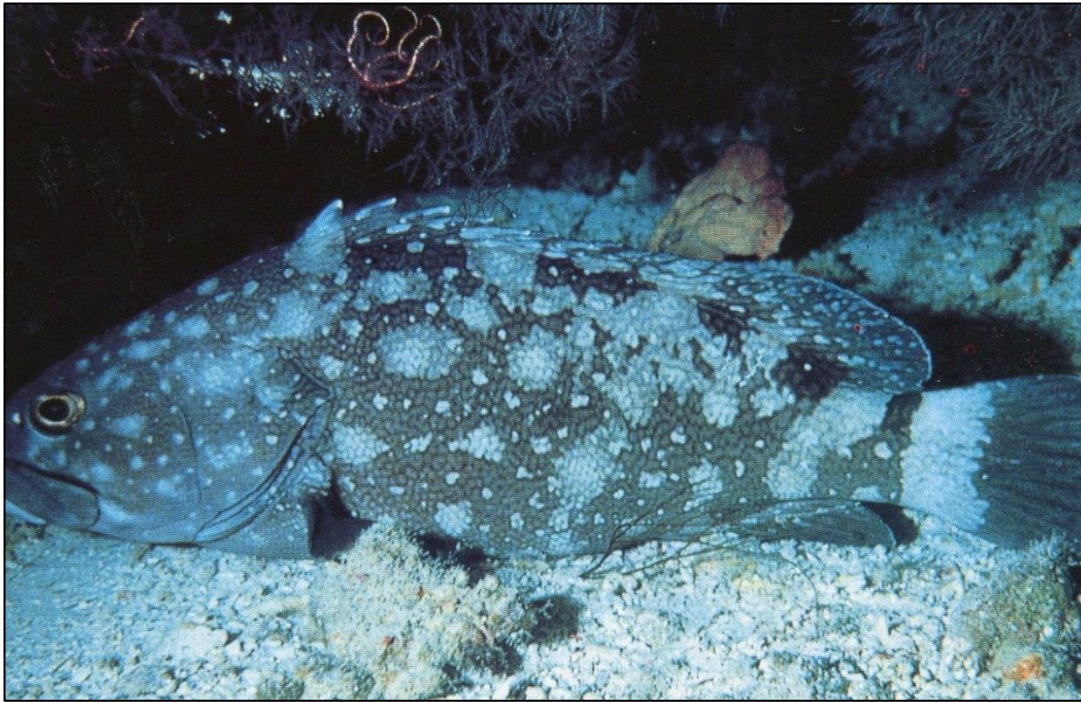


Plate 16 (Above left): A whitespotted Grouper fish

Source: Carpenter (1997)

Plate 17 (Above right): Banner Butterflyfish

Source: Carpenter (1997)

Plate18 (Left): A moon Wrasse

Source: Carpenter (1997)

Chapter 5: Discussion

1.0 Site 1- Buenavista:

1.1 Coral analysis:

Coral data collected from the MPA at Buenavista shows that there is a higher proportion of coral individuals outside the protected area compared to inside furthermore, it demonstrates different diversity trends suggesting alternate variables are impacting different parts of the reef.

The results indicate that the most abundant life form is live hard coral, with a profusion of 88% inside and 84% outside the MPA, a significant ascendancy within the results supported by the moderately high dominance statistics. Hard corals, composed from species including *Pocillopora*, *Seriatopora hystrix* and *Lobophyllia*, are often the most abundant life form on the reefs because they are the permanent habitat structures for millions of marine life and fulfil a number of ecological roles that support many reef processes (Bellwood et al 2004). A high degree of hard coral within an ecosystem is an important indicator of the overall health of the reef (Jokiel and Rogers 2007), marine diversity within species of fish and invertebrate can be directly linked to the diversity of the hard corals, thereby the more there is of it, the more life the environment can support (Taylor et al 2004).

A greater proportion of live hard coral from total coral cover inside the MPA may be related to the fact that it is more protected from negative pressures induced by man for instance; destructive fisheries, motor boat damage and pollution (Kühlmann 1988). The protection enforced by the MPA is further supported by the good efforts of local Filipino people within the community at Padre Burgos as well as assistance from NGO's such as CCC (van Bochove et al 2011).

With increased protection and reduced pressures coral reef condition is likely to improve; this in turn encourages more marine species to the area which can increase the diversity of the reef. It has been shown that within MPA's increased abundance of reef species such as Damselfish have improved structure and growth of hard coral species such as *Pocillopora* (Wellington 1982). Not only are the Damselfish territories linked to the increased growth of hard coral, but they have also shown a tendency to protect parts of the reef from damaging corallivore fish such as Triggerfish (Nybakken 2005). Therefore a possible reason for greater hard coral cover inside the MPA may be due to the protection of these important reef fish

from fishermen who want to catch and sell them as exotic species for aquariums all over the world.

There are differences present between inside and outside the MPA but are not of a huge magnitude possibly indicating that the MPA needs longer to yield more significant results. Furthermore past and present pressures on the reef outside the MPA may be more natural and consequently less severe, therefore these moderate levels of disruption may maintain the diversity of the hard corals as stated in Connell's intermediate disturbance hypothesis (Connell 1978).

The reefs outside the MPA are composed of greater white dead coral and dead coral with algae possibly linked to the areas susceptibility to eutrophication and pollution from surrounding villages which is common within the bay and more significantly around Padre Burgos. Increased nutrients within the water can stimulate excess algal growth which then has the possibility of outcompeting coral for things such as light and space which may inevitably destroy it (van Bochove et al 2011). Increased algae may also be due to the complete lack of sea urchins which feed on and maintain balance on the reef, for example, in the Caribbean in 1970's urchin populations reduced drastically due to overfishing creating significant algal blooms which are still a problem today (Bellwood et al 2004). Coral death rates at Buenavista are worrying, however they are extremely low in comparison with locations such as the Caribbean where sampled reefs had less than 10% hard coral cover; the remaining had died through extensive coral bleaching events (Bellwood et al 2004).

Coral bleaching has been identified as one of the most damaging natural phenomena to impact hard coral cover as it involves the loss of zooxanthellae from coral tissues when there are changes in UV radiation or temperature levels within the water. In recent times, records show from approximately 1840 (Glynn 1993), this natural process has been enhanced by humans through global warming (Tait and Dipper 1998), it is now more prolonged leading to large scale degradation and death of corals. A period of severe bleaching occurred in 1998/1999 within the Indo-Pacific region due to an extreme *El Niño* Southern Oscillation (van Bochove et al 2011), which resulted in killing much hard coral cover on the reefs and similar impacts were later felt around the Caribbean in 2004/2005 which led to the loss of approximately half of the reefs affected (World Meteorological Organization 2010).

Fortunately, Sogod Bay was not significantly affected by the bleaching until 2002, the site managed to escape the full impact due to the movement of cooler water from deeper parts of

the bay around the reef which allowed for a less stratified water column (Taylor et al 2004). This can possibly explain why hard coral cover inside and outside the MPA is quite high compared to other reefs around the world, especially other areas within the Philippines.

Outside the MPA there is a greater profusion of soft corals and sponges this may be because this area of the bay is quite naturally abundant in them, whereas inside the MPA there are higher levels of rubble, sand and silts likely to be due to large scale deforestation a major problem throughout South East Asia (Hodgson 1999).

The steep topography of the land around the bay is composed of thousands of hectares of valuable hardwood trees which are deforested creating runoff that will be carried into the bay through either one of six rivers. The consolidated material smothers the coral eventually killing it (Knowlton 2001), something the bay is thought to be already severely affected by (Calumpong et al 1994). Furthermore the absence of seagrass at both sites may be linked to the continued deforestation but also the extensive construction and development around the bay (Wilkinson 2008).

The findings suggest that the reef both inside and outside the MPA is composed of different matters with the Shannon H statistic suggesting that outside has a greater diversity because it has a wider variety of components composing the reef but it does not necessarily indicate a healthier environment as more of it is made up of dead corals and other animals.

Therefore some significant differences can be seen between inside and outside the MPA at Buenavista however there are inconsistencies, for example, concerning the Fishers Alpha index. This may be due to the limited sample numbers collected from each site as overall the amount of coral recorded for the given area is very small, therefore, it can be seen that there are differences in coral abundance and diversity between inside and outside the MPA but with this current level of research one cannot tell whether the reef is healthier or justify whether the differences are because of the protection provided by the marine sanctuary or because of other variables impacting the reef.

1.2 Invertebrate analysis:

Invertebrate data from Buenavista clearly shows a much higher number and wider diversity of species inside the MPA compared to outside where only two species of invertebrate were recorded. This finding can be supported by the Shannon H statistic and may be due to the presence of the protected area in that it has reduced the amount of overexploitation, often

caused by local people taking advantage of the mollusc populations for food (Sorokin 1993). As populations grow in the no-take area, genetic diversity can also increase meaning the reef can support a greater variety and abundance of species (Bellwood and Hughes 2001).

Giant clam populations are higher inside the MPA, this may be linked to the larger proportion of coral cover as clams are more attracted to vast areas of rocky hard substrate (Sorokin 1993), and are important as components for reef structure and rugosity (van Bochove et al 2011).

However both sites do not show any record of COTs present and this is not necessarily a positive characteristic as they are still a natural part of the ecosystem and a lack of them could possibly indicate reduced coral diversity in that similar to fish invertebrate species may not join a community until there is a sufficient amount and variety of live hard coral (Bell and Galzin 1984). However, hard coral abundance both inside and outside the MPA show percentages of over 80%, therefore this absence of COTs and overall low figures for invertebrates can be more reliably linked to a possible error in data collection in that divers did not recognise or record an accurate identity of specific invertebrates on the reef.

Therefore the results indicate some significant differences between the MPA and non MPA data for invertebrates, but again alike to coral not all of the aspects tested were proven to be significant, for example, the Fishers Alpha index. It is clear that there are differences in abundance and diversity, but it is impossible to pinpoint whether these inconsistencies are due to the presence of the MPA or whether there has been some error in data collection therefore to gain a better sense of clarity one needs to compare results from both sites within the bay.

1.3 Fish analysis:

Fish data from Buenavista shows overall there are a higher number of fish individuals outside the MPA but a greater amount of taxa inside and this finding may be linked to a larger percentage of dead coral and algae as it has been seen that the demise of a coral can attract many herbivorous species of fish as food supply within the ecosystem is increased, however this attraction of reef fish is short term as the dead coral will eventually stop producing food (Wood and Johannes 1975). Greater fish abundance outside the MPA may also be due to different times in which the surveys were conducted; fish move through various parts of the reef at different times within their cycles, often following smaller fish for food therefore surveys conducted outside may have been at a more abundant time of year than when surveys

were conducted inside (Dubinsky 1990). A greater amount of individuals outside the MPA may also be linked to the spill-over effect, in that the MPA generates large populations of fish and eventually leads to a point where abundance is too high within the protected area that species 'leak out' into surrounding non protected reefs thus creating a period in which fish abundance is greater outside the MPA (Samoilys et al 2007).

The greatest abundances within species both inside and outside the MPA are that of Anthias, Damselfish and Fusiliers, these being some of the largest, most common and targeted fish on the reefs (Samoilys et al 2007).

Inside the MPA Anthias are the most abundant species found, linked to a high dominance statistic and this may be because the fish are predatory and consequently responded well to the enforcement set up by the no-take area. High abundances of this species relating to marine protection can also be seen in a number of other worldwide studies, in countries such as Australia, Brazil, Egypt, Kenya and Tanzania (Samoilys 1988, Watson and Ormond 1994, Wantiez et al 1997, Russ and Alcala 1998, McClanahan et al 1999, Williamson et al 2004, Ashworth and Ormond 2005 and Floeter et al 2006). This species is important for both the local fisherman but also within reef conservation as they have important life histories which increase insight into the past and present health of the reef (Samoilys et al 2007).

Outside the MPA there is a higher percentage of Fusiliers, this may because this species are known to be more 'cryptic', in that they are less desired by fisherman. The fish found most abundantly inside and outside the MPA are some of the most common but conversely they are not species that necessarily show how healthy the reef is, for example, Wrasse is well distributed but is known to be quite generalist within coral reefs as demonstrated by Samoilys et al (2007) in other marine studies. Although initially it can be assumed that there is a healthier reef within the MPA due to a greater amount of taxa, this finding is not well supported as the difference is not statistically significant and fish abundances are of common species which do not necessarily indicate reef health.

Both sites exhibit fairly low stocks of targeted commercial fish such as Snappers, Emperors and Goatfish and this could be due to too short a duration for fish recovery inside and continued pressure from fishing affecting stocks outside as reef fish populations are incredibly sensitive to overharvesting (Russ 1991). Yet the MPA may be having more of a positive effect on commercial fish populations than the results indicate as it has been proven

that species such as Emperors and Snappers are notoriously difficult to observe due to their movement and behaviour (Wantiez et al 1997).

Fish stocks inside the MPA are fairly low for the given area of Buenavista and this may be because the MPA in general is of a relatively small size at only 8 hectares and it may not be large enough to support wide fish abundance and diversity (Galzin et al 1994). However this idea does not hold strong validity as outside the MPA similar results can be seen on the reef where there is no restriction in size of area available to marine life and it could simply be that low fish abundance is due to the conditions present on this part of the reef, both natural and anthropogenic.

Significant differences can be seen between inside and outside by indicators such as dominance and diversity but again alike to coral data there are some inconsistencies present in that tests working on similar variables show different results, possibly due to small observation numbers that could be related to different times in which surveys were completed. Overall, there does seem to be a difference in abundance and diversity; however this cannot be proven to be statistically significant therefore one cannot justify whether one area is healthier than the other due to the presence of the MPA, again comparisons need to be made with the other site at Napantao.

1.4 Site 2- Napantao:

1.5 Coral analysis:

Coral data from Napantao shows overall there is the same amount of taxa at both sites but less coral individuals inside the protected area, a finding that may be associated with the history of the reef, in that levels of disruption were higher in this area and that coral cover has not yet recovered, hence why it became protected in 2008. At both sites live hard coral is the most abundant, with inside showing a greater proportion of the total at 46% compared to outside at 36%, however these figures in comparison with Buenavista are very low, showing that dominance is not centred around one or two main species. This may be expected from the MPA at Napantao as it has not been in place for as long as Buenavista, however the three year difference it not likely to show such drastic dissimilarities between hard coral cover, considering that this is a major component of the reef. It could indicate poor diversity on this part of the reef, a negative finding in relation to conservation as it has been shown within

marine studies reduced hard coral cover and degradation can lead to reduced fertility and reproduction of species of fish and invertebrate (Knowlton 2001).

However, the level of invertebrates present at Napantao is significantly higher than Buenavista which demonstrates there is a factor regulating diversity and that reduced hard coral cover may be linked to the smaller size of Napantao, it being 3 hectares smaller than site one.

The second most abundant components on the reef at site 2 are sands and silts showing very high figures of 26% inside and 27% outside. Again these results are likely to be related to the severe sedimentation from the surrounding environment that affects Sogod Bay however, higher figures at this site may also be because Napantao is located closer to the entry points of the six main rivers flowing into the bay, locations such as Bontoc and Pandan, meaning that the material is less diluted when it reaches the reef (van Bochove et al 2011). The sedimentation may also be a reason for lowered hard coral cover as the materials such as sand and silt can swamp polyps and kill them (Sorokin 1993).

Dead coral with algae is also present at Napantao and this is also likely to be due to similar reasons affecting Buenavista, increased siltation and waste products entering the bay from nearby communities. Other animals are present at Napantao, but unlike to site one, there is no seagrass present probably related to coastal development and clearing for aquaculture (Wilkinson 2008).

The diversity statistics indicate some significant differences but not in all components tested therefore preventing one from determining fundamental differences in abundance and diversity between inside and outside. Limitations can be related to small observation numbers, comparisons can be made with site one but because it was established 3 years prior to site two there will be a different set of variables acting on the reef that one would not be able to separate and analyse with this breadth of research.

1.6 Invertebrate analysis:

Invertebrate data shows a much healthier number of invertebrates present on the reef at Napantao however it is still a low amount for a protected area possibly affected by the short duration of its establishment. The data shows the highest species abundance inside and outside is that of 'other' supported by the moderate dominance indexes, instead of target invertebrates which have been specifically chosen as they indicate reef health, for example,

gastropods and crustaceans, such as Triton shells and lobsters, create ecological feedback mechanisms with the corals that increase general diversity (Stella et al 2011) and enhance the overall degree of coral cover (Meyer and Schultz 1985).

Napantao shows a greater profusion of urchins compared to Buenavista with there being a larger quantity outside the MPA compared to inside possibly suggesting that the protected area has greater ecological stability for example, more predatory fish are protected from fisherman, such as Triggerfish, therefore urchin predations are maintained and create more of an environmental balance (van Bochove et al 2011).

COTs are found at low levels, less than 3-4/km² (Sorokin 1993), both inside and outside the MPA nonetheless a positive finding concerning reef health compared to Buenavista and even though the species are regarded as threatening to the corals, at natural levels they play a fundamental role within the ecosystem therefore research and management concerning these invertebrates needs to be continued on the reefs within the bay.

Overall no significant differences can be seen between the MPA and the non-protected area suggesting that either there is a limitation in data observation, not enough was collected, or that the MPA has not or is not working sufficiently enough to increase species diversity and abundance.

1.7 Fish analysis:

Fish data from Napantao shows a greater number of individuals inside the MPA as well as a significant difference in the diversity of fish species, possibly expected due to the protection enforced.

An overall lower fish count can be witnessed at Napantao compared to site 1, perhaps because site 2 may have experienced more severe fish harvesting and has not been established as an MPA for as long.

The most dominant species both inside and outside is Fusiliers; this may be because this species is not overly desired by fisherman (Samoilys et al 2007). Inside there is a greater abundance of Surgeonfish, a fish heavily targeted by local people for the meat it provides due to its large body size (Samoilys et al 2007), therefore increased commercial fish populations can be linked to the protective measures imposed by the marine sanctuary (Wantiez et al 1997). Positive findings such as this indicate the MPA is working with high diversity

indicated through the Shannon H statistic however there are inconsistencies, for example lower populations of other commercial fish such as Spinecheeks and Anthias.

An absence of Wrasse both inside and outside the MPA is quite surprising because it is quite a general fish within the reefs as demonstrated from twelve marine studies within the Philippines where Wrasse was always fairly dominant within the data sets (Samoilys et al 2007). This species of fish is heavily dependent on hard coral for food supply and shelter, therefore its absence within the data set may be linked to low total area of hard coral (Bell and Galzin 1984). This idea can also be demonstrated regarding small populations of Butterflyfish, a species also closely related to hard coral cover indicating possible poor reef health (Bell and Galzin 1984).

Some significant differences can be seen in abundance and diversity of fish populations at Napantao, however comparable to the other data sets there are contradictions within analysis which make it difficult to distinguish whether differences are due to the presence of the MPA or inconsistencies within the data sets.

1.8 Comparisons between Buenavista and Napantao:

Discrepancies can be seen between the sites at Buenavista and Napantao, for instance site 1 has a lower quantity of coral individuals but of a superior quality and perhaps health, as fewer reefs are composed of dead corals and algae. Generally a healthy reef is one which can support a vast array of marine life and sustain a yield of approximately 20 tonnes or more of edible products per km² per year (White et al 2000), however the characteristics of a 'healthy reef' are not uniform around the world.

Differences can also be seen within the abundance and diversity data for invertebrates and fish between these sites, suggesting that even though there are MPAs present in both areas, there are a number of other variables impacting the reefs, of which are challenging to establish and therefore make it difficult to know whether one part of the reef is healthier than the other. More significant differences can be seen at Buenavista generally positive perhaps because the protected area has been unified for longer however; it is difficult to make such predictions due to the lack of past data on protected areas (Russ and Acala 1989, 1994; Roberts and Polunin 1991, 1992).

Due to reasons such as this it is difficult for local communities to understand the long term benefits of MPAs as they do not always yield significant results on realistic timescales, therefore this has led to a growing body of evidence against them, with people not believing

that they are not efficient enough to protect corals from large-scale degradation (Jones et al 2004).

Consequently, many MPAs within the Philippines have started to become less efficiently managed no longer having positive effects on the reefs; reasons for failure include initial and maintenance costs that can be too expensive for poor communities and this makes it difficult for the MPA to continue to run efficiently, for example on the Apo island it cost US\$ 75,000 to set up the MPA and US\$ 5,000 each year to maintain it (White et al 2000). Furthermore resentment towards MPAs is made worse by local people not truly understanding the goals and purposes of protection, there are often no structures in place to explain and educate communities (Rinkevich 2008). Continued debates concerning active versus passive management add to the controversy, not contributing to the possible success of MPAs (Rinkevich 2008) and the debates are active within Sogod Bay, however not to such a significant extent compared to other areas within the Philippines because of the continued donor work and assistance from NGO's such as CCC and this integrated management needs to continue to ensure maximum success of these MPAs.

The results presented within this report indicate that the MPA's are having an impact on the reefs within the bay but it is unknown to what degree these impacts are positive therefore greater research is required and perhaps management of a different approach for example, as suggested by Rinkevich (2008), more of a balance between passive and active management, with increased rationale derived from terrestrial approaches such as siviculture. This approach involves an active step of transplantation of coral seedlings to degraded areas as well as a passive step of protection of existing reef colonies (Rinkevich 1995) however; again there are concerns about the expense and scale of projects such as these in poor communities.

In conclusion, it may not necessarily be that schemes such as siviculture are imposed within Sogod bay or wider within the Philippines but it is definitely evident that coral conservation needs to continue to be managed efficiently so successful results can be yielded on realistic timescales and important lessons can be learnt from the current MPA failure which can educate and point the correct direction for future management of the reefs.

It is apparent that the MPAs at Sogod bay have an important impact on coral reef health but with this level of research, one cannot accept or reject either the experimental or null hypotheses, more in depth comparable studies need to be conducted within the bay for these hypotheses to be tested in the near future.

Chapter 6: Conclusion and Evaluation

Through the collaborative work of volunteers within the NGO CCC this project has produced a significant amount of findings which will contribute to the field of coral reef conservation.

Overall, the abundance and diversity data demonstrates that there are differences present between inside and outside the MPAs at Buenavista and Napantao within Sogod bay but at present it is difficult to establish whether it is the MPAs impacting or whether the influences are due to external factors affecting the reef because the results generated are not statistically significant. It is also difficult to identify whether the results inside the MPAs in relation to increased reef health are positive because there are inconsistencies; for example, at Buenavista there is a greater degree of total hard coral cover inside the MPA, important as a primary reef component, however, equally, the overall number of coral individuals is greater outside the MPA which questions whether reef health is better inside the MPA or outside.

In order to understand the differences in abundance and diversity of certain marine species including overall reef health a greater degree of research is therefore required over a longer period of time on these distinguishable ecosystems.

It is evident that research relating to coral reef health is usually undertaken over a longer time frame as processes within these ecosystems are gradual and it is also apparent why great controversy surrounds these schemes because results are not generated instantaneously and so regarded as worthless and expensive by local Filipino people within coastal communities.

However, contradictorily, within the wider literature there is evidence that MPAs can be successful with the ecological data from protected areas within Kenya as a prime example which demonstrate they have improved and maintained reef life in comparison to heavily utilised unprotected reefs (McClanahan and Shafir; McClanahan and Mutere 1994; McClanahan and Obura 1995). Additionally, other successful MPAs have been seen within the Philippines at Tubbataha Reef National Park in the centre of the Sulu Sea near Palawan (White and Vogt 2000). In order to reassure local people and to encourage a sustainable work ethic towards the reef local communities require adequate education in respect of the long term benefits of these projects as ultimately they are serving an important purpose within conservation.

Providing suitable education and support is made available this will lead to greater clarity in the relationship between the protection provided and the ecological benefits (McClanahan

1999), which will then improve the management of these schemes to continue the positive work into the future.

To further enhance this project and reduce inconsistencies for future studies a few limitations need to be addressed including:

- Within the data sets larger sample numbers collected are required to enable a greater level of analysis, something which may hinder the generation of significant differences within this project; however this is dependent upon whether there are enough volunteers to conduct more surveys.
- Larger sample numbers to enable a greater amount of analysis compared to other findings from the same times of year allowing for more of a comparable analysis.
- A more detailed examination of other variables which impact the MPAs within the bay to gain a greater scope of insight from which to draw more conclusions.

In conclusion, the null and experimental hypothesis are both difficult to interpret because of the inconsistencies within the results as some parts suggest there are important differences, whereas others contradict this, it is therefore important that these hypotheses can be tested in the future through the continued and highly valued work of CCC within Sogod bay.

Bibliography:

- Alcala, A. C. (1988) 'Effects of protective management of marine reserves on fish abundances and fish yields in the Philippines'. *Ambio* 17, 194-199.
- Allen, G. R., & Werner, T. B. (2002) 'Coral reef fish assessment in the 'coral triangle' of southeastern Asia'. *Environmental Biology of Fishes*, 65(2), 209-214.
- Ashworth, J.S., Ormond, R.F.G., (2005) 'Effects of fishing pressure and trophic group on abundance and spillover across boundaries of a no-take zone'. *Biological Conservation* 121, 333–344.
- Bell, J. D., & Galzin, R. (1984) 'Influence of live coral cover on coral-reef fish communities'. *Mar. Ecol. Prog. Ser.*, 15(3), 265-274.
- Bellwood, D. R., T. P. Hughes, C. Folke, and M. Nyström (2004) 'Confronting the coral reef crisis.' *Nature* 429, no. 6994, 827-833.
- Bellwood, David R., and Hughes, Terry P. (2001) 'Regional-scale assembly rules and biodiversity of coral reefs.' *Science* 292, no. 5521, 1532-1535.
- Bonham, C. A., Sacayon, E., & Tzi, E. (2008). 'Protecting imperiled "paper parks": potential lessons from the Sierra Chinajá, Guatemala'. *Biodiversity and Conservation*, 17(7), 1581-1593.
- Calumpong H.P., L.J. Raymundo, E.P. Solis- Duran, M.N.R. Alava and R.O. de Leon (Eds.). (1994). *Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines-Final Report*.
- Carpenter, K. E. (1997). *The corals and coral reef fishes of Kuwait*. Kuwait Institute for Scientific Research, Fahad Al-Marzouk Printing and Publishing Establishment.
- Carpenter, Kent, E., and Springer, Victor G., (2005) 'The center of the center of marine shore fish biodiversity: the Philippine Islands.' *Environmental biology of fishes* 72, no. 4 (2005): 467-480.
- Christie P, White A and Deguit E (2002) 'Starting point or solution? Community-based marine protected areas in the Philippines', *Journal of Environmental Management*, 66, 441-454
- Connell, J.H., (1978) 'Diversity in tropical rain forests and coral reefs'. *Science* 199 (21), 1302–1310.
- Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P. and Van den Belt. M.

- (1997) 'The value of the world's ecosystem services and natural capital'. *Nature* 387 (15), 253-260.
- Darwin, C., (1842) *On the Structure and distribution of coral reefs*. London and Felling-on-Tyne, The Walter Scott Publishing CO., LTD.
 - Dipper, F., & Tait, R. (1998). *Elements of Marine Ecology*. Butterworth-Heinemann.
 - Dubinsky, Z. (1990). *Ecosystems of the world 25: Coral reefs*. Ecosystems of the World 25: Coral Reefs, Elsevier
 - Floeter, S.R., Halpern, B.S., Ferreira, C.E.L., (2006) 'Effects of fishing and protection on Brazilian reef fishes'. *Biological Conservation* 128, 391–402.
 - Galzin, R., Planes, S., Dufour, V., & Salvat, B. (1994) 'Variation in diversity of coral reef fish between French Polynesian atolls'. *Coral Reefs*, 13(3), 175-180.
 - Gardener, T.A., Cote, I.M., Gill, J.A., Grant, A., and Watkinson, A.R., (2003). 'Long-term region wide declines in Caribbean corals'. *Science*, 301, 958–960.
 - Gillett, D. J., Pondella, D. J., Freiwald, J., Schiff, K. C., Caselle, J. E., Shuman, C., & Weisberg, S. B. (2012) 'Comparing volunteer and professionally collected monitoring data from the rocky subtidal reefs of Southern California, USA'. *Environmental monitoring and assessment*, 184(5), 3239-3257.
 - Glynn, P. (1993). 'Coral reef bleaching ecological perspectives'. *Coral Reefs* 12: 1-17.
 - Google Maps, <https://maps.google.co.uk/maps?hl=en> (Last Visited 23rd January 2013)
 - Groom J, (n.d) 'Life on the Reef', Oxford Press Educational Series, Oxford.
<http://www.coralcay.org/app/download/5781247960/9.pdf> (Last Visited 17th January 2013)
 - Harper, D. A. T. (ed.) (1999). *Numerical Palaeobiology. Computer-Based Modelling and Analysis of Fossils and their Distributions*. Chichester, New York, Weinheim, Brisbane, Singapore, Toronto: John Wiley & Sons.
 - Hodgson G. (1999) 'A global assessment of human effects on coral reefs'. *Marine Pollution Bulletin* 38: 345-355
 - Jokiel, P.L. and Rodgers, K.S., (2007). 'Ranking coral ecosystem "health and value" for the islands of the Hawaiian'. *Archipelago Pacific Conservation Biology*, 13, 60–68.
 - Jones, Geoffrey P., McCormick, Mark I., Srinivasan, Maya, and Janelle V. Eagle, (2004) 'Coral decline threatens fish biodiversity in marine reserves.' *Proceedings of*

the National Academy of Sciences of the United States of America 101, no. 21, 8251-8253.

- Kaczmarek L and Richardson L (2011) 'Do Elevated nutrient and organic carbon on Philippine reefs increase the prevalence of coral diseases?' *Coral Reefs* 30, 253-257
- Knowlton, N. (2001) 'The future of coral reefs.' *Proceedings of the National Academy of Sciences*, 98(10), 5419-5425.
- Kühlmann, D.H.H, (1988) 'The Sensitivity of Coral Reefs to Environmental Pollution' *Ambio*, Vol. 17, No. 1, 13-21
- McClanahan TR, Mutere JC (1994) 'Coral and sea urchin assemblage structure and interrelationships in Kenyan reef lagoons'. *Hydrobiologia* 286:109-124
- McClanahan TR, Obura D (1995) 'Status of Kenyan coral reefs'. *Coast Manag* 23:57-76
- McClanahan TR, Shafir SH (1990) 'Causes and consequences of sea urchin abundance and diversity in Kenyan coral reef lagoons' *Oecologia* 83:362-370
- McClanahan, T. R. (1999) 'Is there a future for coral reef parks in poor tropical countries?' *Coral Reefs*, 18(4), 321-325.
- McClanahan, T.R., Muthiga, N.A., Kamukuru, A.T., Machano, H., Kiambo, R.W., (1999) 'The effects of marine parks and fishing on coral reefs of northern Tanzania'. *Biological Conservation* 89, 161-182.
- McIntyre, A. (Ed.) (2011). *Life in the world's oceans: Diversity, distribution, and abundance*. Wiley-Blackwell.
- Meyer, J.I. & Schultz, E.T. (1985) 'Tissue condition and growth rate of corals associated with schooling fish'. *Limnology and Oceanography* 30, 157-166.
- Nybakken, J. W. (2005) 'Tropical communities', in *Marine biology: an ecological approach*, Pearson education, pp 407-452-
- Rinkevich, B. (1995) 'Restoration strategies for coral reefs damaged by recreational activities: The use of sexual and asexual recruits'. *Restoration Ecology* 3, 241-251.
- Rinkevich, Baruch (2008) 'Management of coral reefs: We have gone wrong when neglecting active reef restoration.' *Marine pollution bulletin* 56, no. 11, 1821-1824.
- Roberts, C.M, Polunin, N.V.C (1991) 'Are marine reserves effective in management of reef fisheries'. *Rev Fish Biol Fisheries* 1: 65-91.
- Roberts, C.M, Polunin, N.V.C (1992) 'Effects of marine reserve protection on Northern Red Sea fish populations'. *Proc 7th Int Coral Reef Symp* 2: 969-977.

- Roff, G., & Mumby, P. J. (2012) 'Global disparity in the resilience of coral reefs'. *Trends in ecology & evolution*, 27 (7) 404-413.
- Russ G.R, Alcala A.C, (1989) 'Effects of intense fishing pressure on an assemblage of coral reef fishes', *Mar Ecol Prog Ser* 56: 13-27.
- Russ G.R, Alcala A.C, (1994) 'Sumilon reserve: 20 years of hopes and frustrations'. *NAGA the ICLARM Quarterly* July 1994: 8-12.
- Russ, G.R, (1991) 'Coral reef fisheries: effects and yields', in: Sale, P.F, (ed.) *The ecology of fish on coral reefs*. Academic Press, San Diego, USA, pp 601-635
- Russ, G.R., Alcala, A.C., (1998) 'Natural fishing experiments in marine reserves 1983–1993: roles of life history and fishing intensity in family responses'. *Coral Reefs* 17, 399–416.
- Samoilys, M. A., Martin-Smith, K. M., Giles, B. G., Cabrera, B., Anticamara, J. A., Brunio, E. O., & Vincent, A. C. (2007) 'Effectiveness of five small Philippines' coral reef reserves for fish populations depends on site-specific factors, particularly enforcement history'. *Biological Conservation*, 136(4), 584-601.
- Samoilys, M.A., (1988) 'Abundance and species richness of coral reef fish on the Kenyan coast: the effects of protective management and fishing'. In: Choat, J.H., Barnes, D., Borowitzka, M.A., Coll, J.C., Davies, P.J., Flood, P., Hatcher, B.G., Hopley, D., Hutchings, P.A., Kinsey, D., Orme, G.R., Pichon, M., Sale, P.F., Sammarco, P., Wallace, C.C., Wilkinson, C., Wolanski, E., Bellwood, O. (Eds.), *Proceedings of the 6th International Coral Reef Symposium*, vol. 2, pp. 261–266.
- Sorensen J.D, McCreary S.T, Hershman M.J (1990). *Institutional arrangements for management of coastal resources*. Narragansett, RI: University of Rhode Island Coastal Resources Center.
- Sorokin, Yu I. (1993) *Coral reef ecology*, Ecological studies, Vol. 102, Springer-Verlag.
- Stella, JS, Pratchett, MS, Hutchings, PA and Jones, GP (2011). 'Coral-associated invertebrates: diversity, ecological importance and vulnerability to disturbance'. *Oceanography and Marine Biology: an Annual Review* 49: 43-11
- Taylor, J., O'Farrell, S., Walker, R., Fenner, D. and Raines, P. (2004) *Southern Leyte Coral Reef Conservation Project – Second Year Report and Coral Species List For Sogod Bay*. Coral Cay Conservation, London, UK.

- van Bochove, J., Harding, S., Raines, P. (2007) *Southern Leyte Coral Reef Conservation Project – Results of Scientific and Community Work*. Coral Cay Conservation, London, UK.
- Wantiez, L., Thollot, P., & Kulbicki, M. (1997) 'Effects of marine reserves on coral reef fish communities from five islands in New Caledonia'. *Coral Reefs*, 16(4), 215-224.
- Wantiez, L., Thollot, P., Kulbicki, M., (1997) 'Effects of marine reserves on coral reef fish communities from five islands in New Caledonia'. *Coral Reefs* 16, 215–224.
- Watson, M., Ormond, R.F.G., (1994) 'Effect of an artisanal fishery on the fish and urchin populations of a Kenyan coral reef'. *Marine Ecology Progress Series* 109, 115–129.
- Wellington, G. M. (1982). 'Depth zonation of corals in the Gulf of Panama: control and facilitation by resident reef fishes'. *Ecol. Monogr.* 52(3): 223-241
- White A, Vogt H and Arin T (2000) 'Philippine coral reefs under threat: The economic losses caused by reef destruction' *Marine Pollution Bulletin* Vol 40, 598-604
- White, A. T., Eisma-Osorio, R. L., & Green, S. J. (2005) 'Integrated coastal management and marine protected areas: Complementarity in the Philippines'. *Ocean & coastal management*, 48(11), 948-971.
- White, A. T., Vogt, H. P., & Arin, T. (2000) 'Philippine coral reefs under threat: the economic losses caused by reef destruction'. *Marine Pollution Bulletin*, 40(7), 598-605.
- Williamson, D.H., Russ, G.R., Ayling, A.M., (2004) 'No-take marine reserves increase abundance and biomass of reef fish on inshore fringing reefs of the Great Barrier Reef'. *Environmental Conservation* 31, 149–159.
- Wood, E. F., & Johannes, R. E. (Eds.) (1975) *Tropical marine pollution*, Vol. 12, Elsevier Science.
- Wood, O. (2007) *Coral Cay Conservation: Philippines survey species identification guide*, Butler and Tanner, Frome.
- World Meteorological Organization (2010) 'Climate, Carbon and Coral Reefs' WMO number 1063,
http://www.wmo.int/pages/prog/wcp/agm/publications/documents/Climate_Carbon_CoralReefs.pdf (Last visited 17th January 2013)

Appendices

1.0 Site 1- Buenavista: raw data, graphs and statistics

1.1 Site 2- Napantao: raw data, graphs and statistics

1.2 Sample baseline survey forms

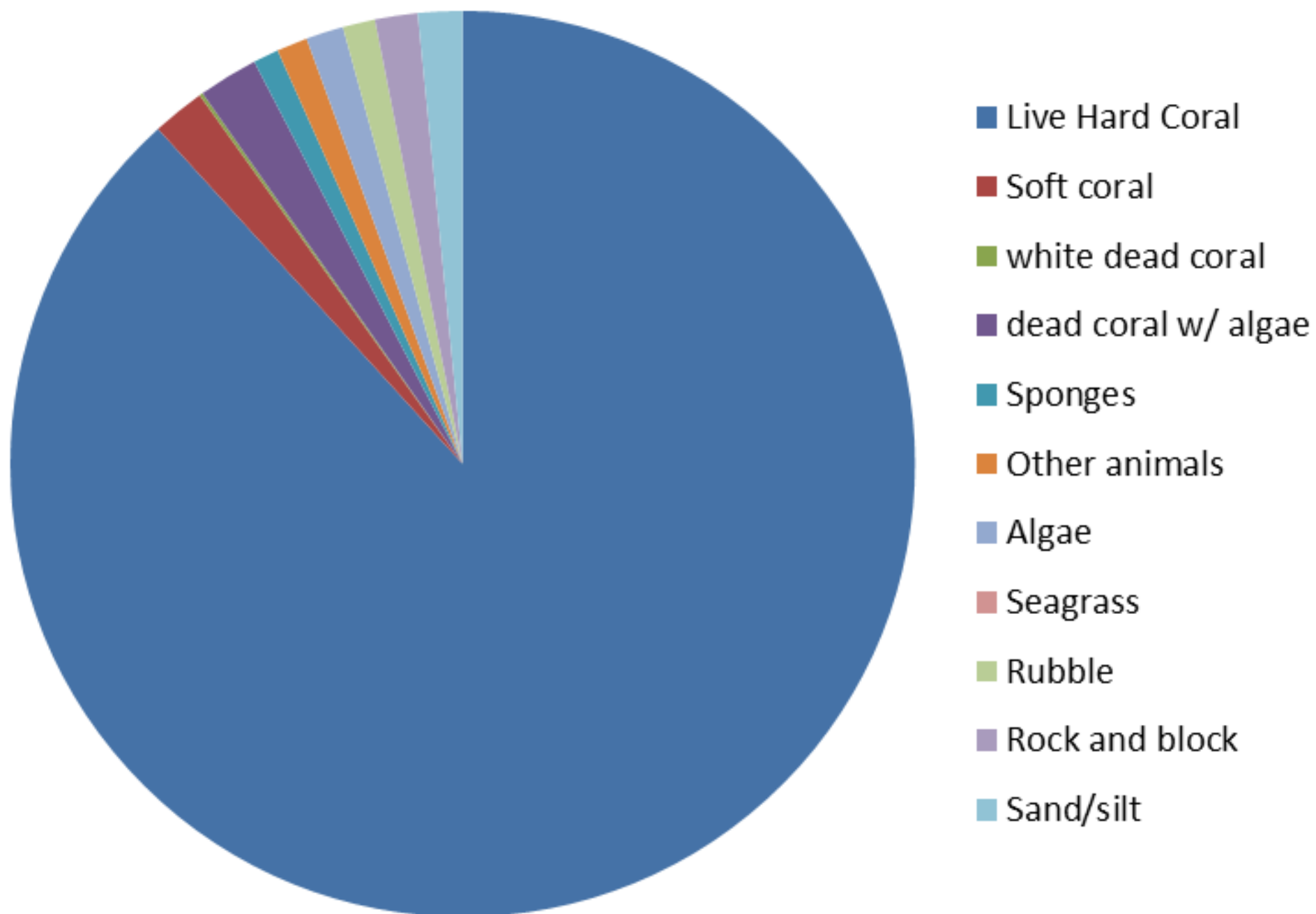
1.0

Coral:	IN	OUT	PERCENTS IN	PERCENTS OUT
Live Hard Coral	724	690.5	88.23887873	82.94294294
Soft coral	15.5	22.5	1.889092017	2.702702703
White dead coral	1	14.5	0.121876904	1.741741742
Dead coral w/ algae	17.5	53.5	2.132845826	6.426426426
Sponges	7.5	10.5	0.914076782	1.261261261
Other animals	9	2.5	1.096892139	0.3003003
Algae	11	15.5	1.340645948	1.861861862
Seagrass	0	0	0	0
Rubble	9.5	10.5	1.157830591	1.261261261
Rock and block	12.5	7.5	1.523461304	0.900900901
Sand/silt	13	5	1.584399756	0.600600601
Total:	820.5	832.5	100	100

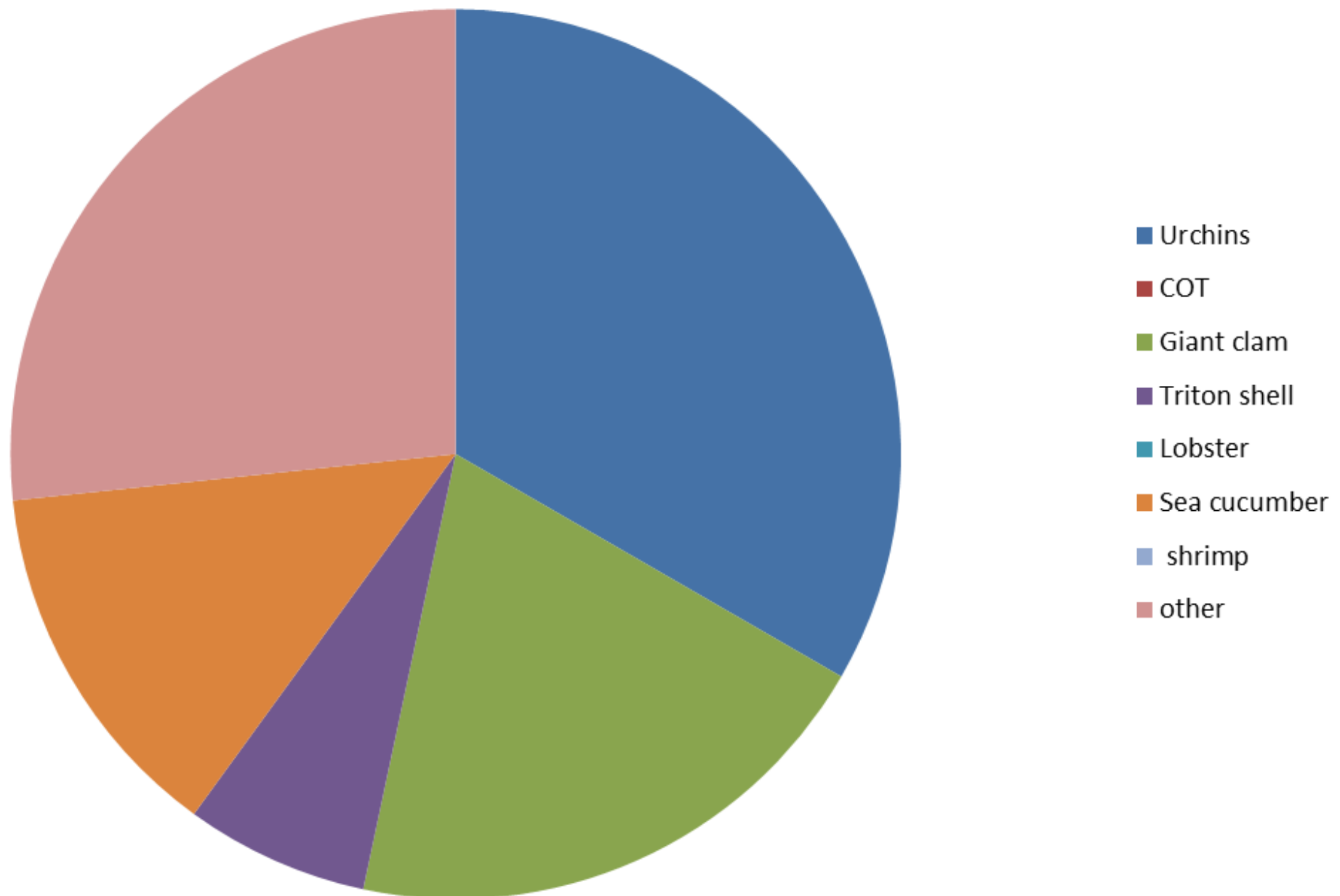
Inverts:	IN	OUT	PERCENTS IN	PERCENTS OUT
Urchins	5	0	33.33333333	0
COT	0	0	0	0
Giant clam	3	1	20	10
Triton shell	1	0	6.666666667	0
Lobster	0	0	0	0
Sea cucumber	2	0	13.33333333	0
Shrimp	0	0	0	0
Other	4	9	26.66666667	90
Total:	15	10	100	100

Fish:	IN	OUT	PERCENTS IN	PERCENTS OUT
Groupers	4	4	0.041701418	0.037264766
Barramundi Cod	0	0	0	0
Snapper	15	13	0.156380317	0.12111049
Sweetlips	1	3	0.010425354	0.027948575
Emperors	0	0	0	0
Jacks / Trevally	0	0	0	0
Fusiliers	425	1289	4.430775646	12.0085709
spinecheeks	11	16	0.114678899	0.149059065
Goatfish	3	5	0.031276063	0.046580958
Triggerfish	2	0	0.020850709	0
Butterfly fish	69	55	0.719349458	0.512390535
Angelfish	16	50	0.166805671	0.465809577
Wrasse	98	82	1.021684737	0.763927706
Parrotfish	34	45	0.354462052	0.419228619
Surgeonfish	1	7	0.010425354	0.065213341
Rabbitfish	5	20	0.052126772	0.186323831
Filefish	0	0	0	0
Damselfish	4297	4725	44.79774812	44.01900503
Anthias	4600	4370	47.95663053	40.71175703
Moorish Idol	11	50	0.114678899	0.465809577
Other	0	0	0	0
Total:	9592	10734	100	100

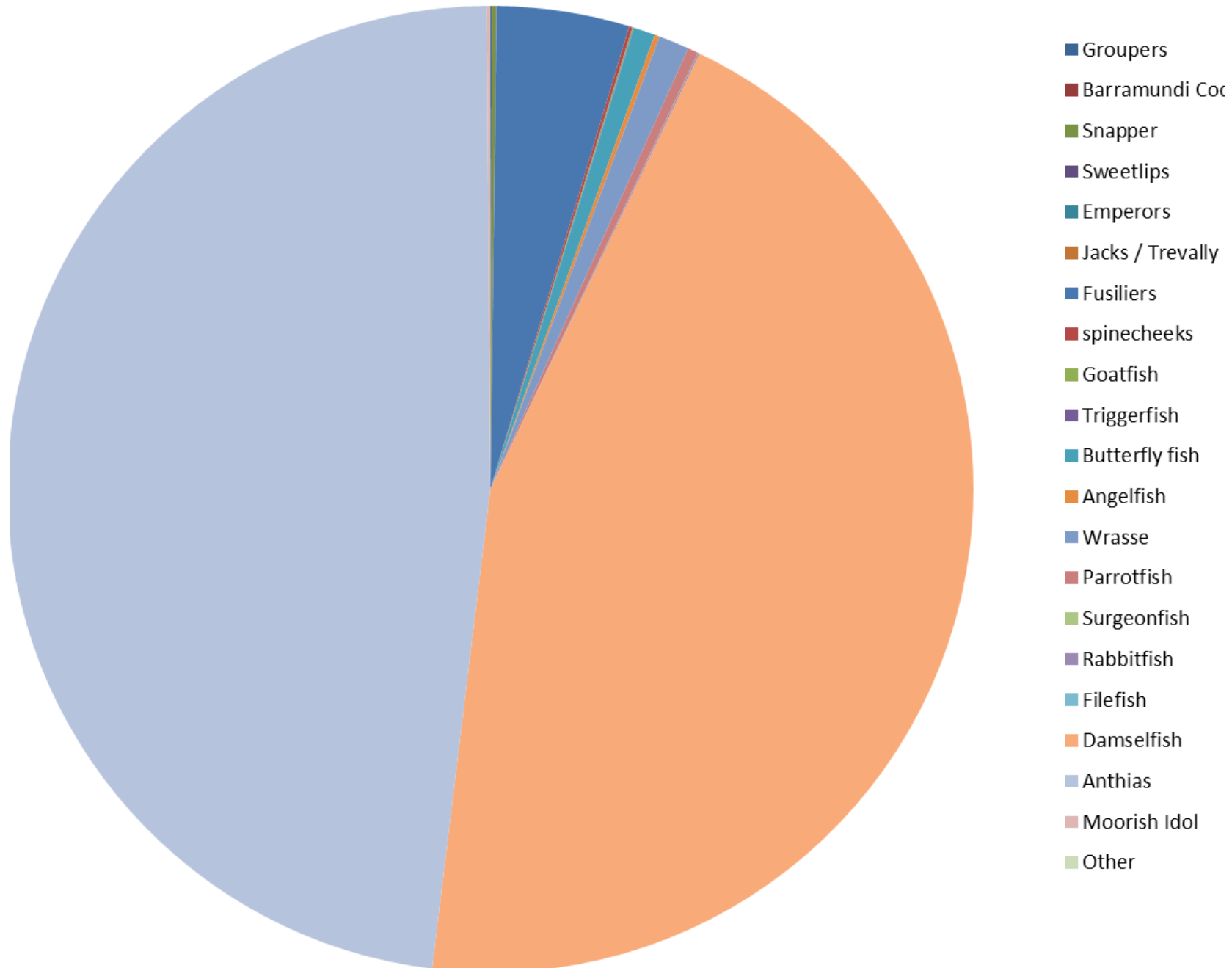
Coral abundance inside the MPA at Buenavista



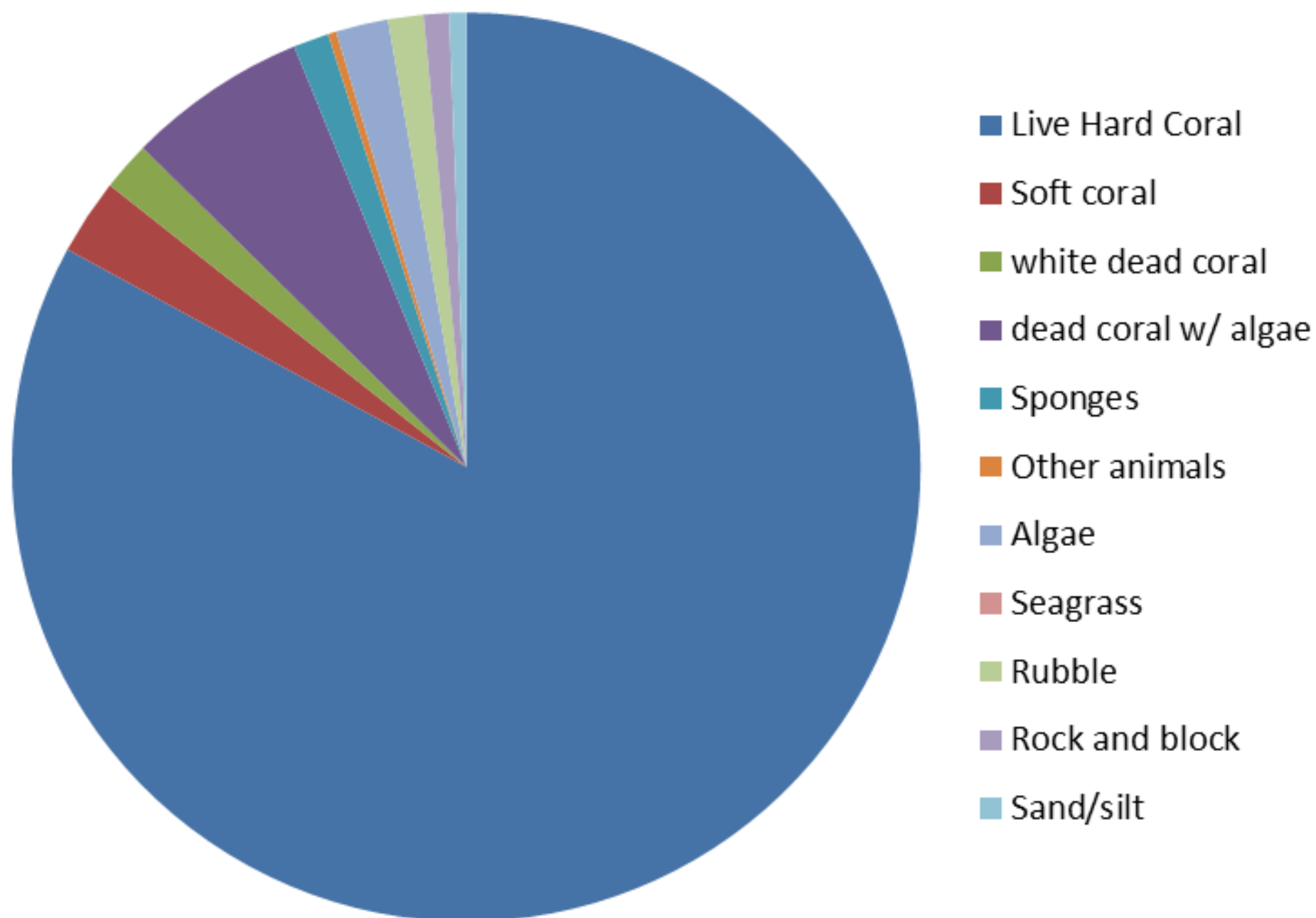
Invertebrate abundance inside the MPA at Buenavista



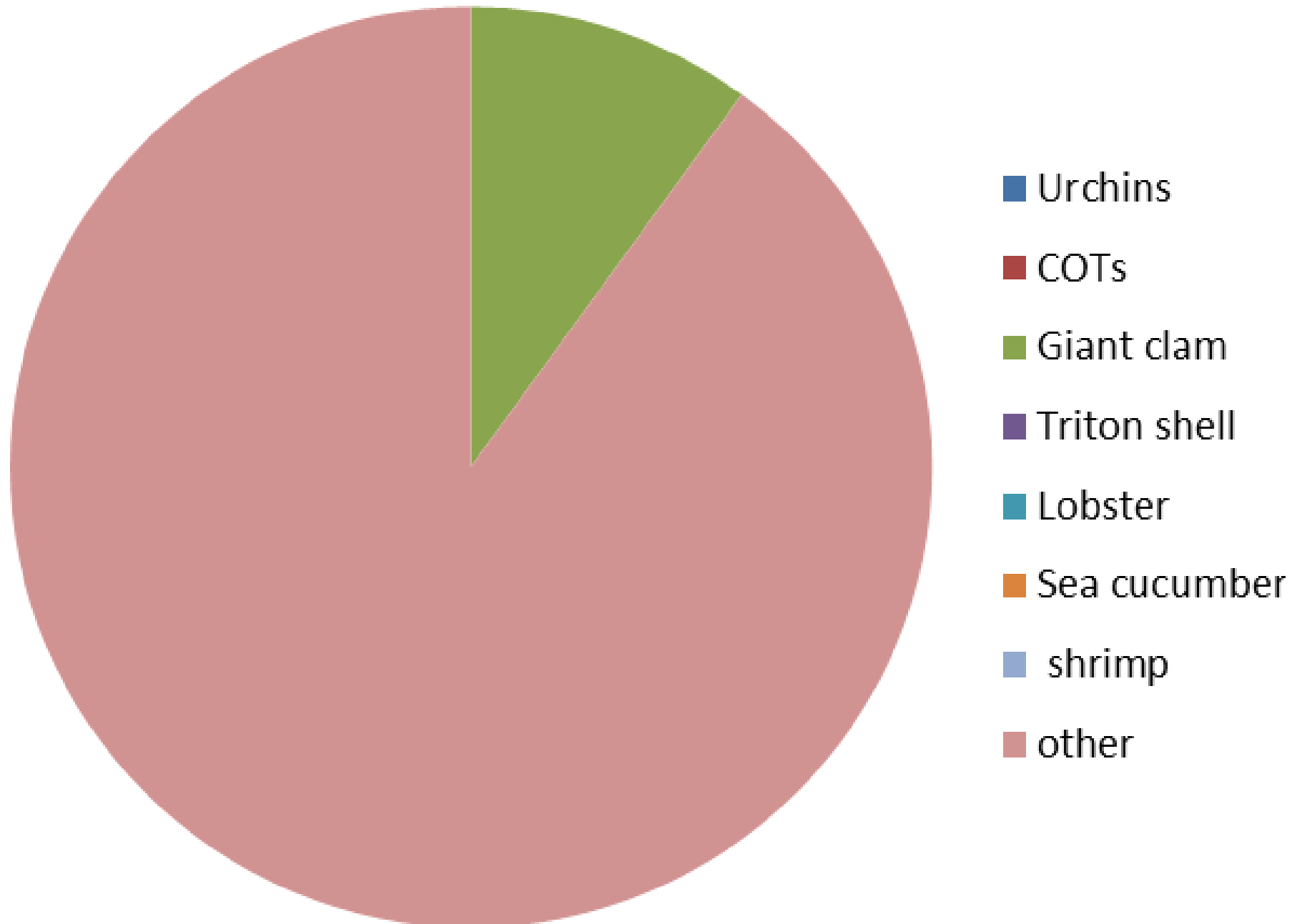
Fish abundance inside the MPA at Buenavista



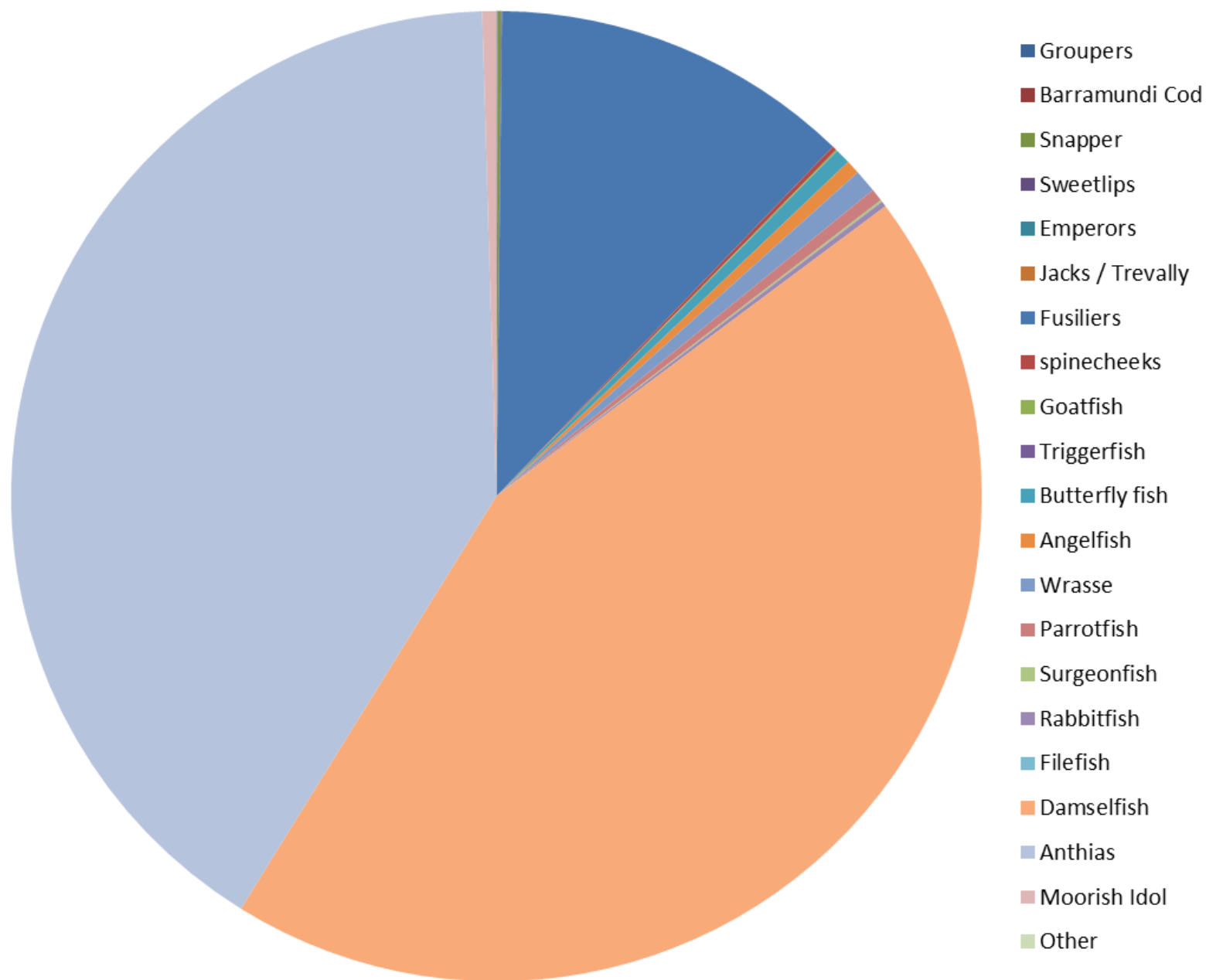
Coral abundance outside the MPA at Buenavista



Invertebrate abundance outside the MPA at Buenavista



Fish abundance outside the MPA at Buenavista



BUENAVISTA

No Significant Difference (Figure above 0.05)

Significant Difference (Figure below 0.05)

Fish Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	16	15	0.574	0.533
Individuals	9592	10734	0	0
Dominance	0.4328	0.3741	0.001	0.001
Shannon H	1.002	1.162	0.001	0.001
Evenness e ^{H/S}	0.1703	0.2131	0.003	0.001
Fisher alpha	1.873	1.716	0.284	0.258

Invert Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	5	2	0.018	0.022
Individuals	15	10	0	0
Dominance	0.2444	0.82	0.002	0.001
Shannon H	1.49	0.3251	0.002	0.001
Evenness e ^{H/S}	0.8872	0.6921	0.178	0.209
Fisher alpha	2.626	0.7517	0.101	0.214

Coral Data:	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	10	10	1	1
Individuals	818	828	0	0
Dominance	0.7852	0.7015	0.004	0.002
Shannon H	0.6057	0.7735	0.009	0.01
Evenness e ^{H/S}	0.1833	0.2167	0.01	0.01
Fisher alpha	1.603	1.6	1	1

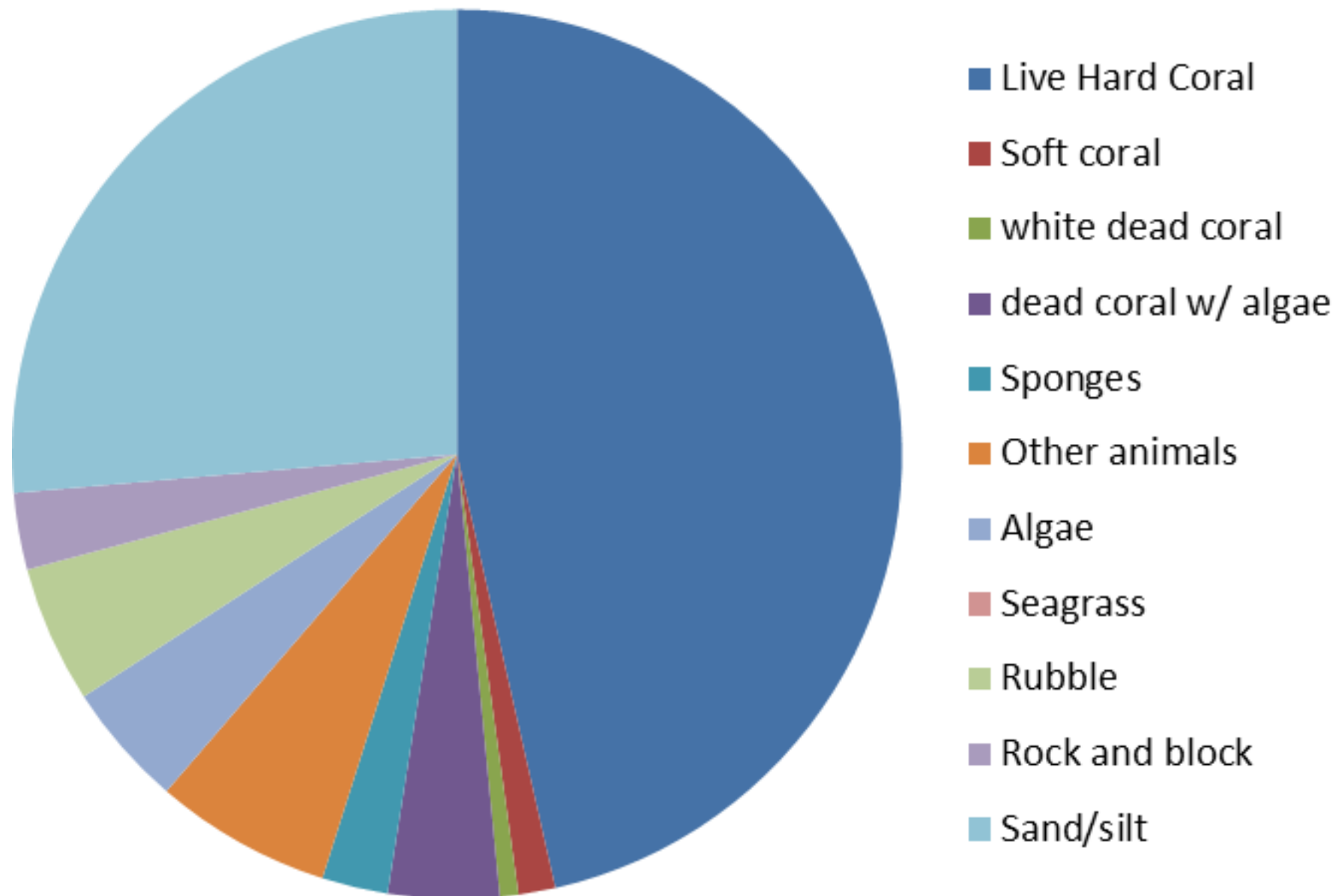
1.1

Coral:	IN	OUT	PERCENTS IN	PERCENTS OUT
Live Hard Coral	484	496	46.44913628	36.63220089
Soft coral	14	27	1.343570058	1.994091581
Wwhite dead coral	7	3	0.671785029	0.221565731
Dead coral w/ algae	42	51	4.030710173	3.76661743
Sponges	25	32	2.399232246	2.363367799
Other animals	67	94	6.429942418	6.94239291
Algae	47	91	4.510556622	6.720827179
Seagrass	0	0	0	0
Rubble	52	133	4.990403071	9.822747415
Rock and block	29	51	2.783109405	3.76661743
Sand/silt	275	376	26.3915547	27.76957164
Total:	1042	1354	100	100

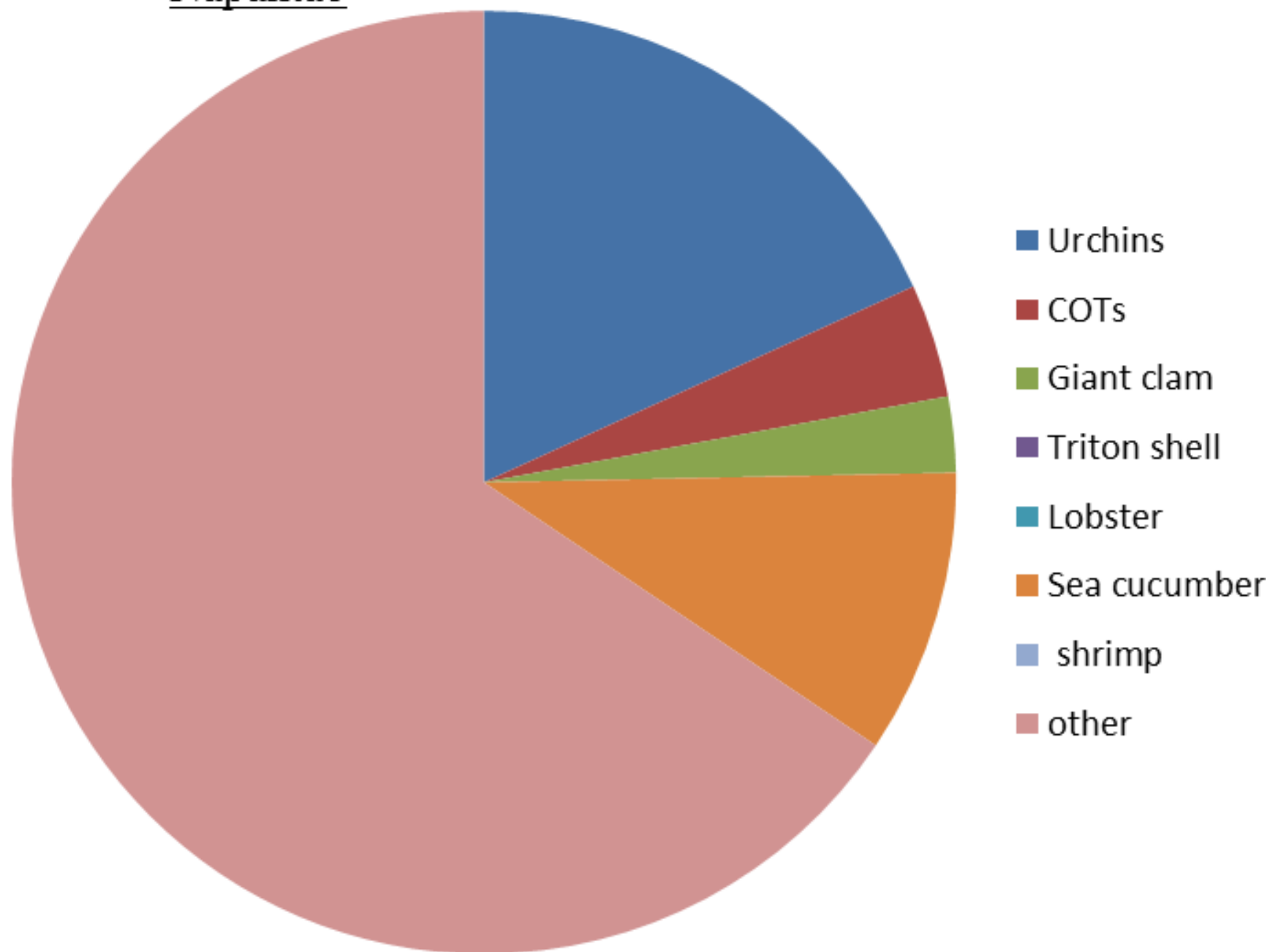
Inverts:	IN	OUT		PERCENTS
Urchins	28	118	18.18181818	38.94389439
COT	6	7	3.896103896	2.310231023
Giant clam	4	3	2.597402597	0.99009901
Triton shell	0	0	0	0
Lobster	0	0	0	0
Sea cucumber	15	8	9.74025974	2.640264026
Shrimp	0	3	0	0.99009901
Other	101	164	65.58441558	54.12541254
Total:	154	303	100	100

Fish:	IN	OUT	PERCENTS IN	PERCENTS OUT
Groupers	29	4	2.099927589	0.369344414
Barramundi Cod	0	0	0	0
Snapper	81	20	5.865314989	1.846722068
Sweetlips	0	0	0	0
Emperors	2	0	0.144822592	0
Jacks / Trevally	1	0	0.072411296	0
Fusiliers	378	334	27.37146995	30.84025854
spinecheeks	53	67	3.837798697	6.186518929
Goatfish	41	46	2.968863143	4.247460757
Triggerfish	48	10	3.475742216	0.923361034
Butterfly fish	165	209	11.94786387	19.29824561
Angelfish	44	63	3.186097031	5.817174515
Wrasse	0	0	0	0
Parrotfish	220	279	15.93048516	25.76177285
Surgeonfish	274	35	19.84069515	3.23176362
Rabbitfish	9	1	0.651701665	0.092336103
Filefish	6	4	0.434467777	0.369344414
Damselfish	0	0	0	0
Anthias	0	0	0	0
Moorish Idol	30	11	2.172338885	1.015697138
Other	0	0	0	0
Total:	1381	1083	100	100

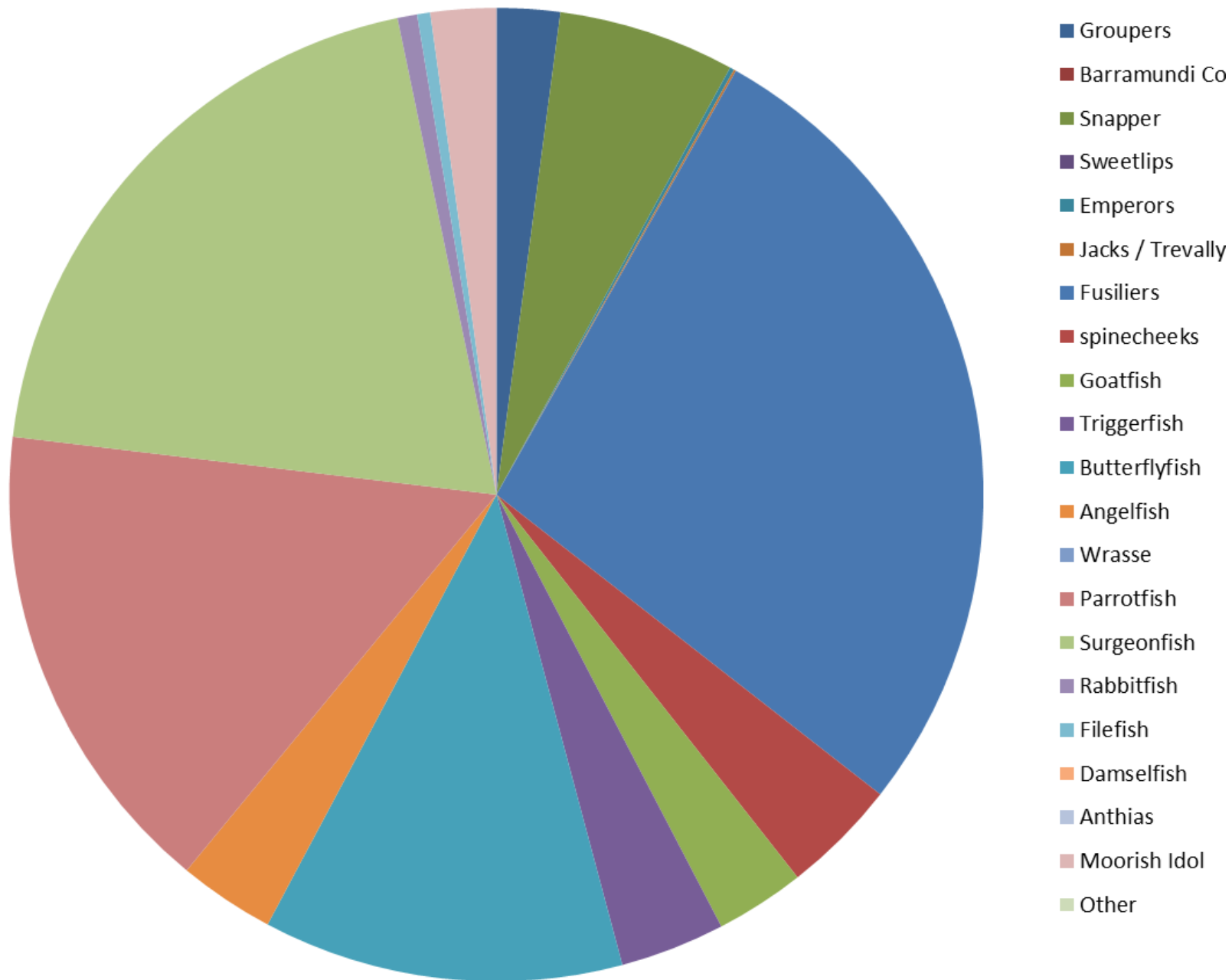
Coral abundance inside the MPA at Napantao



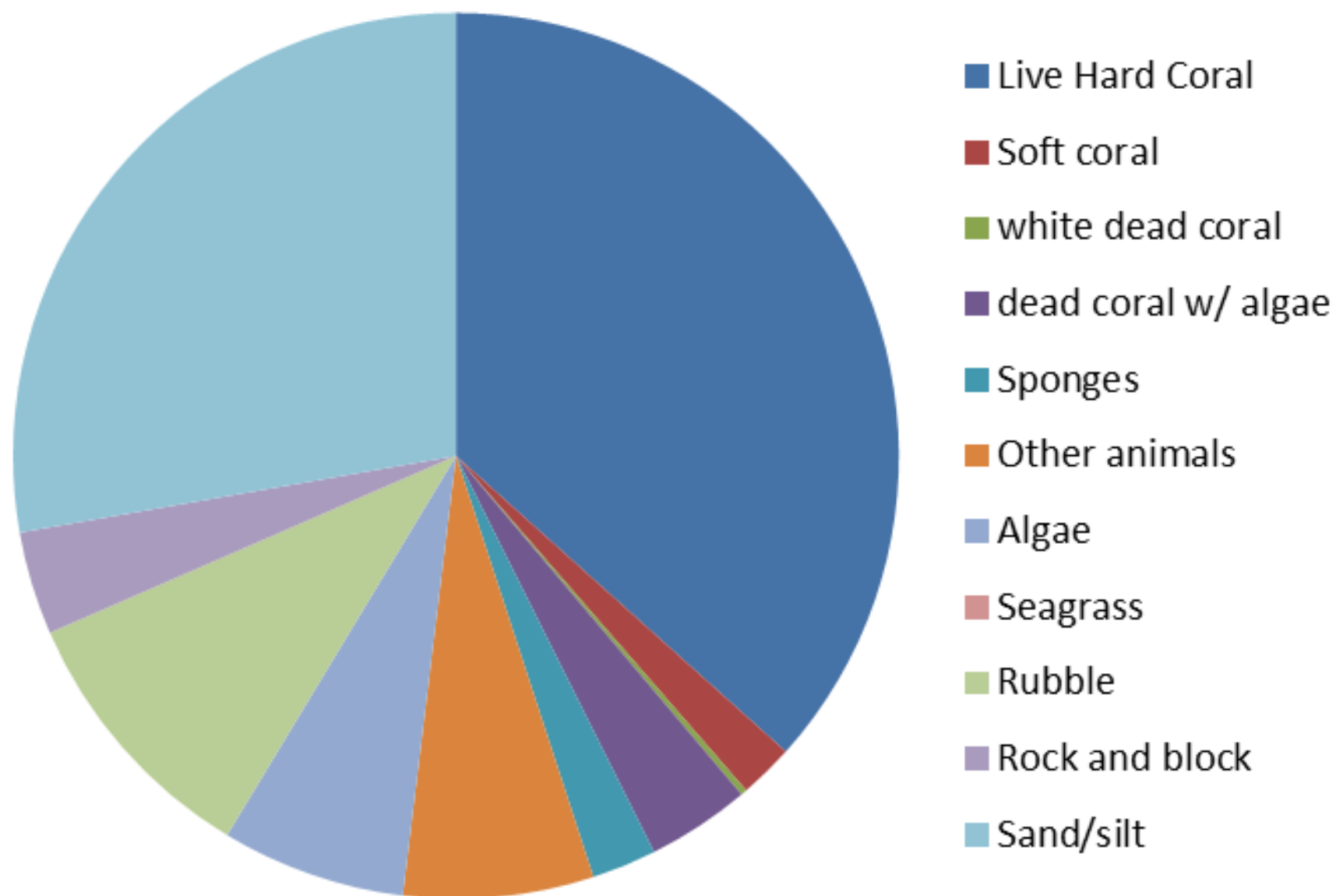
Invertebrate abundance inside the MPA at
Napantao



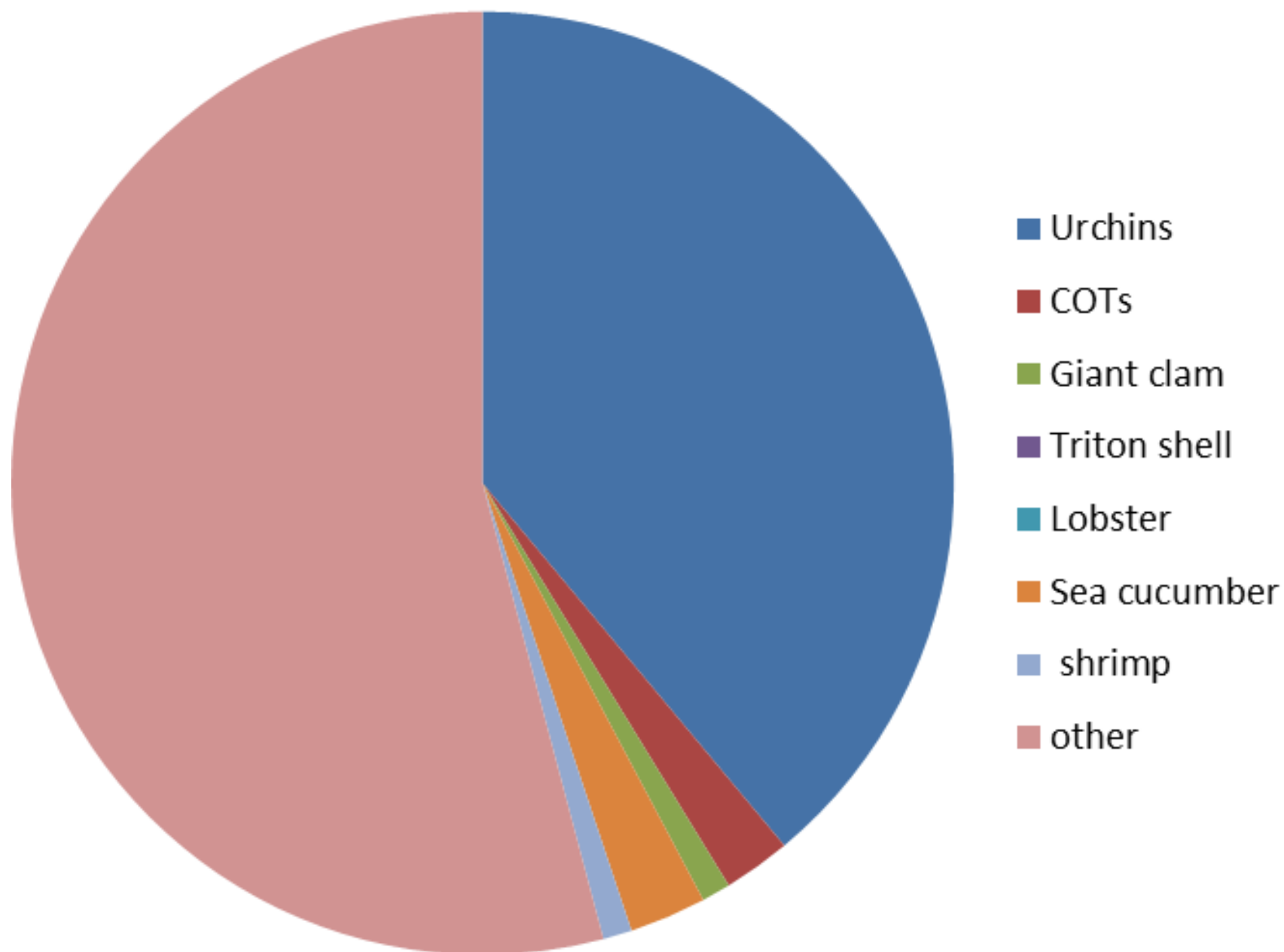
Fish abundance inside the MPA at Napantao



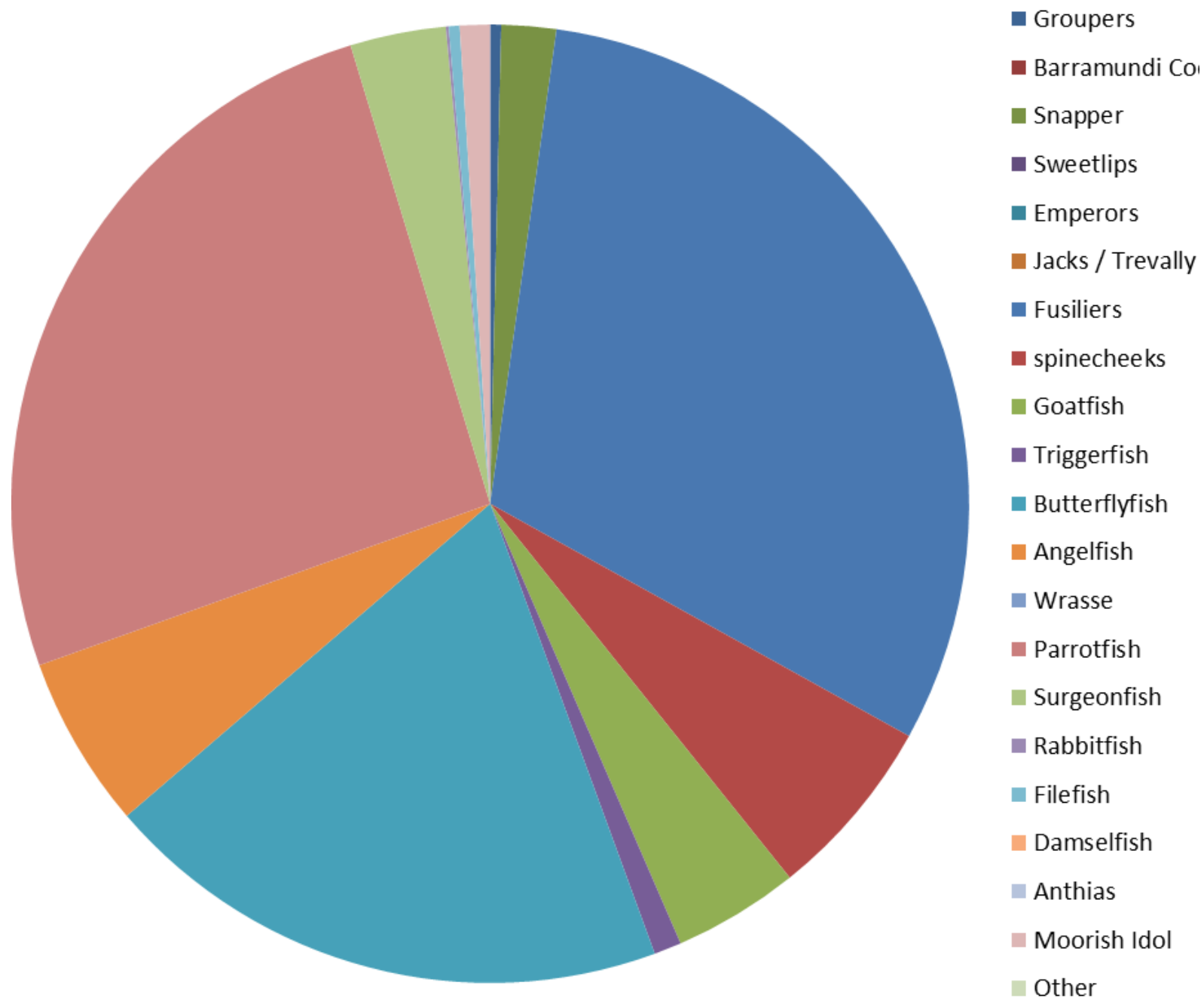
Coral abundance outside the MPA at Napantao



Invertebrate abundance outside the MPA at
Napantao



Fish abundance outside the MPA at Napantao



<u>Coral Data:</u>	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	10	10	1	1
Individuals	1042	1354	0	0
Dominance	0.2973	0.2341	0.001	0.001
Shannon H	1.584	1.745	0.001	0.001
Evenness e ^{H/S}	0.4873	0.5728	0.001	0.001
Fisher alpha	1.533	1.464	1	1
<u>Invert Data:</u>	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	5	6	0.446	0.395
Individuals	154	303	0	0
Dominance	0.4749	0.446	0.42	0.422
Shannon H	1.035	0.9739	0.513	0.488
Evenness e ^{H/S}	0.5629	0.4414	0.069	0.051
Fisher alpha	0.9893	1.06	1	1
<u>Fish Data:</u>	INSIDE	OUTSIDE	Boot p(eq)	Perm p(eq)
Taxa S	15	13	0.124	0.256
Individuals	1381	1083	0	0
Dominance	0.1629	0.2093	0.001	0.001
Shannon H	2.08	1.824	0.001	0.001
Evenness e ^{H/S}	0.5336	0.4766	0.134	0.258
Fisher alpha	2.352	2.077	0.346	0.46

BUENAVISTA

No Significant Difference (Figure above 0.05)

Significant Difference (Figure below 0.05)

TRANCODE						TRANSECT/PHYSICAL FORM				
SURVEY DATE:										
START TIME:			END TIME:			FISH BOUY DEPTH:				
END DEPTH:			START DEPTH:			REPEAT VISIT: (Y/N)				

Geomorphical Classes Surveyed during entire Dive (ONLY 1 REQD PER SURVEY)
Remember: each new zone is a new habitat, so requires a new biological recording form for each.

	tick	
Lagoon		Shallow zone between backreef and land. Soft substratum
Backreef		Shallow zone between reef crest and lagoon.
Reef Crest		Shallowest (often emergent zone); separates fore from backreef
Forereef		Sloping face of reef unto 45 degrees
* Reef Front		Forereef slope from 3-10m
* Upper Reef Slope		Forereef slope from 10-20m
* Lower Reef Slope		Forereef slope from 20-30m
Escarpment ("wall")		Any area of reef whose slope is greater than 45 degrees
Dense Patch Reef		Area of coral 'bommies' >70% hard coral, often sand between
Diffuse Patch Reef		Area of coral 'bommies' <70% hard coral, often sand between

UNDERWATER IMPACTS		IMPRESSION OF THE SITE					
LITTER		AESTHETIC	POOR	AVERAGE	GOOD	V. GOOD	EXCELLENT
SEWAGE		BIOLOGICAL	POOR	AVERAGE	GOOD	V. GOOD	EXCELLENT
CORAL DAMAGE		GENERAL LOCATION					
LINES/ NETS		(SHORE REFERENCE)					
FISH TRAPS		TOPOGRAPHY	LOW		MEDIUM		HIGH
SEDIMENTATION		MAIN HABITATS					
DISEASE		ORIENTATION					
BLEACHING		DISTANCE TRAVELLED	m				
DYNAMITE		APPROX DISTANCE REMAINING	m				
OTHER							

LATITUDE START:	07	LATITUDE END	07
LONGITUDE START:	1	LONGITUDE END	1

CURRENT STRENGTH	NONE	WEAK	MEDIUM	STRONG	WIND STRENGTH (BEAUFORT)	
CURRENT DIR. (revolve)	(N,NW etc.)				WIND DIR. (true)	
TEMPERATURE		AT DEPTH OF			SURFACE TEMPERATURE	
SALINITY		AT DEPTH OF			SURFACE SALINITY	
SECCHI						

SURFACE ACTIVITY			SURFACE IMPACTS		
OCCUPANTS	PROXIMITY	ACTIVITY*			
			LITTER		
			ALGAE		
			SEWAGE		
			NETS		
			DRIFTWOOD		
			OTHER		

	FIRST NAME	SURNAME	NO. SURVEYS
PHYSICAL			
FISH			
CORAL			
ALGAE/INVS			

DATABASE INFO	
ENTERED BY	
DATE	
LOGGED?	
CHECKED BY	
DATE	

SPECIES ABUNDANCE		Rating	Abundance Scale (zone, substratum, algae)	Numbers (fish/inverts)
N.B. ALL CORAL AND FISH TARGET SPECIES MUST ALSO BE COUNTED IN THE APPROPRIATE FAMILY OR LIFEFORM		0	None	0
		1	Rare	1-5
		2	Occasional	6-20
		3	Frequent	21-50
		4	Abundant	51-250
		5	Dominant	250+

MICRO-ALGAE		MARINE PLANTS		Molluscs	
Cyano-Bacteria: Blue-Green	1	Sea Grass	102	Gastropods:	Abalone
		Thalassia sp.	108		Murex sp.
		Halophila sp.	105		Conch
		Other:			Cowrie
		Mangroves	114		Titon
		TOTAL PLANTS			Cone Shell
		(Not Including Algae)			Druppella sp.
		TARGET INVERTEBRATES			Limpet
		Polychaeta: Sponges			Topshell
		Tube	126		Nudibranch
		Barnel	146		Other
		Elephant Ear	128		Bi-Valves:
		Branching	143		Oyster
		Encrusting	130		Giant Clam
		Lumpy	145		Other Clam
		Rope	144		Other
		Vase	125		Chiton
		Further Green Algae:			Cephalopods:
		Dictyota sp. (Flat-Branching)	44		Cuttlefish
		Paddle sp. (Fan Blade)	50		Squid
		Lobophora sp. (Blade/Ruffle)	49		Octopus
		Hydrodictyon sp.	48		
		Turbinaria sp. (Pyramid)	55		
		Brown Filamentous	42		
		Sargassum sp. (Bladder)	53		
		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
		Lobophora sp. (Blade/Ruffle)	49		
		Hydrodictyon sp.	48		
		Turbinaria sp. (Pyramid)	55		
		Brown Filamentous	42		
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		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
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		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
		Lobophora sp. (Blade/Ruffle)	49		
		Hydrodictyon sp.	48		
		Turbinaria sp. (Pyramid)	55		
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		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
		Lobophora sp. (Blade/Ruffle)	49		
		Hydrodictyon sp.	48		
		Turbinaria sp. (Pyramid)	55		
		Brown Filamentous	42		
		Sargassum sp. (Bladder)	53		
		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
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		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
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		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
		Lobophora sp. (Blade/Ruffle)	49		
		Hydrodictyon sp.	48		
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		Turbinaria sp. (Pyramid)	55		
		Brown Filamentous	42		
		Sargassum sp. (Bladder)	53		
		Further Brown Algae:			
		Dictyota sp. (Flat-Branching)	44		
		Paddle sp. (Fan Blade)	50		
		Lobophora sp. (Blade/Ruffle)	49		
		Hydrodictyon sp.	48		
		Turbinaria sp. (Pyramid)	55		
		Brown Filamentous	42		
		Sargassum sp. (Bladder)	53		
		Further Brown Algae:			
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		Paddle sp. (Fan Blade)	50		
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