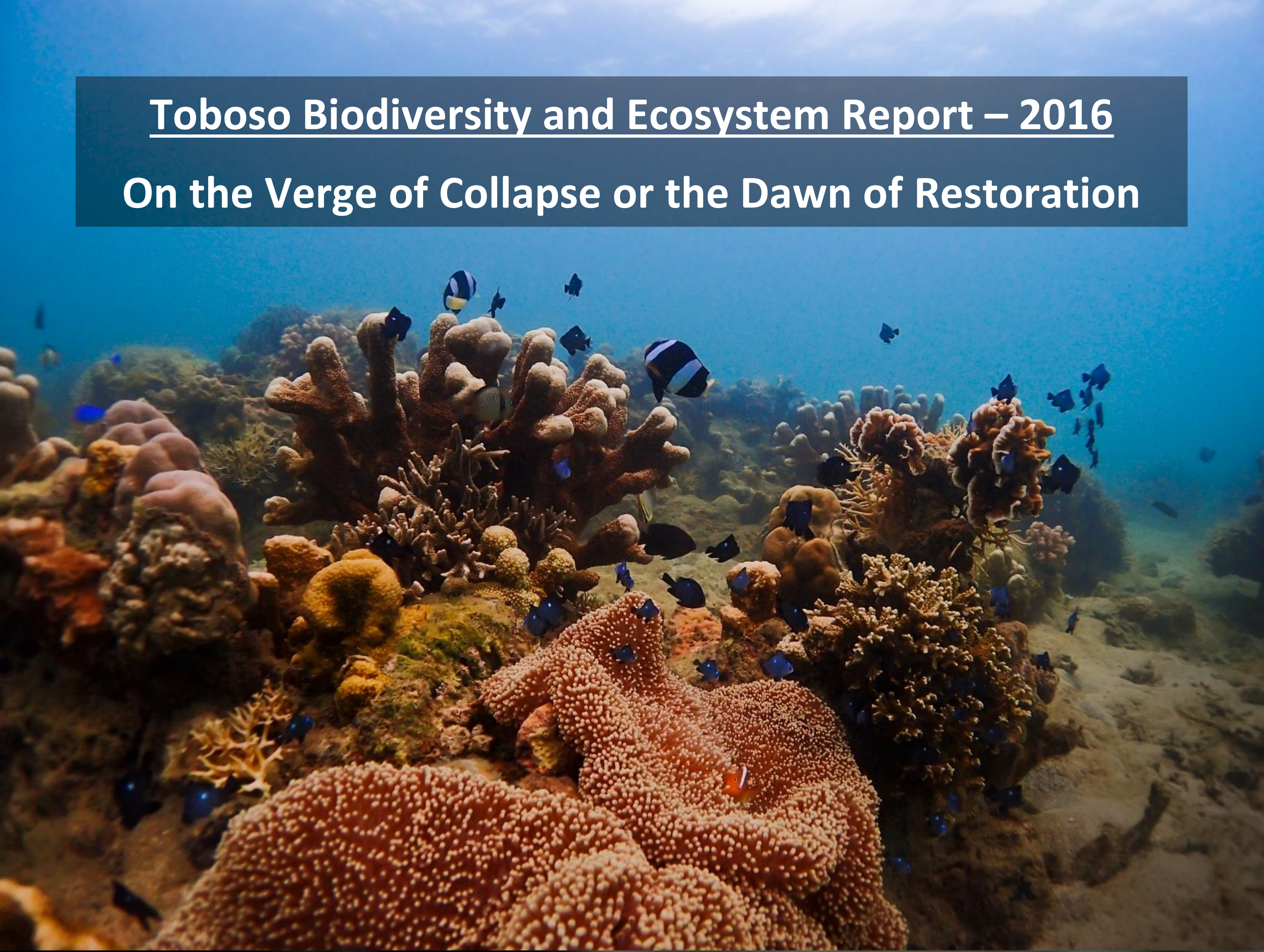
Toboso Biodiversity and Ecosystem Report – 2016

On the Verge of Collapse or the Dawn of Restoration



New Heaven Reef Conservation Program

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Preliminary Ecological Assessment Project
Supported by **Worldreef Toboso**. In collaboration with **Conservation Diver** and the
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Contents and Figures

Introduction

The Municipality of Toboso is located in the North-East of the island of Negros in the Philippines and currently holds a population of approximately 41,000 (PNSO, 2010), and includes a coastline of approximately 11km. Currently, the economy in the area is largely driven by agriculture and to a smaller extent, fishing. At present there is no tourism industry in the area to speak off and therefore Toboso is largely supported by extraction of its natural resources. The coastline is fringed in many areas by coral reef habitats and seagrass/algal beds in the shallows. Intertidal and terrestrial nearshore areas at many locations around the coast have natural mangrove growth and plantations. Based off the Worldbank Philippines Environment Monitor Report (Bebet et al., 2005), the Philippines currently includes over 35,000km of coastline, bordering 226,000 km2 of coastal waters and almost 2 million km2 of deeper, oceanic waters. Philippines Fisheries statistics put the total area of coral reef within the Philippines (within 18-36 meters) at approximately 27,000 km2 (Padilla, 2008). The exceptional level of marine diversity found in the Philippines has been extensively discussed in scientific literature, and continues to play host to a wide array of taxonomic and ecological research efforts (i.e Carpenter, 2005; Veron et al, 2009). Sitting at the heart of the so called 'Coral Triangle', the reefs of the Philippines are representative of some of the most diverse and complex coral reef ecosystems around the world. Toboso is included within the region described by Veron et al. (2009) as South-East Philippines, which was found to have 533 species of hard coral, thereby representing a diversity larger than 50% of the global zooxanthellate coral diversity.

Data from the past couple of decades (Burke et al 2002; White and Cruz-Trinidad, 1998) have suggested values of greater than 100 million USD per annum gained from tourism and recreation at coral reefs of the Philippines. The same data also suggests annual savings of greater than 300 million USD from erosion prevention and other enhancements to coastal substrate in the Philippines. Both figures pale in comparison to the stated value of more than 600 million USD gained from sustainable fisheries (including aquaculture). Given the sharp declines in fish catch and apparent collapse of much of the nearshore fishery at Toboso, and the complete lack of any current marine tourism activity, it can safely be said that the largest economic gains currently benefiting Toboso from coral reefs come from coastal protection. This does not however detract from the massive potential value to be gained from sustainable use of these natural resources. Padilla (2008) states that there are approximately 2,818 species of fish are recorded from the Philippines, with 1,727 species being classified as 'reef associated'. This suggests therefore that the majority of species recorded in the Philippines thus far, depend in some way or another on healthy coral reef habitats. Aliño and Tiquio (2008) further break down the habitat associations by number of genera, with 307 associated with coral reefs, 30 genera being associated with mangrove ecosystems, and only 19 species being associated with seagrass beds. This data however only pertains to fish species, and are widely accepted to be underestimates due to the ongoing taxonomic efforts in the region.

Many of the coastal ecosystems within the Philippines face ever mounting threats and already show incredible signs of degradation (White and Cruz-Trinidad, 1998; BFAR, 2004; Logan et al., 2014). Among the leading efforts to combat much of this degradation within the country, and throughout Indo-Pacific tropics, is the creation and delineation of zonation areas along the coast, particularly in the form of Marine Protected Areas (MPAs). In principal, these areas are tailor made to the area in question, and offer significant protections to ecosystems and fauna within the zoned areas, by enforcement of specific legislation. MPAs throughout the world have shown varying degrees of success, and certainly provide a legal standing to deter unregulated extraction or utilisation of these areas (McClanahan et al., 2006; Almany et al., 2007; Stobart et al., 2009). A number of in-depth analyses have been carried out on the concept and success of MPAs in the Philippines, including those relatively near Toboso (i.e Pollnac et al., 2001, Christie et al., 2009). This body of literature, and the results and recommendations within it, must be taken into consideration if a resilient zonation scheme is to be implemented in modern day Negros.

However, MPAs are not always as effective as their potential would imply, with a number contrasting opinions on their usefulness. Within the Philippines for example, it was found that of the 439 MPAs designated throughout the country by 1999, only 44 were fully enforced (White et al., 2002). Additionally, poorly designed or implemented MPAs have been known to be a cause of tension between industries that are sometimes seen as competing, namely marine tourism, and fisheries. For example, in the Mabini area of the Philippines, MPAs are largely set up to support the growing snorkelling and dive tourism industry, but have caused tension with local fisher folk, primarily due to different expectations as to the role and priority of the given MPAs (Oracion et al., 2005; Majanen, 2007). Creation of these areas must also come with efforts to spread awareness and get perspectives of all stakeholders, and most importantly creation and awareness must be supported by appropriate and up to date scientific literature. Friction between the fishery industry and other industries utilising the marine environment, may largely be depending on the relative size and scale of the fishery and the rate of extraction of certain waters. Fishing activities at Toboso are almost exclusively categories as municipal level fishing, as opposed to true commercial fishing, with the key differences being that municipal fishing activities are mostly seen as ‘small scale’ relatively, with vessels of 3 gross tonnes or less (Padilla, 2008). Though the fishing activities in Toboso are commercial in nature, relatively little is exported beyond the borders of the municipality, and the majority of all fishing vessels at the municipality are within the 3 tonne category. Contrasting to this, true commercial fishing vessels are classified as those of between 3 gross tonnes to up to and over 150 gross tonnes.

Table 1 – Philippines fisheries catch data in metric tonnes from 2006, based on source habitat and catch type

Species group	Ecosystem					
	Coastal				Oceanic	Total
	Mangrove	Seagrass	Coral reef	Other coastal		
Small pelagic	10,100	-	83,272	950,743	-	1,044,115
Large pelagic	178	-	1,355	-	603,372	604,904
Demersal	12,991	3,089	34,272	299,097	-	349,448
Other fish	-	-	-	9,883	-	9,883
Invertebrates	6,833	5,292	75,851	52,805	-	140,781
Mammals	-	-	536	4,822	-	5,357
Aquatic plants	-	29	285	-	-	314
Total	30,102	8,410	195,570	1,317,349	603,372	2,154,802
% to row total	1.40	0.39	9.08	61.14	28.00	100.00

Data taken from Padilla 2008 (Table 1) shows proportional catch values in metric tonnes based on catch type and ecosystem source, during 2006. Of the three ecosystems specifically analysed, the coral reef areas host the greatest proportion of catch in all categories. However, these values are less than 10% of the fish catch sourced from 'other coastal' areas, outside the reef. Additionally, all three ecosystems had a significant portion of their catch being that of invertebrate fauna, however these proportions are not maintained in other coastal nor oceanic fishing. Given that a sizeable portion of invertebrate catch in the tropics is squid fishing in open sea and oceanic areas, the relative intensity of these values indicate broad range in invertebrate species being caught at these ecosystems. As of yet no baseline work has ever been carried out in the Toboso region to assess diversity or state of the fishery in the nearshore marine ecosystems. The lack of a baseline study on ecosystem health around the area limits the accuracy of any management initiatives concerning those ecosystems, and poses challenges to future ecological studies in the area.

Project Overview

The primary purpose of this pilot endeavour was to establish a quantifiable baseline for the coastal marine resources at Toboso. This was broadly divided into a broad, holistic analysis of biodiversity inventory, and an ecological assessment of key coastal ecosystems. At present, the authors could find no published scientific literature regarding marine resources for the Toboso region, and only a handful for the entirety of Negros Occidental. Given the unique level of pressures faced by ecosystems at Toboso, extrapolating data from other regions of Negros was deemed to be of little value. It should be noted however that the nearby locations at which studies were conducted coincide with diverse coral reef communities and areas with established MPAs, with studies carried out sporadically over the past decades, with increasing frequency in recent years. (i.e. Alcala and Luchavez, 1981; Reyes and Yap, 2001; White et al., 2003; Beger et al., 2004).

At present, a very small number of local Non-Governmental Organisations (NGO's) and a portion of the governing body show support for management of the coastal resources. Though this rarely converts to action, there appears to be a consensus to shift activities towards more sustainable and alternative means of resource use, due to the dire state of present coastal fisheries. Numerous accounts from multiple long term residents of Toboso, have clearly stated severe declines in landings of commercially valuable species from the local fishery. This is of course, not unique by any means from the perspective of both regional and global fisheries. The rate of this decline cannot be easily quantified due to the amount of publicly available data of past fish stocks, which is severely lacking.

With novel discussions and planning regarding creation and implementation of a Marine Protected Area and bordering reserve at the region, it becomes all the more important to assess the baseline of data of marine ecosystems, both within the proposed MPA, and throughout the region as a whole. The timing of this analysis is deemed all the more crucial as, at the time of writing, the Indo-Pacific region succumbs to one of the worst El-Nino (El-Nino Southern Oscillation, hereby abbreviation to ENSO) events in global recorded history. From the perspective of valuable marine ecosystems, particular note is made of the impacts on coral reef ecosystems, where significant media coverage and records are being made of widespread coral bleaching observed all the way from Australia, through Thailand, to the Maldives and further, and of course in the Philippines (Arceo et al., 2001, Carpenter et al., 2008, Logan et al., 2014).

Objective 1

A primary objective of the expedition was to catalogue and organise a preliminary inventory of species found in conjunction with the coastal marine environment. The necessity of this is twofold; the first was to meet the minimum species richness standard of 100 species, set by the provincial governing bodies, to qualify an area of municipality to host an MPA and/or MR; the second was to assess the type of species present from the perspective of ecosystem health and economic value from both tourism and fishery perspectives.

Species inventory data was collected from past observations and surveys (largely intertidal) and local fisheries catch. Additional snorkeling and SCUBA surveys were carried out in mangrove, seagrass, algal and coral reef habitats. Surveys were conducted at various stages of the coastline throughout Toboso, with particular focus on coral reef habitats due to the supported biodiversity within. A significant preliminary database of species had already been initiated prior to the present work, but was reorganised and re-evaluated within the present work. Species identification was largely carried based on photographic support, with reconfirmation in-situ during surveys. Identification of species was confirmed as closely as possible with published literature and a number of guides by established taxonomists. Given the broad spectrum of species to be identified (multiple phyla of both flora and fauna), identification was carried out to the closest degree of taxonomic accuracy with reliable identification. Current taxonomic status of a number of specific taxa were verified using WORMS (2016). Though we accept the need for certain areas of the database to be updated and will likely be outdated in coming years due to the turbulent nature of taxonomy, particularly in light of the growing emphasis on molecular methods, the vast majority is accurate at the time of writing.

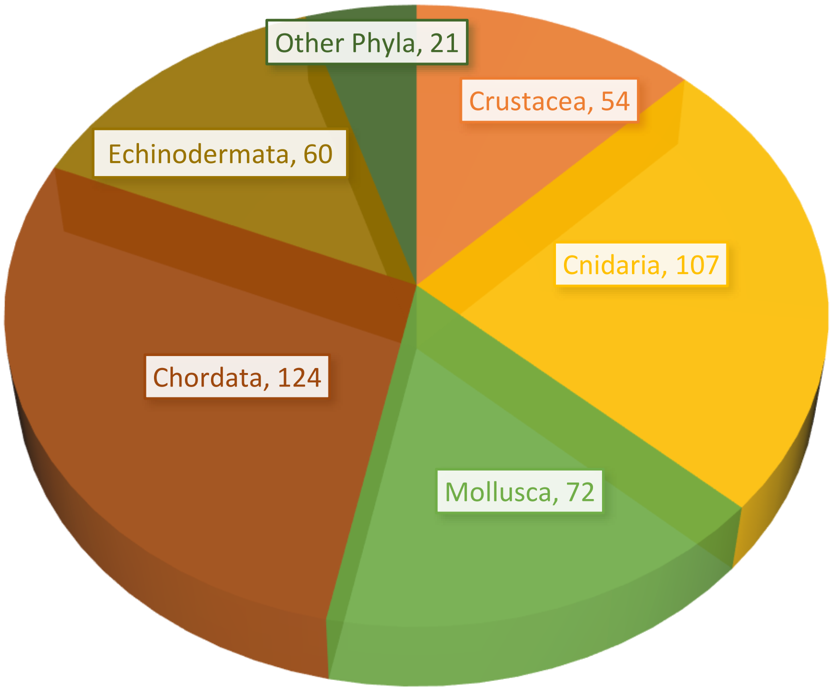
Objective 2

The second major objective of the present work was to assess the ecosystem health and pressures, with major focus on coral reef environments, throughout the region. Particular attention was paid to the areas of the currently proposed MPA location to assess the ecological value of these sites. Key habitats for marine life in the regions were divided as Mangrove, Seagrass/Macro-algal, and Coral Reef systems. Ecosystem health analysis was focused on Coral Reef environments due to their key importance in regional biodiversity and relatively slow growth and recovery rates. The floral ecosystems (Mangrove, Seagrass and Macro-algal) were assessed primarily by roving and random transects, whereas the coral reef environments were assessed via regular belt transects throughout a large portion of the fringing reef along the coastline of Toboso. Belt transect methodology followed the Ecological Monitoring Program protocol according to Scott (2014) after being adapted for regional variables (faunal diversity, ecosystem pressures etc.). Transects were divided to provide a high resolution representation of substrate composition, vertebrate diversity and invertebrate diversity, with particular focus on indicator and keystone species. This methodology was particularly useful in identifying variation in reef health at different locations along the coast and therefore plays a crucial role in zonation processes, including MPA and MR locations.

Results

This preliminary work has yielded a total of 435 species of fauna associated with the marine and coastal ecosystems of Toboso. These species are divided into 197 families, from multiple phyla (Appendix 1). An additional 18 species of flora (mangroves, sea grass and algae) were found from the area (Appendix 2), creating a total species inventory of 453 species. This figure is more than four times the minimum value quoted by the provincial bodies for the establishing of an MPA. Though significantly higher than local estimates, this value is by no means an indication of a complete inventory. The species found herein are simply an effective baseline by which future work can be compared to and contributed to. The most diverse phyla found were the Chordata and Cnidaria both with over 100 species recorded (Fig. 1). Within these, the most specious animals were the fish (Actinopteri) with 120 species and over 60 species of hard coral (Scleractinia). This was followed by Mollusca with over 70 species.

Figure 1 - Faunal Species Diversity Comparison of Phyla at Toboso, Philippines



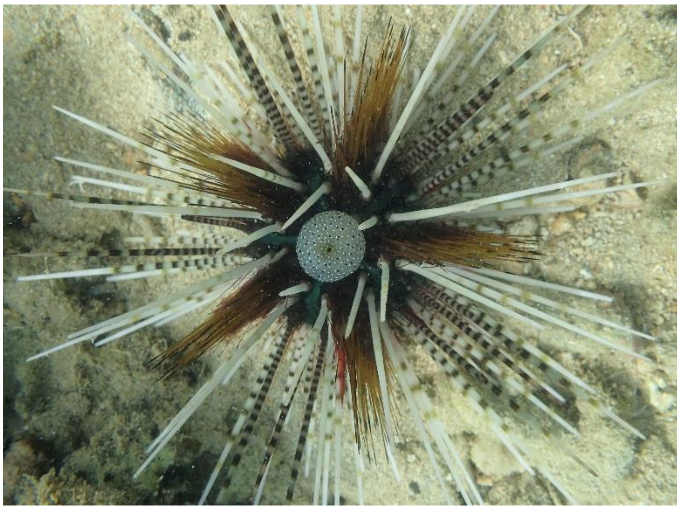
1: Species of Ecological Importance.

A number of indicator species were identified that play a significant role within key coastal ecosystems of the region. For the purposes of this analysis, the key ecosystem of focus that will be discussed is the Coral Reef ecosystem. This is due to facts that species diversity and composition recorded within the coral reef areas were significantly higher than species found in Mangrove, Seagrass/Macroalgal and Dynamic Benthic (soft sediment) ecosystems combined and a number of discussed species were also observed outside the reef systems. Additionally, the prevailing threats and the potential economic utility of coral reef areas make them a priority habitat for assessment.

The coral reef communities of Toboso are comprised of at least 65 different species in 15 different families of Scleractinia, forming the majority of hard substrate off shore. Riverine input at multiple locations along the coast has resulted in significant sedimentation pressure along most near-shore reef areas, and regions of high turbidity. A small number of areas are pockmarked with clear signs of significant physical damage to the reef, primarily by use of anchors and historic dynamite fishing practices. During the present study, bleaching was observed at all reef habitats, with an estimated maximum of 50% bleached coral at a given site. Additionally, there was observation at all locations of recent large scale mortality of corals, providing strong indications of a prolonged bleaching event that predated the present investigations. Due to an extremely limited local survey input at the reef areas, this could not be directly verified. There were no outbreaks of disease observed on the reefs.

The high demand for commercially valuable species has resulted in a severely depleted abundance of wildlife. With regards to key invertebrate fauna, this depletion is particularly apparent in the abundance of Giant Clams (*Tridacna* spp.) which play a crucial role in filter feeding and zooxanthellae stocks, not to mention creation of substrate (Cabaitan *et al.* 2008; Neo *et al.*, 2015). However, extraction of the species has been extremely high resulting in a total of 8 individual clams observed throughout the entire study (*T. crocea* x 4 and *T. squamosa* x 4). High nutrient input, most likely from estuarine influence, has resulted in significant macroalgal coverage in the shallower parts of most reefs surveyed. Macroalgal growth is a well-documented competitor of coral reef habitats during periods of high nutrient input, often outcompeting new recruits and large colonies alike due to rapid growth rates (Lirman, 2001; McCook *et al*., 2001; Barott *et al*., 2012).

Key herbivorous invertebrates such as sea urchin species help to regulate the abundance of algae on reef systems (Jessen and Wild, 2013; Humphries et al., 2014), and multiple species were found to be abundant throughout reef and algal dominated habitats throughout the region. Of particular note were high abundances of *Diadematidae* spp., including *Echincothrix calamaris* and *Diadema setosum* in shallower areas and *Diadema savignyi* becoming more abundant with depth. Of the sea cucumber species, signs of overexploitation were apparent in the highly depleted stocks of *Holothuridae* and *Stichopodidae* spp., multiple species of which are regularly collected both in shallower and deeper areas for consumption. Species of synaptid sea cucumber were significantly more abundant, perhaps due to their relatively low demand as consumables in the local community. A number of sea cucumbers species, included many of those observed at Toboso, play important roles in nutrient cycling and breakdown of organic matter in coral reefs (Bakus, 1973; Uthicke, 1999; Mangion *et al.,* 2004; Nestler *et al*., 2014). Invertebrates that pose a risk to corals in particular include bioeroders such as boring organisms and large aggregations of sea urchin species, and coralivores. Of the coralivores, notable observations included the Crown of Thorns sea star (*Acanthaster planci*), the cushion star *Culcita novaeguinea* and species of Drupella sea snail (*Muricidae*: Drupella spp.). Abundances of Drupella were found to be low however and *A. planci* was largely localised to a small number of individuals observed within a single 200m stretch. *C. novaeguinea* was observed preying on *Pavona frondifera* and *Fungia fungites*, but these observations made up a small portion of all individuals observed.



A high diversity of fish species was catalogued from the region, including several that play important ecosystem roles on the reef. However, abundances of any fish greater than approximately 30cm were largely absent with only 4 individuals being observed throughout the study (not including eels). Absence of many species of predators or mesopredators was apparent with only records of certain species such as elasmobranchs or barracuda being known from historic observations in the fish market. Algivorous and obligate herbivorous species, such as parrotfish and rabbitfish, were rare with incredibly low diversity and abundance. Diversity of Butterflyfish (*Chaetodontidae*) was among the highest of all vertebrate families found at Toboso, with 10 species recorded thus far. These fish play an important role as consumers, particularly as corallivores (Pratchett, 2007; Cole et al., 2008; Gregson et al., 2008), controlling and influencing the dominance of some corals over others (i.e. Cox, 1986) and have been shown to be effective indicators for species richness estimates in reef environments (Kulbicki and Bozec, 2005).

2: Species of Economic Importance

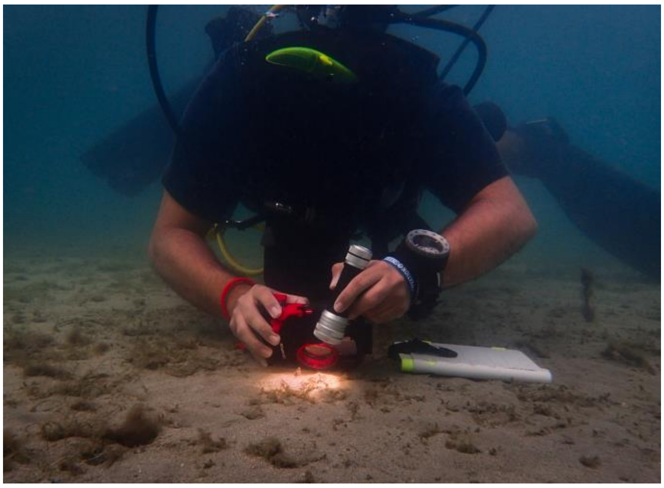
a) Tourism

The local economy of Toboso has historically been driven by marine resources, almost exclusively from the local fishery. This has however changed in recent years as annual catch rates declined heavily and the fishery industry was rapidly replaced with a greater focus on agriculture. Though there currently exists no tourism industry in the area, coral reefs in nearby areas around the island have contributed significantly to the expansive marine tourism industry of the Philippines. A number of species found in the present work are shown to be popular in SCUBA and snorkeling tourism in the region and therefore carry potential economic value to instigate a drive towards marine tourism activities in the area. However, a point that will continue to come up repeatedly in this report is the substantial and far reaching impacts of the overexploitation of much of the coastal fauna, including a number of species that would indeed have played significant roles in tourism activities.

The fauna that hold little demand for local consumption are those that remain abundant at, and around the reefs, and given the broad range of species commercially caught, the charismatic species to be found are largely invertebrates or small chordates. The Philippines boasts a large number of locations with strong economies based around recreational marine tourism, in particular revolving around macro photography (i.e Anilao, Batangas). This has therefore established a strong base of wildlife with commercial value to tourism, including, among the vertebrates, small and colourful fish species like sygnathids and cryptic species such as frogfish and stonefish. On Toboso, by far the dominant species of *Sygnathidae* is the pipefish species *Corythoichthys haematopterus*. A number of other species have also been observed that could prove valuable in marine tourism such as seahorse species (*Hippocampus* spp.). Aposematically colourful venomous species such as lionfish are also known to be popular, of which 2 species are recorded from Toboso.

By far among the most popular of reef fish globally are the anemonefish, followed closely by the damselfish, together making up the bulk of *Pomacentridae*. Currently, 5 species of anemonefish are recorded at Toboso, as part of the total 16 species of Pomacentrids, unsurprisingly resulting in the largest family of chordates found at Toboso. In terms of charismatic colouration in coral reef environments, butterflyfish are seen as the iconic reef fish and have a wide array of patterns and colours on display, undoubtedly contributing to their popularity. Over half of all butterflyfish observed at Toboso were in their subadult stages (<10cm approx.

diameter) but the reefs hosted a diversity of 10 different species. Juvenile and subadult fish can on occasion be of greater charismatic value than the adult stages, such as the harlequin sweetlips (*Plectorhinchus chaetodonoides*) which was observed during the survey during both juvenile and intermediate transitionary growth phases. A number of different eel species were observed, including garden eels (*Heteroconger* sp.) and snowflake eels (*Echidna nebulosa*), that are frequently included as species of interest in the diving and snorkeling industries of the tropics.



Vertebrate species make up only a portion of the diversity of species valued by macro enthusiasts, with large portion of these valued species belonging to the number of invertebrate phyla found in the regional waters. Of the species found during surveys at Toboso, 34 species of heterobranch sea slug were observed. Sea slugs play a major role in macro photography around the world due to their ornate morphology and their brightly coloured mantles. Though this figure is significantly lower than national estimates for sea slug diversity due to the highly reduced survey effort, this provides a strong baseline of species that can be lucrative to marine recreational tourism. Other mollusc species that are strong contenders for touristic highlights include the cephalopods, bobtail squid (*Euprymna* sp.), seen in abundance after sunset, and octopus (*Abdopus* sp.) living in the shallows.

Similarly, a number of charismatic crustacean species, such as *Hymenocera picta* and *Neopetrolisthes maculatus* which are known to be target species for macro photography enthusiasts. A number of mantis shrimp species (Stomatopoda) and species in the family *Palaemonidae* could also contribute to the list of species of value to marine tourism in the area. Among the echinoderm species, the high abundance of crinoids in the reef and certain colourful asteroids at various habitats including species of *Ophidiasteridae* and *Oreasteridae*, particularly species such as *Linckia laevigata,* could play a major role in shallow water tourism activities. These species are easy to spot and observe given their high abundance and relatively large sizes when compared to some of the macro species mentioned above. When combined with the diversity of sand and reef dwelling anemones, the wide array of charismatic invertebrate life may support a developing tourism industry in the area.

b) **Fisheries**

An extensive array of species found at Toboso appear to sit somewhere along the spectrum of commercial value ranging from typical/high value species such as snapper and grouper and the large diamondback squid (*Thysanoteuthis rhombus*) which could contribute to local exports, to more specialist/unconventional species such as Sipuncula spp. and *Dolabella auricularia*. The diversity and potential for fishery activity is present, however stocks of almost all species of any value have shown clear indications of heavy depletion. Mean size ratios for fish species throughout the coast have been discussed, with specific examples compared (Fig. 2). With very few species considered bycatch, and most fishing methods being nonspecific regarding target species, it is unsurprising therefore that mean fish size throughout the coasts has suffered across the fish community. Additionally, fishing activity is persistently active at shallower environments such as seagrass, mangrove and coral reef environments, actively displacing juvenile fish and disrupting the important role of these ecosystems as nurseries for fish. With pressure on both adult and juvenile fish, it is only a matter of time before specific areas or species fail to recover entirely. The pelagic nature of fish larvae can significantly, and no doubt currently does, contribute to population restocking in the area, but it is unlikely that the excessive rate of exploitation is limited to the Toboso area only.

It is understood that aquaculture zones have been set out in addition to the MPA and MR as part of the developing zonation scheme, and undoubtedly these will provide significant economic benefits, if conducted sustainably. A number of commercially valuable molluscan species such as bivalves and edible gastropods such as abalone species are already present in the area (Appendix 1) and could work well as part of invertebrate aquaculture scheme. Additionally, *Tridacna* nursery programmes could be put in place as part of a restocking effort to promote reef health and diversity and support the heavily dwindling population of giant clams. Aquaculture schemes for native fish are also a possibility and could significantly decrease the pressure on wild stocks in the area, thereby allowing many areas of the coast to recover much of the lost ecosystem, which would also support any potential marine tourism. As it currently stands, the past years and decades has seen the fishery industry in the area shrink to a fraction of what it was (according to local reports), with much of the economic drive shifting from fishing to terrestrial agricultural based work. A successful and carefully controlled aquaculture programme could promote more of the general population to re-engage with the marine environment in a far more sustainable and productive manner.

A number of key measures however must be taken into account in the short term to support the recovery of many of the fish populations at Toboso, particularly if rates of offshore exploitation remain uncontrolled or if fixed quotas are not set. Firstly, large scale fishing activity at key nursery habitats mentioned above, must be stopped, so as to allow where possible juvenile fish developing into sexually mature adults, promoting population recovery. This would also support recovery of certain invertebrate species such as large bivalve species and a number of holothurian to recover. Habitat degradation on coral reef environments must be stopped, with the key culprit in place being the regular and indeterminate use of anchors to moor boats. Deploying and maintaining regular mooring lines in areas of particular interest is an inexpensive feat that could stop destruction of large areas of coral reef. On a broader scale, a highly under-utilised aspect of management by stakeholders is inclusion of up to date protocols and strategies as highlighted in published scientific literature. From a biological, environmental and socio-economic standpoint, currently published literature on all factors must be taken into account and act as a basis for any management strategy to be implemented. For example, factors determining current practices and management protocols for sea cucumber fisheries such as that of Toboso, are analysed and discussed in Purcell *et al*. (2013). Broader analyses on fisheries and management, particularly for the Philippines are also covered in a number of papers (i.e. White and Cruz-Trinidad, 1998; BFAR, 2004; Licuanan et al., 2008, Padilla, 2008; White et al., 2014)

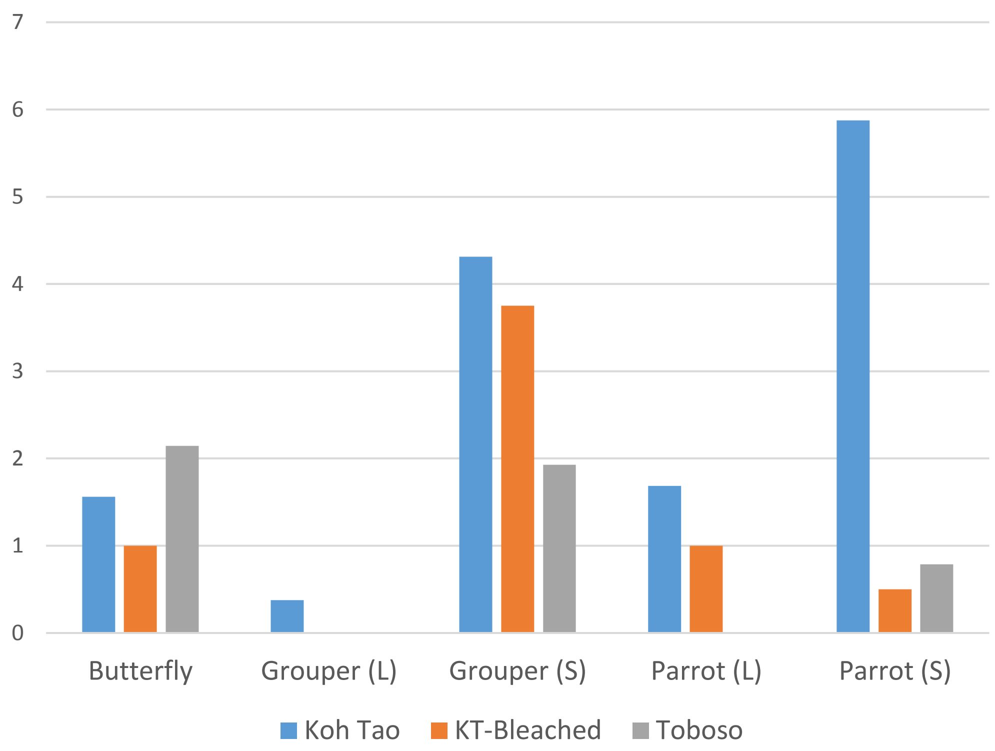
Ecological Monitoring Assessment

Transect surveys were carried out at multiple locations along the coast but were largely limited to depths from 3-5 meters. A small number of transects were carried out in deeper reefs via SCUBA, however these had few replicates and could not be carried out at all sites. This is largely due to numerous issues regarding equipment access and significant lack of organization from both governmental and NGO collaborators. Therefore, data analysis is restricted to shallow belt transects and roving diver observations. Mean coral cover for shallow reef areas ranged from 15% to 50% coral cover with total mean of 24.8% coverage for reef areas. Coral bleaching was observed at all reefs surveyed with varying degrees of bleaching. Percentage of corals that were bleached at surveyed locations ranged from 9% to 31% of colonies. Additionally, a large number of colonies at every transect showed signs of relatively recent mortality, indicating prolonged bleaching prior to surveys carried out. Most locations showed some degree of macroalgal growth in the shallows, with only one survey location showing significant coverage along the reef (57.5% algae covered substrate).

All sites showed significant depletion of fish stocks and numerous invertebrate species. Coral health, coral coverage, fish diversity and fish abundance all greatly increased with depth. All large bivalves greatly increased in abundance with depth, including all 4 individuals of *Tridacna squamosa* which were found at depths greater than 5m. This however, does not reduce the significance of severe depletion in both shallow and deep areas throughout the coast. Key examples include indicator species such as parrotfish and rabbitfish species which play an important role as herbivores on the reef, regulating algal growth, among a great many other things, in reef systems. A total of 7 individual rabbitfish were witnessed throughout the study, none within the transects and all were deemed to be less than 20cm in size. Parrotfish were found in the study but with an incredibly low mean density of 0.79 individuals per 100m² transect (Fig. 2). All individuals found in the transect were found to be of 30cm or less max length based on observation, with only a single individual being greater than that size observed throughout the survey, outside the transects. Average densities of grouper and butterflyfish were higher with 1.93 and 2.14 individuals per 100m² respectively. However again all individuals found were less than 20cm in length. Charismatic species with potential tourism value were found to be similarly low in abundance with anemonefish, pipefish and razorfish abundances at 1.9, 1.3 and 0.6 individual per $100m^2$ each. Invertebrate densities were found to be significantly higher in some cases, with a mean of 32.4 individuals of *Diademitidae* spp. found per transect. However, holothurian and *Tridacna* (*crocea*) densities were incredibly low with mean values of 0.21 and 0.29 individuals per transect. Given the rate of extraction of most holothurian and large bivalve species, these values are unsurprising but nonetheless deemed to be incredibly low for the reef size and density found at Toboso.

As requested by members of the municipal governing body, a comparison is provided below between findings of the present work, and those of reefs of similar quality. The most complete data following similar criteria and variables presently accessible, is that of EMP data carried out at Koh Tao, Thailand. Both locations undergoing simultaneous bleaching events provided some degree of viable comparison, however it must be noted that the coasts of the Philippines sit at the heart of the so called 'Coral Triangle' renowned for the diversity and density of coral life on a global scale. Therefore, species richness and abundance is expected to be on average, significantly higher than many reef systems in the Gulf of Thailand. Data collected at Koh Tao, both during the time of the present work, and mean values over the past year are compared with mean values found at Toboso (Fig. 2). Representative data for Koh Tao is taken from a single site that most closely matches coral cover percentage values found at Toboso (mean 28% at 'Twins' site at Koh Tao vs. mean 24.8% at Toboso) and is therefore not representative for the whole island, and lacks a high degree of resolution as it is simply a comparison between two sites. Furthermore, data used in the comparison during the 2016 bleaching event for Koh Tao is taken from a single date of data collection (four replicates) and represents the earlier stages of the bleaching event for the island as opposed to the later stages hypothesized for Toboso.

Figure 2 - Key Indicator Fish Species Comparison between Toboso and Koh Tao. (L) indicates large fish of approximately 30cm or greater and (S) indicates fish of smaller than 30cm. Values provided are mean values for individuals per transect replicate ($100m^2$) at respective reef habitats.



In most cases certain trends are relatively similar when comparing mean abundances. In all categories of parrotfish and grouper, values observed at Toboso are significantly lower than the current mean annual abundance values of a reef of similar HC%. No values are present for Toboso for larger individuals of either fish type to be compared with Koh Tao. Mean butterfly fish values are higher for Toboso than Koh Tao, and abundances of smaller parrotfish are higher at Toboso than during the surveys carried out at the onset of the bleaching at the studied site.

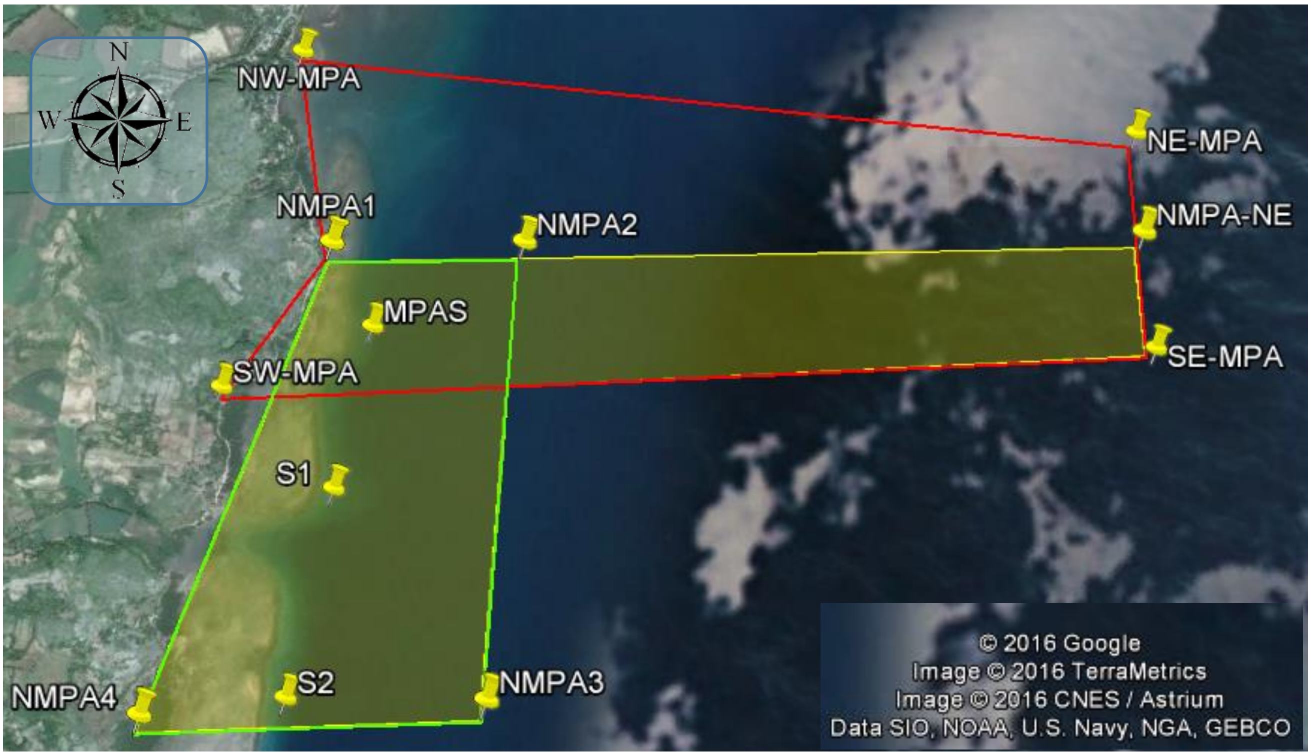
Table 2 – Site names with descriptions and coordinates for areas of belt transect surveys.

Site	**Site Description**	**GPS**	
MLTBN	Malangtang Bay North	N10°43'14.6	E123°31'19.9
MLTBS	Malangtang Bay South	N10°43'53.5	E123°31'45.8
APST	Arcolon Point – Shallow	N10°43'07.8	E123°31'44.4
MPAN	North Transect within Proposed MPA	N10°41'56.0	E123°30'42.3
MPAS	South Transect within Proposed MPA	N10°41'41.4	E123°30'38.8
S1	South 1	N10°41'22.8	E123°30'34.1
S2	South 2	N10°40'59.6	E123°30'28.5
NW-MPA	North-West point of Proposed MPA	N10°42'14.90	E123°30'30.70
SW-MPA	South-West point of Proposed MPA	N10°41'34.95	E123°30'21.20

Figure 3 – Approximate map of roving surveyed areas (circled) and precise points of transect survey locations. Surveys carried out from, and up to 150 meters away from, specified sites.

As seen in Fig. 3, significant portions of the coastline were surveyed, with particular focus on reef areas. Pinned sites (see Table 2) within surveyed areas were central locations for transect surveys. Among those sites, MLTBS showed the highest coral coverage and additionally the highest relative portion of bleaching from transect data. The fringing reef off MPAN (within the proposed MPA area) showed highly degraded reefs and very little coral abundance when compared to all other sites. Additionally, sedimentation levels were very high, relative to all sites. Sites S1 and S2 showed the highest coral diversity based on transect data and largest reefs and greatest faunal diversity at greater depths. It must be noted however that all (n=3) Crown of Thorns sea stars (*Acanthaster planci*) observed during surveys were found at transects at site S1, but that includes all individuals of *A. planci* observed throughout coastal surveys. Though transect data is not available for deeper reefs at site APST, observational data shows dense areas of reef coverage with depth.

Figure 4 – Approximate delineations of currently proposed MPA, Alternate proposed MPA (based on current work), and Extended MPA, expressed from GPS data collected.



Based on observational and transect data, the currently proposed MPA area includes little to none of the healthy or diverse marine habitats of Toboso. Seen in Fig. 4 is the very rough markup of the currently proposed MPA (red line) measuring 250 hectares approximately, going approximately 3.5km out to sea at the southern border and approximately 3km out along the northern border. Some managers of the current proposal have indicated some importance in including deeper waters offshore, hence the extensive length of northern and southern borders, to ensure protection is extended to any potential fauna in deeper waters (including any/all sessile fauna yet to be discovered). In contrast to this, a growing stakeholder opinion suggests that the deeper waters are the among the prime fishing grounds for the region and protection of shallower areas would be less disputed. It is understood that, prior to this study, no detailed analysis of substrate or biota has been carried out at any point for any of the intertidal, nearshore or offshore marine habitats currently enclosed by the MPA. This study has found that the majority of shallower water habitats included within the proposed MPA are extremely poor in health, diversity and abundance of marine life, when compared to a large number of other areas along the coast of Toboso.

Table 3 – GPS coordinates for all points seen in Figure 4 and areas to which they pertain (Proposed, Alternate or Extended MPA)

Area	Coordinate Name	GPS	
P-MPA	NW-MPA	N10°42'14.90	E123°30'30.70
P-MPA	NE-MPA	N10°42'0.83	E123°32'10.82
P-MPA	SE-MPA	N10°41'35.03	E123°32'11.06
P-MPA	SW-MPA	N10°41'34.95	E123°30'21.20
A-MPA	NMPA1	N10°41'51.33	E123°30'34.03
A-MPA	NMPA2	N10°41'50.49	E123°30'56.90
A-MPA	NMPA3	N10°40'58.22	E123°30'51.35
A-MPA	NMPA4	N10°40'58.25	E123°30'11.88
E-MPA	NMPA-NE	N10°41'48.60	E123°32'10.70

The present authors have therefore recommended changes to the current zonation and do strongly recommend that the currently proposed MPA location be altered so as to be an effective means to protect the remnants, and support the recovery, of the coastal habitats of Toboso. This map does not include details of delineations of the proposed Marine Reserve, which has been designed to act primarily as a buffer between unregulated waters and the MPA in the zonation process, and can be altered to accommodate any changes to core MPA areas. Details and locations of the Marine Reserve will not be included in this report, suffice to say that it can continue to act as the buffer between zones in any finalized zonation result. Proposed changes include two key areas, highlighted in Fig. 4. In green (covered by points NMPA1-4) is the newly proposed area for core MPA, based on analysis carried out. This area covers approximately 150 hectares and includes within much of the key Coral Reef, Seagrass and Macroalgal ecosystems for the Toboso region, and makes up the basis for a more ecologically rich, 'Alternate' MPA (hereby A-MPA). The area reaches approximately 1.1km offshore along the southern border and 700m offshore along the northern border, with a north-south distance of approximately 1.5km. The viability and potential for this area regarding habitat restoration and possible tourism value far surpasses that currently enclosed by current proposal (NW,NE,SE,SW-MPA points). The key purpose of creating the MPA must re-visited by all interested parties and government bodies as designation of protection (given that this is a Marine 'Protected' Area) is best utilized if there is habitat included that can be protected. Currently, it is believed that the designation is primarily put in place to support and reinforce economic growth for what is referred to as a '3rd class' municipality, with particular focus on allowing recovery of the regional fishery. The value of coral reef, sea grass and mangrove habitats as nursery environments for vast number of fish species is extremely well documented (Nagelkerken et al., 2000; Paillon et al., 2014).

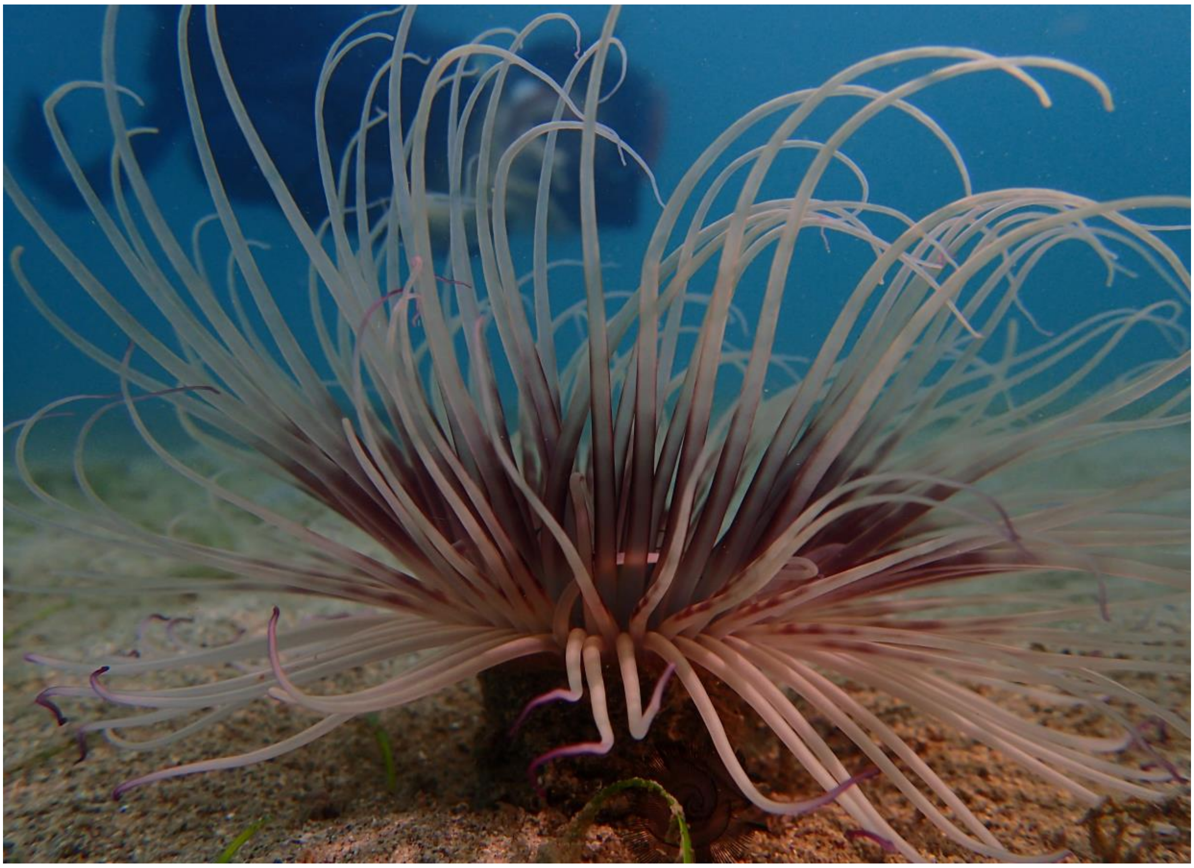
Another key difference between the two proposed areas is the exclusion of the deeper water habitats from the A-MPA area. This is due to the relatively low value for fishery restoration, tourism and coastal enrichment that is provided for by these deep water habitats. The pressure of effective enforcement as a measure of success in an MPA, particularly in the Philippines, is also well documented (White et al., 2002) and it is believed that a zonation legislation in a smaller area would be more easily enforced, and therefore more effective than a larger area. It must be stated however that deeper, open sea environments, also play a crucial role in coastal fisheries and act as unique habitats for many forms of marine life. These areas primarily act as migration routes for schools of adult fish, and importantly, the locally rare large pelagic species such as *Mola mola*, large elasmobranchs such as oceanic shark and ray species, and the great diversity of cetacean species that regularly inhabits the Tañon Strait. Additionally, the authors could find limited records of regional deep sea benthic analysis and therefore it is not known what deep sea fauna and flora may reside at the deeper regions of the area. Taking this into account, a second proposed area to match the current MPA plan in spatial coverage, is included in the figure (shown in yellow). This second area covers approximately 250 hectares and incorporates a significant portion of the deeper areas of the original MPA plan, as part of the A-MPA plan proposed in the present study. Given that this area acts as an extension of the newly proposed A-MPA, this area referred to as the Extended MPA (E-MPA). GPS coordinates for all points marking the areas of the three MPA areas are covered in Table 3.

Conclusion

At present, over 400 species of fauna are recorded from marine environments at Toboso. Of the different ecosystems, coral reef environments are by far the densest and richest in terms of species diversity and abundance, and though there are signs of significant abiotic factors causing stress to coral reefs at Toboso, the reef remains relatively healthy and hosts by far the dominant portion of wildlife at Toboso. A large number of species found at Toboso hold present and potential economic value in terms of tourism and fisheries. The majority of these species are found at the coral reef environments of Toboso. Prospects for the creation and development of a tourism industry based on marine recreation activities such as SCUBA and snorkeling are good, if carried out sustainably. A number of commercially valuable species of fish persist in the area, though heavily depleted, and currently only exist as juveniles before being caught, indicating that populations of a number of different species could be on the verge of complete collapse if all adults are exploited before they are able to reproduce.

The vast majority of all sizeable marine animals have been displaced of depleted due to anthropogenic pressures, predominantly overfishing activities at Toboso. Based on the current faunal abundance at all habitats surveyed, a large portion of marine life at Toboso is threatened and many have already been extirpated. To support the recovery of the ecosystem left, coastal fishing pressure throughout the region must be reduced and managed more carefully, and key areas of fish life must receive legal protection from exploitation, such as via marine protected areas. Furthermore, the development and careful deployment of permanent mooring lines must be put in place to reduce the damage on the fragile, slow growing, coral reefs due to anchor damage from any boat stopping at coastal areas. With proper technique, this solution can rapidly benefit both boat owners and the ecosystem from further pressure.

Based on these results, the location of the current proposed MPA is found to be greatly inefficient in protecting key areas of marine life at Toboso. The effectiveness of the marine zonation effort in the area could be vastly improved by adopting alternate areas for inclusion within the MPA, such as those recommended. The present study provides simply an initial baseline with a lot more work to be carried out in the area before more species are lost and the environment loses its potential to be a sustainable economic driver. Further work to be carried out would be to explore the deeper areas of the coast to broaden the understanding of wildlife in Toboso, including areas offshore, and to assess the viability of a number of restoration techniques to support the recovery of the area. As it currently stands, the marine environment at Toboso is in dire need of effective restoration as much of the life has already been lost, and what is left may soon follow. The environmental and economic gains of this restoration could be substantial, should stakeholders work together to capitalize on it.



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Appendix 1 – Complete list of species currently found in marine environments at Toboso, Philippines. Species that could not be identified with available resources were left as sp. Authorities are provided to Family level. Species in red could not be identified to sufficient enough resolution as other taxa, but were deemed morphologically different enough to be suggested as independent species. All images are available at **Worldreef Toboso**.				
No.	Phylum	Higher Taxon		Authority
	Chordata	**Actinopteri**		
	Vertebrata		***Acanthuridae***	Bonaparte, 1835
1			*Ctenochaetus sp.*	
			Apogonidae	Günther, 1859
2			*Apogon sp.*	
3			*Archamia zosterophora*	
4			*Cheilodipterus artus*	
5			*Cheilodipterus quinquelineatus*	
6			*Ostorhinchus hoevenii*	
7			*Ostorhinchus parvulus*	
8			*Pristicon trimaculatus*	
9			*Zoramia sp.*	
			Blenniidae	Rafinesque, 1810
10			*Meiacanthus atrodorsalis*	
			Bothidae	Smitt, 1892
11			*Asterorhombus sp.*	
			Caesionidae	Bonaparte, 1831
12			*Caesio cuning*	
			Carangidae	Rafinesque, 1815
13			*Scomberoides commersonnianus*	
14			*Trachurus sp.*	
			Centriscidae	Bonaparte, 1831
15			*Aeoliscus strigatus*	
			Chaetodontidae	Rafinesque, 1815
16			*Chaetodon adiergastos*	
17			*Chaetodon kleinii*	
18			*Chaetodon lunula*	
19			*Chaetodon octofasciatus*	
20			*Chaetodon rafflesii*	
21			*Chaetodon triangulum*	
22			*Chaetodon vagabundus*	
23			*Chelmon rostratus*	
24			*Heniochus acuminatus*	
25			*Heniochus varius*	
			Cirrhitidae	Macleay, 1841
26			*Cirrhitichthys falco*	
			Congridae	Kaup, 1856
27			*Conger cinereus*	
28			*Heteroconger sp.*	
			Coryphaenidae	Rafinesque, 1815

29			*Coryphaena hippurus*	
			Diodontidae	Bonaparte, 1835
30			*Diodon holocanthus*	
			Ephippidae	Bleeker, 1859
31			*Platax teira*	
			Fistulariidae	Stark, 1828
32			*Fistularia commersonii*	
			Gerreidae	Bleeker, 1859
33			*Gerres erythrourus*	
			Gobiesocidae	Bleeker, 1859
34			*Diademichthys lineatus*	
			Gobiidae	Cuvier, 1816
35			*Amblyeleotris sp.*	
36			*Gnatholepis sp.*	
37			*Periophthalmus sp.*	
			Haemulidae	Gill, 1885
38			*Diagramma pictum*	
39			*Plectorhinchus chaetodonoides*	
			Hemiramphidae	Gill, 1859
40			*Hemiramphidae sp.*	
			Labridae	Cuvier, 1816
41			*Bodianus mesothorax*	
42			*Cheilinus chlorourus*	
43			*Cheilio inermis*	
44			*Choerodon anchorago*	
45			*Halichoeres melanurus*	
46			*Halichoeres sp.*	
47			*Labroides dimidiatus*	
48			*Thalassoma lunare*	
			Lethrinidae	Bonaparte, 1831
49			*Lethrinus sp.*	
			Lutjanidae	Gill, 1861
50			*Etelis carbunculus*	
51			*Lutjanus biguttatus*	
52			*Lutjanus decussatus*	
53			*Lutjanus ehrenbergii*	
			Monacanthidae	Nado, 1843
54			*Monacanthus chinensis*	
55			*Pseudomonacanthus macrurus*	
			Moringuidae	Gill, 1885
56			*Moringua raitaborua*	
			Mugilidae	Jarocki, 1822
57			*Valamugil sp.*	
			Mullidae	Rafinesque, 1815

58			*Parupeneus multifasciatus*	
59			*Upeneus tragula*	
			Muraenidae	Rafinesque, 1815
60			*Echidna nebulosa*	
61			*Gymnothorax annulatus*	
62			*Gymnothorax fimbriatus*	
63			*Gymnothorax minor*	
64			*Muraenidae sp.*	
			Nemipteridae	Regan, 1913
65			*Scolopsis bilineata*	
			Ophichthidae	Günther, 1870
66			*Ophichthus sp.*	
			Pinguipedidae	Günther, 1860
67			*Parapercis cylindrica*	
68			*Parapercis xanthozona*	
69			*Parapercis sp.*	
			Plotosidae	Bleeker, 1858
70			*Plotosus lineatus*	
			Pomacentridae	Bonaparte, 1831
71			*Abudefduf sexfasciatus*	
72			*Amphiprion clarkii*	
73			*Amphiprion frenatus*	
74			*Amphiprion ocellaris*	
75			*Amphiprion perideraion*	
76			*Chromis amboinensis*	
77			*Dascyllus aruanus*	
78			*Dascyllus reticulatus*	
79			*Dascyllus trimaculatus*	
80			*Dischistodus pseudochrysopoecilus*	
81			*Neoglyphidodon nigroris*	
82			*Pomacentrus grammorhynchus*	
83			*Pomacentrus moluccensis*	
84			*Pomacentrus philippinus*	
85			*Pomacentrus simsiang*	
86			*Premnas biaculeatus*	
			Priacanthidae	Günther, 1859
87			*Chaetodontoplus mesoleucus*	
88			*Priacanthus sagittarius*	
89			*Pygoplites diacanthus*	
			Rachycentridae	Gill, 1896
90			*Rachycentron canadum*	
			Scaridae	Rafinesque, 1810
91			*Chlorurus bleekeri*	
			Scombridae	Rafinesque, 1815

92			*Euthynnus sp.*	
93			*Thunnus sp.*	
			Scorpaenidae	Risso, 1827
94			*Dendrochirus sp.*	
95			*Pterois antennata*	
96			*Pterois volitans*	
97			*Scorpaenopsis oxycephala*	
98			*Scorpaenopsis sp*	
			Serranidae	Swainson, 1839
99			*Cephalopholis boenak*	
			Siganidae	Richardson, 1837
100			*Siganus canaliculatus*	
			Soleidae	Bonaparte, 1833
101			*Synaptura sp.*	
			Sphyraenidae	Rafinesque, 1815
102			*Sphyraena flavicauda*	
			Synanceiidae	Swainson, 1839
103			*Synanceia horrida*	
			Syngnathidae	Bonaparte, 1831
104			*Corythoichthys haematopterus*	
105			*Dunckerocampus dactyliophorus*	
106			*Hippocampus sp.*	
107			*Syngnathoides biaculeatus*	
			Synodontidae	Gill, 1861
108			*Saurida gracilis*	
			Terapontidae	Richardson, 1842
109			*Terapon jarbua*	
			Tetraodontidae	Bonaparte, 1831
110			*Arothron hispidus*	
111			*Arothron immaculatus*	
112			*Arothron manilensis*	
113			*Arothron nigropunctatus*	
114			*Arothron reticularis*	
115			*Arothron sp.*	
116			*Canthigaster papua*	
117			*Canthigaster solandri*	
118			*Chelonodon patoca*	
			Zanclidae	Bleeker, 1876
119			*Zanclus cornutus*	
			Zenarchopteridae	Fowler, 1934
120			*Zenarchopterus sp.*	
		Aves		
			Ardeidae	Leach, 1820
121			*Butorides striata*	

		Mammalia		
			Delphinidae	Gray, 1821
122			*Delphinidae sp.*	
		Reptilia		
			Acrochordidae	Bonaparte, 1831
123			*Acrochordus granulatus*	
			Cheloniidae	Oppel, 1811
124			*Chelonia mydas*	
	Tunicata	**Ascidiacea**		
			Diazonidae	Seeliger, 1906
125			*Rhopalaea crassa*	
			Didemnidae	Giard, 1872
126			*Didemnum molle*	
127			*Didemnum sp.*	
128			*Tunicata sp.*	
	Cnidaria	**Anthozoa**		
		Ceriantharia	***Arachnactidae***	McMurrich, 1910
129			*Arachnactidae sp.*	
			Cerianthidae	Milne Edwards & Haime, 1852
130			*Cerianthus sp.*	
		Hexacorallia		
		Actiniaria	***Actiniidae***	Rafinesque, 1815
131			*Condylactis sp.*	
132			*Entacmaea quadricolor*	
			Actinodendridae	Haddon, 1898
133			*Actinodendron glomeratum*	
134			*Actinostephanus haeckeli*	
			Boloceroididae	Carlgren, 1924
135			*Boloceroides sp.*	
			Discosomidae	Verrill, 1869
136			*Amplexidiscus fenestrafer*	
			Hormathiidae	Carlgren, 1932
137			*Calliactis sp*	
			Stichodactylidae	Andres, 1883
138			*Heteractis aurora*	
139			*Heteractis crispa*	
140			*Stichodactyla gigantea*	
141			*Stichodactyla mertensii*	
142			*Stichodactyla tapetum*	
			Thalassianthidae	Milne Edwards, 1857
143			*Cryptodendrum adhaesivum*	
144			*Heterodactyla sp.*	
145			*Actiniaria sp. 1*	
146			*Actiniaria sp. 2*	

147			*Actiniaria sp. 3*	
148			*Actiniaria sp. 4*	
		Antipatharia	***Antipathidae***	Ehrenberg, 1834
149			*Cirrhipathes sp*	
			Acroporidae	Verrill, 1902
150		Scleractinia	*Acropora awi*	
151			*Acropora humilis*	
152			*Acropora sp.*	
153			*Acropora sp. 1*	
154			*Acropora sp. 2*	
155			*Anacropora puertogalerae*	
156			*Astreopora myriophthalma*	
157			*Astreopora sp.*	
158			*Isopora palifera*	
159			*Montipora hirsuta*	
160			*Montipora stellata*	
161			*Montipora sp.*	
			Agariciidae	Gray, 1847
162			*Leptoseris explanata*	
163			*Pachyseris rugosa*	
164			*Pachyseris speciosa*	
165			*Pavona frondifera*	
166			*Pavona sp.*	
			Dendrophylliidae	Gray, 1847
167			*Turbinaria peltata*	
			Diploastreidae	Chevalier & Beauvais, 1987
168			*Diplastrea heliopora*	
			Euphylliidae	Alloiteau, 1952
169			*Euphyllia ancora*	
170			*Euphyllia glabrescens*	
171			*Euphyllia yaeyamaensis*	
172			*Galaxea astreata*	
173			*Galaxea fascicularis*	
			Flabellidae	Bourne, 1905
174			*Flabellidae sp.*	
			Fungiidae	Dana, 1846
175			*Ctenactis echinata*	
176			*Danafungia horrida*	
177			*Danafungia scruposa*	
178			*Fungia fungites*	
179			*Heliofungia actiniformis*	
180			*Herpolitha limax*	
181			*Lithophyllon undulatum*	
182			*Pleuractis paumotensis*	

183			*Polyphyllia talpina*	
			Lobophylliidae	Dai & Horng, 2009
184			*Cynarina lacrymalis*	
185			*Lobophyllia hemprichii*	
186			*Lobophyllia sp.*	
187			*Lobophylliidae sp.*	
188			*Oxypora crassispinosa*	
189			*Symphyllia recta*	
			Merulinidae	Verrill, 1865
190			*Caulastraea tumida*	
191			*Coelastrea aspera*	
192			*Coelastrea palauensis*	
193			*Cyphastrea sp.*	
194			*Echinopora lamellosa*	
195			*Favites halicora*	
196			*Goniastrea edwardsi*	
197			*Goniastrea minuta*	
198			*Goniastrea pectinata*	
199			*Hydnophora exesa*	
200			*Merulina ampliata*	
201			*Paragoniastrea australensis*	
202			*Pectinia paeonia*	
203			*Platygyra lamellina*	
			Montastraeidae	Yabe & Sugiyama, 1941
204			*Montastraea sp.*	
			Mussidae	Ortmann, 1890
205			*Favia sp.*	
			Pocilloporidae	Gray, 1842
206			*Pocillopora verrucosa*	
207			*Seriatopora hystrix*	
			Poritidae	Gray, 1842
208			*Alveopora tizardi*	
209			*Goniopora sp.*	
210			*Porites sp.*	
			Psammocoridae	Chevalier & Beauvais, 1987
211			*Psammocora profundacella*	
			Scleractinia incertae sedis	
212			*Leptastrea sp.*	
213			*Oulastrea crispata*	
214			*Plerogyra sp.*	
		Zoantharia	***Sphenopidae***	Hertwig, 1882
215			*Palythoa sp.*	
216			*Zoantharia sp.*	
		Octocorallia	***Acrossotidae***	Bourne, 1914

217			*Acrossota sp.*	
			Alcyoniidae	Lamouroux, 1812
218			*Alcyoniidae sp.*	
219			*Cladiella sp.*	
220			*Lobophyton sp.*	
221			*Sarcophyton sp.*	
222			*Sinularia sp.*	
			Gorgoniidae	Lamouroux, 1812
223			*Rumphella sp.*	
			Helioporidae	Moseley, 1876
224			*Heliopora coerulea*	
225			*Heliopora sp.*	
			Tubiporidae	Ehrenberg, 1828
226			*Tubipora sp.*	
			Virgulariidae	Verrill, 1868
227			*Virgularia sp.*	
			Xeniidae	Ehrenberg, 1828
228			*Heteroxenia sp*	
		Cubozoa		
			Carybdeidae	Gegenbaur, 1857
229			*Carybdea marsupialis*	
			Chiropsalmidae	Thiel, 1936
230			*Chiropsalmus sp.*	
		Hydrozoa		
			Milleporidae	Fleming, 1828
231			*Millepora sp.*	
		Scyphozoa		
			Cassiopeidae	Agassiz, 1862
232			*Cassiopea sp.*	
			Catostylidae	Gegenbaur, 1857
233			*Catostylus sp.*	
			Mastigiidae	Stiasny, 1921
234			*Mastigias papua*	
			Ulmaridae	Haeckel, 1880
235			*Aurelia aurita*	
	Mollusca	**Bivalvia**		
			Cardiidae	Lamarck, 1809
236			*Cardiidae sp. 1*	
237			*Hippopus hippopus*	
238			*Tridacna crocea*	
239			*Tridacna squamosa*	
			Limidae	Rafinesque, 1815
240			*Limaria fragilis*	
			Mytilidae	Rafinesque, 1815

241			*Brachidontes sp.*	
			Pinnidae	Leach, 1819
242			*Atrina sp.*	
243			*Pinna bicolor*	
244			*Pinnidae sp.*	
			Pteriidae	Gray, 1847
245			*Pinctada margaritifera*	
246			*Pteriidae sp.*	
		Cephalopoda		
			Idiosepiidae	Appellöf, 1898
247			*Idiosepius sp*	
			Octopodidae	d'Orbigny, 1840
248			*Abdopus sp.*	
			Sepiolidae	Leach, 1817
249			*Euprymna sp.*	
			Thysanoteuthidae	Keferstein, 1866
250			*Thysanoteuthis rhombus*	
		Gastropoda		
			Aglajidae	Pilsbry, 1895 (1847)
251			*Chelidonura amoena*	
252			*Chelidonura pallida*	
253			*Chelidonura sandrana*	
254			*Chelidonura varians*	
			Aplysiidae	Lamarck, 1809
255			*Aplysia sp.*	
256			*Dolabella auricularia*	
			Arminidae	Iredale & O'Donoghue, 1923 (1841)
257			*Dermatobranchus albus*	
			Cassidae	Latreille, 1825
258			*Semicassis bisulcata*	
			Chromodorididae	Bergh, 1891
259			*Chromodoris lineolata*	
260			*Chromodoris magnifica*	
261			*Goniobranchus preciosus*	
262			*Goniobranchus reticulatus*	
263			*Hypselodoris tryoni*	
264			*Mexichromis mariei*	
			Conidae	Fleming, 1822
265			*Conus textile*	
			Costasiellidae	K. B. Clarke, 1984
266			*Costasiella kuroshimae*	
267			*Costasiella usagi*	
			Cypraeidae	Rafinesque, 1815
268			*Cypraea tigris*	

269			*Lyncina carneola*	
270			*Mauritia eglantina*	
			Dendrodorididae	O'Donoghue, 1924 (1864)
271			*Dendrodoris fumata*	
			Discodorididae	Bergh, 1891
272			*Discodoris boholiensis*	
273			*Sebadoris nubilosa*	
			Facelinidae	Bergh, 1889
274			*Pteraeolidia semperi*	
275			*Sakuraeolis sp.*	
			Gymnodorididae	Odhner, 1941
276			*Gymnodoris sp.*	
			Muricidae	Rafinesque, 1815
277			*Drupella sp.*	
278			*Muricidae sp. 1*	
			Naticidae	Guilding, 1834
279			*Mammilla maura*	
280			*Polinices sp.*	
			Olividae	Latreille, 1825
281			*Miniaceoliva miniacea*	
			Onchidiidae	Rafinesque, 1815
282			*Onchidiidae sp. 1*	
283			*Onchidiidae sp. 2*	
			Phyllidiidae	Rafinesque, 1814
284			*Phyllidia coelestis*	
285			*Phyllidia elegans*	
286			*Phyllidia ocellata*	
287			*Phyllidiella nigra*	
288			*Phyllidiella pustulosa*	
			Plakobranchidae	Gray, 1840
289			*Elysia marginata*	
290			*Plakobranchus cf. ocellatus*	
291			*Plakobranchus papua*	
292			*Plakobranchus sp. 1*	
293			*Plakobranchus sp. 2*	
294			*Thuridilla gracilis*	
295			*Thuridilla lineolata*	
			Pleurobranchidae	Gray, 1827
296			*Pleurobranchus forskalii*	
			Strombidae	Rafinesque, 1815
297			*Lambis lambis*	
298			*Strombus sp.*	
			Terebridae	Mörch, 1852
299			*Myurella kilburni*	

			Trochidae	Rafinesque, 1815
300			*Trochidae sp.*	
			Velutinidae	Gray, 1840
301			*Coriocella nigra*	
			Volutidae	Rafinesque, 1815
302			*Cymbiola vespertilio*	
303			*Gastropoda sp. 1*	
304			*Gastropoda sp. 2*	
		Polyplacophora		
			Chitonidae	Rafinesque, 1815
305			*Acanthopleura gemmata*	
306			*Acanthopleura spinosa*	
			Cryptoplacidae	H. Adams & A. Adams, 1858
307			*Cryptoplax sp.*	
	Echinodermata			
	Asterozoa	**Asteroidea**		
			Acanthasteridae	Sladen, 1889
308			*Acanthaster planci*	
			Archasteridae	Viguier, 1878
309			*Archaster typicus*	
			Asterinidae	Gray, 1840
310			*Asterinidae sp.*	
			Asteropseidae	Hotchkiss & Clark, 1976
311			*Asteropsis carinifera*	
			Astropectinidae	Gray, 1840
312			*Astropecten polyacanthus*	
			Echinasteridae	Verrill, 1870
313			*Echinaster luzonicus*	
			Luidiidae	Sladen, 1889
314			*Luidia maculata*	
			Mithrodiidae	Viguier, 1878
315			*Mithrodia fisheri*	
			Ophidiasteridae	Verrill, 1870
316			*Linckia guildingi*	
317			*Linckia laevigata*	
318			*Nardoa sp.*	
			Oreasteridae	Fisher, 1911
319			*Choriaster granulatus*	
320			*Culcita novaeguinea*	
321			*Pentaceraster alveolatus*	
322			*Pentaster obtusatus*	
323			*Protoreaster nodosus*	
		Ophiuroidea		
			Ophiocomidae	Ljungman, 1867

324			*Ophiomastix annulosa*	
325			*Ophiomastix variabilis*	
	Crinozoa			
		Crinoidea		
			Comatulidae	Fleming, 1828
326			*Comatulidae sp.*	
327			*Crinoidea sp. 1*	
328			*Crinoidea sp. 2*	
	Echinozoa			
		Echinoidea		
			Clypeasteroida	
329			*Clypeasteroida sp*	
			Spatangoidea	
330			*Spatangoidea sp. 1*	
331			*Spatangoidea sp. 2*	
			Cidaridae	Gray, 1825
332			*Plococidaris verticillata*	
			Diadematidae	Gray, 1855
333			*Astropyga radiata*	
334			*Diadema savignyi*	
335			*Diadema setosum*	
336			*Echinothrix calamaris*	
			Echinometridae	Gray, 1855
337			*Echinometra mathaei*	
			Temnopleuridae	A. Agassiz, 1872
338			*Salmacis belli*	
339			*Salmacis sphaeroides*	
			Toxopneustidae	Troschel, 1872
340			*Toxopneustes pileolus*	
341			*Tripneustes gratilla*	
		Holothuroidea		
			Holothuriidae	Burmeister, 1837
342			*Actinopyga sp*	
343			*Bohadschia marmorata*	
344			*Bohadschia sp.*	
345			*Holothuria (Lessonothuria) sp.*	
346			*Holothuria (Mertensiothuria) leucospilota*	
347			*Holothuria (Metriatyla) scabra*	
348			*Holothuria (Theelothuria) kurti*	
349			*Holothuria (Theelothuria) notabilis*	
350			*Holothuria (Thymiosycia) impatiens*	
351			*Holothuria sp.*	
352			*Holothuriidae sp. 1*	
353			*Holothuriidae sp. 2*	

354			*Pearsonothuria graeffei*	
			Stichopodidae	Haeckel, 1896
355			*Stichopus cf. ocellatus*	
356			*Stichopus cf. variegatus*	
357			*Stichopus rubermaculosus*	
358			*Stichopus sp. 1*	
359			*Stichopus sp. 2*	
			Synaptidae	Burmeister, 1837
360			*Opheodesoma sp.*	
361			*Synapta maculata*	
362			*Synaptula sp.*	
363			*Synaptidae sp. 1*	
364			*Synaptidae sp. 2*	
365			*Holothuroidea sp. 1*	
366			*Holothuroidea sp. 2*	
367			*Holothuroidea sp. 3*	
	Arthropoda	**Malacostraca**		
	Crustacea		***Stomatopoda***	
368			*Stomatopoda sp*	
			Alpheidae	Rafinesque, 1815
369			*Alpheidae sp.*	
			Blepharipodidae	Boyko, 2002
370			*Blepharipoda sp.*	
			Calappidae	De Haan, 1833
371			*Calappa hepatica*	
372			*Calappa philargius*	
			Callianassidae	Dana, 1852
373			*Glypturus sp.*	
			Carpiliidae	Ortmann, 1893
374			*Carpilius convexus*	
375			*Carpilius maculatus*	
			Coenobitidae	Dana, 1851
376			*Coenobita cavipes*	
377			*Coenobita sp.*	
			Diogenidae	Ortmann, 1892
378			*Calcinus sp.*	
379			*Clibanarius sp. 1*	
380			*Clibanarius sp. 2*	
381			*Dardanus megistos*	
382			*Dardanus pedunculatus*	
383			*Dardanus sp.*	
			Dromiidae	De Haan, 1833
384			*Dromia erythropus*	
			Ethusidae	Guinot, 1977

385			*Ethusa sp.*	
			Gecarcinidae	MacLeay, 1838
386			*Cardisoma carnifex*	
			Grapsidae	MacLeay, 1838
387			*Grapsus sp.*	
388			*Metopograpsus sp.*	
			Hippolytidae	Spence Bate, 1888
389			*Thor amboinensis*	
			Hymenoceridae	Ortmann, 1890
390			*Hymenocera picta*	
			Inachidae	MacLeay, 1838
391			*Camposcia retusa*	
392			*Camposcia sp.*	
			Macrophthalmidae	Dana, 1851
393			*Macrophthalmus (Macrophthalmus) sp.*	
			Majidae	Samouelle, 1819
394			*Micippa sp.*	
			Matutidae	De Haan, 1835
395			*Ashtoret lunaris*	
			Ocypodidae	Rafinesque, 1815
396			*Uca sp.*	
			Odontodactylidae	Manning, 1980
397			*Odontodactylus sp.*	
			Palaemonidae	Rafinesque, 1815
398			*Ancylomenes magnificus*	
399			*Ancylomenes venustus*	
400			*Cuapetes tenuipes*	
401			*Periclimenes brevicarpalis*	
			Palinuridae	Latreille, 1802
402			*Panulirus versicolor*	
			Parthenopidae	MacLeay, 1838
403			*Daldorfia horrida*	
404			*Rhinolambrus sp.*	
			Penaeidae	Rafinesque, 1815
405			*Penaeus monodon*	
			Pilumnidae	Samouelle, 1819
406			*Pilumnus sp.*	
			Porcellanidae	Haworth, 1825
407			*Neopetrolisthes maculatus*	
			Portunidae	Rafinesque, 1815
408			*Portunus (Portunus) pelagicus*	
409			*Portunus (Portunus) sanguinolentus*	
410			*Scylla olivacea*	
411			*Scylla serrata*	

			Pseudosquillidae	Manning, 1977
412			*Pseudosquilla ciliata*	
			Pyrgomatidae	Gray, 1825
413			*Pyrgomatidae sp.*	
			Sergestidae	Dana, 1852
414			*Acetes sp.*	
			Stenopodidae	Claus, 1872
415			*Stenopus hispidus*	
			Thalassinidae	Latreille, 1831
416			*Thalassina anomala*	
			Xanthidae	MacLeay, 1838
417			*Atergatis floridus*	
418			*Atergatis sp.*	
	Platyhelminthes	**Rhabditophora**		
			Pseudocerotidae	Lang, 1884
419			*Acanthozoon sp.*	
420			*Pseudobiceros flowersi*	
421			*Pseudoceros cf. tristriatus*	
422			*Pseudoceros indicus*	
423			*Pseudocerotidae sp. 1*	
424			*Pseudocerotidae sp. 2*	
	Annelida	**Polychaeta**		
			Amphinomidae	Lamarck, 1818
425			*Chloeia sp.*	
			Eunicidae	Berthold, 1827
426			*Eunicidae sp.*	
			Ikedidae	Bock, 1942
427			*Ikedidae sp.*	
			Pectinariidae	Quatrefages, 1866
428			*Pectinariidae sp.*	
			Sabellidae	Latreille, 1825
429			*Sabellastarte sp.*	
	Porifera	**Demospongiae**		
			Dysideidae	Gray, 1867
430			*Lamellodysidea sp.*	
			Ianthellidae	Hyatt, 1875
431			*Ianthella sp.*	
			Petrosiidae	Soest, 1980
432			*Xestospongia sp.*	
			Phloeodictyidae	Carter, 1882
433			*Oceanapia sagittaria*	
434			*Porifera sp.*	
	Sipuncula			
435			*Sipuncula sp.*	

Appendix 2 – Flora species found to be associated with marine environments of Toboso.				
No.	Phylum	Class		Authority
	Chlorophyta	**Ulvophyceae**		
			Caulerpaceae	Kützing, 1843
1			*Caulerpa sp.*	
			Codiaceae	Kützing, 1843
2			*Codium arabicum*	
			Dasycladaceae	Kützing, 1843
3			*Halicoryne wrightii*	
			Dichotomosiphonaceae	
4			*Avrainvillea sp. 1*	
5			*Avrainvillea sp. 2*	
			Halimedaceae	Link, 1832
6			*Halimeda tuna*	
7			*Halimeda sp.*	
			Valoniaceae	Kützing, 1849
8			*Valonia ventricosa*	
	Ochrophyta	**Phaeophyceae**		
			Dictyotaceae	Lamouroux ex Dumortier, 1822
9			*Canistrocarpus sp.*	
			Sargassaceae	Kützing, 1843
10			*Sargassum sp. 1*	
11			*Sargassum sp. 2*	
12			*Turbinaria sp.*	
			Scytosiphonaceae	Farlow, 1881
13			*Colpomenia sp.*	
14			*Hydroclathrus clathratus*	
	Tracheophyta	**Alismatales**		
			Cymodoceaceae	
15			*Cymodocea sp.*	
			Hydrocharitaceae	
16			*Enhalus acoroides*	
17			*Halophila sp.*	
	Rhodophyta	**Florideophyceae**		
			Halymeniaceae	
18			*Halymenia sp.*	