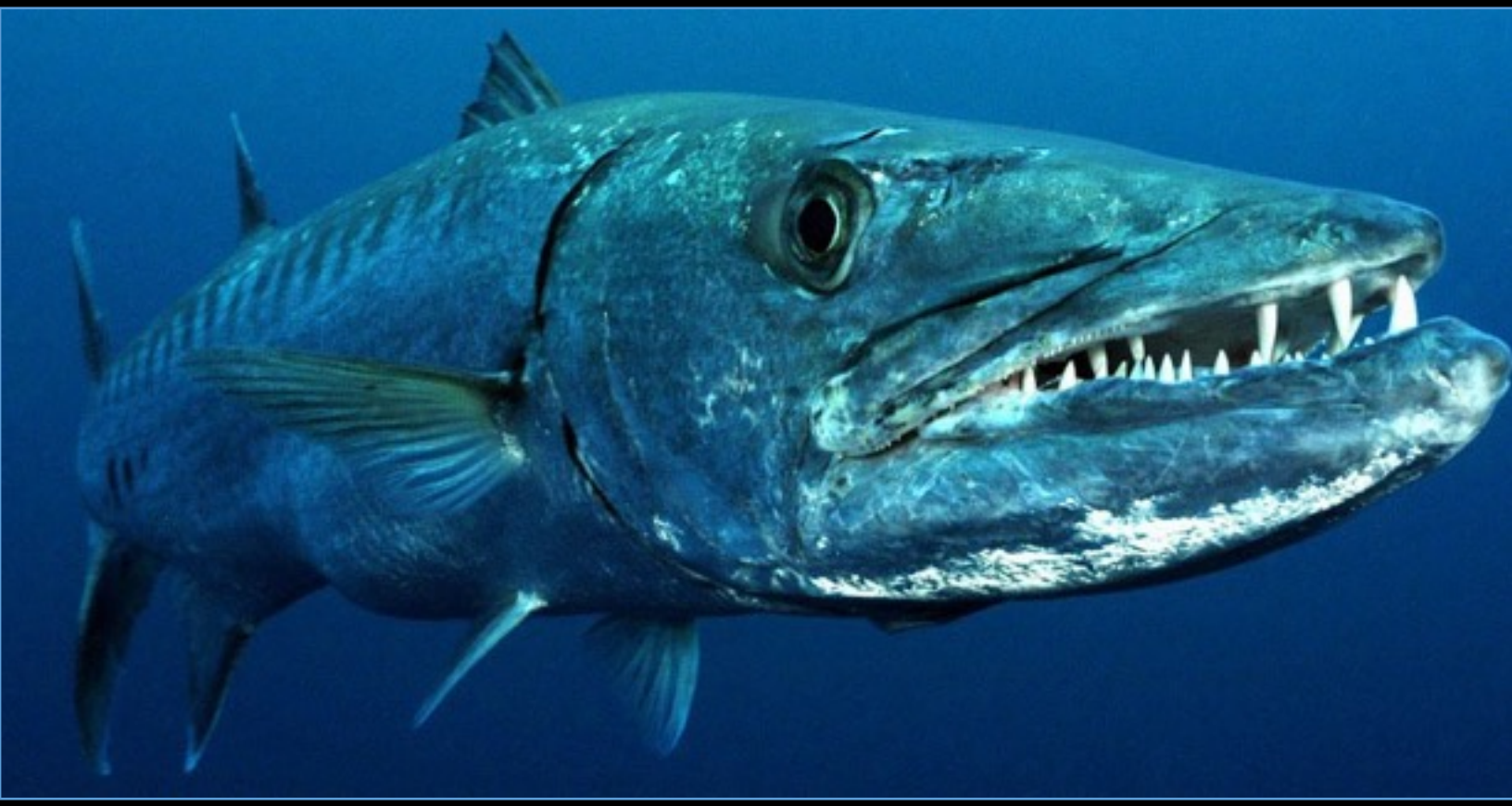
Baseline Survey of Fish Families in Southern Negros Oriental, Philippines



Marine Conservation Philippines

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Acknowledgements

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Abstract

Coral reefs are declining worldwide due to high fishing pressure. In the Visayan region fishing pressure is high for both food consumption and aquarium trade. This same region also has a lot Marine Protected Areas (MPAs), which are proven to increase fish biomass and abundance. This study is a baseline research on fish families in Southern Negros, which will give an insight into which fish species occur at which research sites, with the hypothesis that MPAs have a higher relative abundance and diversity of fish families compared to non-MPAs. The Rapid Visual Census technique was used to conduct 216 surveys. All functional MPAs that were surveyed have a higher relative abundance and diversity for most of the fish families compared to non-MPAs, with Basak having the highest scores. The most important fish families, like herbivorous fish and commercially interesting fish families follow this pattern. The Pomacanthidae follows the exact opposite pattern. This research led to the design of a fish indicator species list of 77 species, which will be used for long term monitoring of the reef with the help of volunteers.

Introduction

Coral reefs and their adjacent ecosystems such as mangroves and seagrass beds are declining worldwide. The reef faces a variety of anthropogenic threats, of which overfishing, agricultural run-off and climate change are the most threatening to the reef. The UN has the goal to protect 10% of the coastal and marine waters; currently we are at 6% (Christie & White 2007; Green & Bellwood 2009; Horta et al. 2016; Honda et al. 2013). The Philippines is part of the Coral Triangle, which is known for its high biodiversity (Christie & White 2007; Honda et al. 2013). Unfortunately, two thirds of the major fishing areas in the Philippines are overfished and surveys show that 97% of large-bodied fish have a low abundance, a restricted distribution, or have disappeared altogether (Lavides et al. 2016). Looking at commercially interesting fish species for both human consumption and aquarium trade, the Visayan region is doing poor compared to other regions in the Philippines, mainly because of overfishing and habitat degradation. However, the Visayas have the highest concentration of Marine Protected Areas (MPAs) (Nañola et al. 2011). MPAs are seen as an important management tool to protect and conserve marine biodiversity. Inside an MPA fish have a higher density, biomass and species diversity. Juvenile fish in MPAs are protected, which gives them the opportunity to reach maturity and reproduce. Marine life in MPA's is more resilient and therefore better able to resist disturbances and recover from them compared to non-MPAs (Christie & White 2007; Mellin et al. 2016; Russ et al. 2004; White et al. 2006). Because of the spill-over effect, areas surrounding MPAs directly benefit from the increase of both larvae and fish which migrate outside MPA boundaries. MPAs are most effective for both conservation and fisheries management if they are part of a network of MPAs (White et al. 2006; Weeks et al. 2010; Green et al. 2015) and include adjacent mangrove and seagrass areas (Honda et al. 2013).

The Philippines is the country with most MPAs worldwide and has been one of the first countries to implement MPAs, but only a fraction of these MPAs are fully functional. Another problem of many MPAs in the Philippines is their small size (90% is smaller than 1 km^2), due to the fact that the border of most community-based MPAs does not pass the border of the barangay (small town within the municipality) (Christie & White 2007; Weeks et al. 2010; MPA Atlas 2016). A functional MPA should be at least twice the size of the home range of the fish species it is supposed to protect (Cabral et al. 2015; Green et al. 2015). MPAs only function if they are well-managed and enforced. Part of a well-managed MPA is conducting a baseline study and monitor the changes of the reef over time is (White et al. 2006).

In this initial study we are interested in which reef fish species occur at specific research sites, to be able to make a selection of relevant indicator fish species for long term monitoring. We assumed that well- managed MPAs have a higher relative abundance and higher relative diversity of fish families compared to other research sites. We explored the differences in fish family abundance and diversity between 3 MPAs, and 6 non-MPAs (of which 3 were control sites for the MPAs). Since most of the data has been collected with volunteers, it was of vital importance to observe only a few fish families at the time and use an easy monitoring method.

Materials and method

Study area

Marine Conservation Philippines started its NGO in 2015 and is based in Zamboanguita, Negros Oriental at 9°4'N; 123°9'E. The 9 selected research sites are within a 20 km radius of the MCP base, see also figure 1. Southern Negros has an almost continuous reef (Cabral et al. 2015). Most of the reefs in Negros, except Apo island, have been surveyed infrequently for various studies, mainly carried out by Silliman University located in Dumaguete (Bucol 2014; Stockwell et al. 2009).

Land temperature varies between 25 and 35 degrees Celsius. Seawater temperature range between 25 and 30 degrees Celsius. Rainy season occurs between half of June until October and in December, with annual rainfall of about 1700mm. The visibility is usually ten meters or more, but declines during rainy season and Habagat or southwest wind, which can create strong surge and waves from March to October on all research sites except Kookoo's Nest. Kookoo's Nest has lower visibility during Amihan or northeast wind, which occurs the other half of the year.

A short description of each research site is listed in table 1. Research has been carried out in the municipalities of Zamboanguita, Siaton and Dauin. The municipality of Dauin has numerous well- protected MPAs. Dauin Poblacion MPA has been selected as an example of a well-managed MPA. In Zamboanguita, 2 MPAs and their control sites were selected as well as Malatapay, which has been included to look at the influence of anthropogenic threats to the reef. Three sites in Siaton have been selected, including an MPA, it's control site and Kookoo's Nest. Kookoo's Nest has a unique geographical location and is the only research site that is protected from typhoons.

Table 1:Description of research sites

Research site	Municipality	MPA	Current	Visibility	Reef structure	Reef depth	Fishing pressure	Description
Dauin Poblacion	Dauin	MPA	Little	Good	Continuous reef	20m	None	Very well-managed MPA, big rubble areas
Malatapay	Zamboanguita	No	Little-Medium	Medium	Continuous reef	>25 m	Medium (mainly cages)	Next to market, lot of garbage in water
Basak	Zamboanguita	MPA	Little-Very strong	Good	Patchy reef	22m	Little (nets and cages)	Enforcement sometimes lacking
Guinsuan	Zamboanguita	Control site Basak	Little-Very strong	Medium	Patchy reef	16m	High (mainly cages)	
Lutoban Pier	Zamboanguita	Control site Lutoban South	Little	Medium	Continuous reef	18m	Medium (nets and cages)	High siltation rate
Lutoban South	Zamboanguita	MPA	Little	Medium	Continuous reef	18m	Medium (nets and cages)	MPA on paper only
Andulay	Siaton	MPA	Little-Medium	Good	Continuous reef	22m	None	
Antulang	Siaton	Control site Andulay	Little-Medium	Good	Partially patchy reef	>25 m	High (mainly cages)	
Kookoo's Nest	Siaton	No	Little-Medium	Good	Continuous reef	22m	High (nets and cages)	High coral cover, lot of soft coral

Figure 1: Research sites
1=Kookoo's Nest, 2=Antulang, 3=Andulay, 4=Lutoban South, 5=Lutoban Pier, 6=Guinsuan, 7=Basak, 8=Malatapay, 9=Dauin Poblacion

Fish visual census

At each research site a group of 3 divers swim over the reef for a duration of 50 minutes using the Rapid Visual Census method (RVC), as suggested by Hill & Wilkinson (2004). The RVC method is a relatively easy counting method, because the observer doesn't count the amount of each species. Schools of fish are marked as one individual and fish species that are already observed in the same block are not counted again, limiting the time that the researcher is looking at his slate. Volunteers have collected most of the research data and because of their limited stay it was not possible to monitor all fish families at the same time, due to the larger inaccuracy and increase in training time.

A survey consisted of 5 blocks, 10 minutes each, in which presence/ absence was noted of all species of the observed group. The RVC method assumes that fish species found during a random swim in the first block are likely very abundant because it takes less effort to be found, while species that are found only in the last block are likely to be less abundant, because it takes more time to encounter them. Each site was sampled 6 times for each group of families to compensate for differences within sites. In total 216 surveys have been carried out. Surveys were conducted between 9.00 -15.00h. The research took place from January 2015 until March 2016. Since the data was mainly collected by volunteers, the number of researchers was high with 42 observers.

The most important fish families have been monitored in four different batches:
Group 1: Chaetodontidae (Butterflyfish) and Pomacanthidae (Angelfish);
Group 2: Serranidae (Groupers), Scaridae (Parrotfish), Haemulidae (Sweetlips), Siganidae (Rabbitfish), Lutjanidae (Snappers);
Group 3: Acanthuridae (Surgeonfish), Caesionidae (Fusiliers) , Lethrinidae (Emperors),

Nemipteridae (Coral Breams), Ballistidae (Triggerfish), Monocanthidae (Filefish), Tetraodontidae (Puffers), Ostraciidae (Boxfish) and Diodontidae (Porcupinefish); Group 4: Labridae (Wrasses) and Mullidae (Goatfish).

Data analysis

The presence/ absence data was randomized over the 5 blocks afterwards, since the swims were not carried out random, but instead started deep and ended shallow since a diver has to follow a certain dive profile and the number of available access points of the reefs were limited. Points (5, 4 , 3, 2 or 1) were awarded to each block by multiplying the presence/ absence for each species per sample. The samples were balanced by compensating for the different amount of samples per research site.

Relative abundance and diversity were calculated with R with relative abundance and diversity as independent variable and research site as independent variable. The relative diversity was calculated with the Shannon-Wiener diversity index (Spellerberg, 2008). This index takes into account both the species abundance and evenness using the following equation

$$H=\Sigma[(pi)\times\ln(pi)]$$

in which (pi) is the relative number of individuals per species in the sample.

Results and discussion

Although the amount of surveys carried out is relatively high, it is difficult to interpret the data. Few other variables have been included in this pilot study, which lead to the inclusion of several personal observations and assumptions that were not looked at into detail at the time this study was carried out. It is also important to realize that we have not observed actual numbers but relative differences and looked at groups of fish families, making it difficult to compare the fish families not observed at the same time. Variances in environmental conditions, seasonal changes and unknown spawning events could change the abundance of fish families during the year, while each family has been observed in a three month period. The results will therefore be interpreted at a very basic level. It is beyond the scope of this study to go into much detail about fish at individual species level, except for some fish species that are commercially interesting or collected as aquarium species.

A total of 308 species have been observed during the Rapid Visual census. Table 2 provides an overview of the number of species observed of each fish family. Few large individual fish species were observed (pers. obs.), as well as fish species that are becoming rare in the Philippines because of the commercial interest, like *Lutjanus argentimaculatus* (Mangrove red Snapper), *Cheilinus undulatus* (Humphead Wrasse) and *Lethrinus microdon* (Smalltooth emperor)(Lavides et al. 2016).

Table 2: Number of observed fish species of each family, their habitat and diet.

Fish families	Number of species observed	Habitat	Diet
Chaetodontidae	33	On reef	Invertebrates, coral, zooplankton
Pomacanthidae	13	Shallow reef	Invertebrates, zooplankton, algae
Serranidae	22	Reef bottom	Fish, crustaceans
Scaridae	22	On reef	Invertebrates, zooplankton, algae
Haemulidae	9	Near reef	Crustaceans
Siganidae	11	On reef	Algae, seagrass
Lutjanidae	21	Near reef	Fish, invertebrates
Acanthuridae	27	On reef	Algae, planton, detritus
Caesionidae	8	Near outer reef	Zooplankton
Lehrinidae	10	Reef fringe	Fish, invertebrates
Nemipteridae	9	On reef, sand and rubble	Invertebrates
Balistidae	10	On reef	Fish, invertebrates, planton, algae
Monocanthidae	8	On reef and seagrass	Invertebrates, algae, seagrass, coral
Tetraodontidae	11	On reef and seagrass	
Ostraciidae	5	On reef	Invertebrates
Diodontidae	3	On reef	
Labridae	77	Bottom dwellers	Invertebrates
Mullidae	10	On reef and sand	Fish and invertebrates

Site description

Basak

Basak has a patch reef that is in good condition. The reef rugosity (structural complexity of the reef) and the percentage coral cover is high (pers. obs.). A high rugosity is good for fish biomass and abundance (Graham & Nash 2013). Although it is an MPA that was established in 2006 (Alcala et al. 2008), illegal fishing sometimes occurs.

Most fish families have a high relative abundance and diversity. The Ostraciidae and Nemipteridae have the highest relative abundance in Basak. The Chaetodontidae and Caesionidae have the highest relative diversity compared to the other research sites. The Pomacanthidae have a low relative abundance and diversity, while the Acanthuridae and Scaridae have only a low relative abundance.

Dauin Poblacion

Dauin has a continuous reef that is in good condition with a high percentage coral cover and high reef rugosity in the shallow areas (5m and up), although it has some rubble areas because of typhoons occurring in 2011 and 2012. Generally, the visibility is very good. The MPA was established in 2000 (Alcala et al. 2008) and is strictly enforced, therefore no illegal fishing occurs. The only anthropogenic threat is the amount of divers that visit the reef. Dauin has a small artificial tyre reef at 20m.

Most fish families have the highest relative abundance in Dauin Poblacion. The Acanthuridae are more abundant and Siganidae are more diverse compared to other research sites. Several species of *Naso* occur at Dauin, which are hardly seen in other areas. Commercially interesting species like *Naso annulatus* (Whitemargin unicornfish), *Naso brevirostris* (Spotted unicornfish), *Acanthurus olivaceus* (Orangeband surgeonfish), *Acanthurus nigricauda* (Blackstreak surgeonfish) occur almost only in Dauin MPA. However, some families have a very low relative abundance and diversity compared to other research sites including the Pomacanthidae, Haemulidae, Lutjanidae and Lethrinidae.

Antulang

Antulang is an almost continuous reef, but has areas were the reef is patchy. The reef is deep with a higher percentage coral cover at areas below 10m (pers. obs.). Part of the reef used to be an MPA that was established in 2007 (Alcala et al. 2008) but abandoned in 2012.

Most fish families have a high relative abundance and diversity. The Balistidae have the highest relative abundance of all research sites and the Ostraciidae have the highest relative diversity. There is no fish family with a low relative abundance or diversity.

Andulay

Andulay is an MPA that is relatively well protected, with illegal fishing occurring rarely. The MPA was established in 1996 (Alcala et al. 2008). There are some rubble areas from earlier typhoon damage, but otherwise it is a continuous reef in good condition.

Most fish families have a high relative abundance and diversity. The Lethrinidae have the highest relative abundance and diversity at Andulay and the Haemulidae have the highest relative diversity of all sites. Some families have a low relative abundance and diversity like the Pomacanthidae, Caesionidae, Monocanthidae and Mullidae. The family of the Ostraciidae have a low relative diversity.

Kookoo's Nest

Kookoo's Nest has a high percentage of soft and hard coral and the highest reef rugosity (pers.obs.) with no river outlets nearby, which implies the conditions are good for fish. The reef was not destroyed by typhoons in 2011 and 2012 because there is a land barrier protecting the research site, resulting in little rubble. However, the fishing pressure is the highest of the observed sites. Both (drag) nets and cages are used in high frequency.

The relative abundance of Chaetodontidae is highest at this research site. The Lethrinidae family has a high relative abundance and diversity. Ceasionidae and Mullidae have a low relative abundance and diversity. There are several fish families with either a high or low relative abundance or diversity.

Malatapay

The shallow part of the reef is continuous and in good condition, however the percentage of coral cover seems low in deeper parts compared to other sites (pers. obs.). Malatapay faces multiple anthropogenic threats including the run-off from the weekly cattle market, large amounts of garbage that has been thrown in or near the water including paint cans, the beach that is used as repair area for the small boats going back and forth to Apo, frequent loading of a sand barge only meters away from the reef in which a lot of sand is spilled and fishing. The visibility is often poor close to the coast, but improves after several meters.

Most fish families are neither very abundant nor very diverse. The Monocanthidae and Nemipteridae have the highest relative diversity of all sites. Mullidae and Pomacanthidae have a high relative abundance and diversity, while Lethrinidae have a low relative abundance and diversity. Large schools of Lutjanidae and Caesionidae were observed at every dive.

Guinsuan

The reef at Guinsuan is very patchy with large stretches of sand in between the coral. It has a small artificial tire reef at 18m, but the coral does not get any deeper than 16m, making it the most shallow reef of all research sites. The river outlet is near, resulting in often poor visibility. The current is the strongest of all research sites. Guinsuan has high fishing pressure with multiple fish cages observed each dive.

At first sight, it looks like there are mainly small fish (pers. obs.). Most fish families are neither abundant or diverse. Lutjanidae, Haemulidae and Diodontidae have the highest relative abundance of all sites. Chaetodontidae and Serranidae have a low relative abundance and diversity.

Lutoban Pier

Lutoban Pier has an almost continuous reef. This research site faces multiple anthropogenic threats, which might explain the low relative abundance and diversity. The fishing pressure is high, with both nets and cages. The reef experiences high siltation rates and garbage runoff due to the adjacent river mouth; but especially because of the current pavement of the Coastal Highway. Sand has been blowing into the water constantly, submerging the coral almost permanently with a fine layer of silt. Visibility can be very low at times.

Lutoban Pier has a low relative abundance and diversity of almost all fish families. Pomacanthidae and Caesionidae have a high relative abundance and diversity compared to other sites.

Lutoban South

Lutoban South has a continuous reef but the percentage coral cover is relatively low compared to other research sites (pers.obs.). It has a small artificial tire reef at 22m, which Haemulidae prefer since we observed them at each dive. The fishing pressure consists of both nets and cages. Although Lutoban South is an MPA on paper and was established in 2002 (Alcala et al. 2008), it is not enforced.

Lutoban South has a low relative abundance and diversity. Pomacanthidae has the highest relative abundance and a high relative diversity compared to other sites. Haemulidae have a high relative abundance and diversity.

Overall relative abundance and diversity

As can be seen in table 3, MPAs have the highest ranking for both relative abundance and diversity. All functional MPAs (Basak, Dauin Poblacion and Andulay) are in the top 4. Basak has a higher ranking than Dauin Poblacion although there is less enforcement (pers. obs.) and while Dauin Poblacion has a continuous reef, Basak has a smaller and much more patchy reef. The higher relative abundance and diversity in Basak could be a result of larvae dispersal from Apo island that reaches Basak more than Dauin (Stockwell et al. 2009, pers comm. Rene Abesamis). If we look at which families have a higher relative abundance and diversity in Dauin, it seems that the more important families, like the herbivorous fish and commercially interesting species have the highest occurrence here. Part of the observed fish families prefer habitats of rubble and sand, or strong currents which are often present in Basak.

Antulang ranks higher than Andulay MPA, which could be the result of the spill-over effect from nearby Andulay MPA and Kookoo's nest. The fishing pressure is lower compared to other non-MPAs (pers.obs.). The reef is a bit deeper compared to most research sites with a relatively high rugosity at depth. This might explain the diversity of overfished species like Scaridae, Serranidae and Lutjanidae. Earlier research done in Andulay and Antulang also showed a higher fish biomass in Antulang compared to Andulay, although at that time part of Antulang was an MPA (Bucol 2014).

The fishing pressure is high in non-MPAs and Lutoban South MPA including a large number of fish cages and lines (pers. observation). In functional MPAs large individual fish species are more abundant compared to outside MPAs, like *Epinephelus fuscogattus* (Brown-marbled grouper) and *Lutjanus bohar* (Red Snapper). Fish species that are commercially interesting, e.g Serranidae, Scaridae, Acanthuridae, Haemulidae, Lutjanidae, Cesionidae and Nemipteridae (Bucol 2014) are generally found more inside MPAs compared to outside MPAs.

It is likely that the fish diversity and abundance correlates strongly with the percentage hard and soft coral (Green & Bellwood 2009). It is therefore not surprising that Lutoban South and Malatapay rank relatively low. This contrasts earlier research. In 1996 the fish diversity in Lutoban was better than in for instance Andulay (Schirm and Vogt 1997), which changed due to the typhoons. The total abundance in Lutoban was already low in 1996 because of fishing and has probably declined since.

Table 3: Ranking of the relative abundance and diversity of combined fish families for each research site.

Research site	Relative Abundance ranking	Relative Diversity ranking
Basak	1	1
Dauin Poblacion	2	3
Antulang	3	2
Andulay	4	4
Kookoo's Nest	6	6
Malatapay	7	5
Guinsuan	5	7
Lutoban Pier	8	8
Lutoban South	9	9

Occurrence of fish families

Chaetodontidae and Pomacanthidae

Chaetodontidae have an overall high relative abundance ranking compared to Pomacanthidae, as can be seen in figure 2. After the Labridae they have the most individual species. Continuous reefs that have a high coral cover in soft and hard cover are more likely to attract corallivore species. At least 8 of the observed families have species that are corallivores, with the Chaetodontidae having the most species (Cole et al. 2008). It explains the high relative abundance of Chaetodontidae in Kookoo's Nest, which is one of the sites with the highest percentage of hard and soft coral. Altough Nanola et al (2011) mention a decline of species in the Visayas region, species that are collected for aquarium trade can be still be found, albeit in small numbers and include *Heniochus singularius* (Singular bannerfish) and *Heniochus monoceros* (Masked bannerfish) at most sites, *Chaetodon citrinellus* (Speckled butterflyfish) in Basak MPA, *Hemitaurichthys polylepsis* (Pyramid butterflyfish), and *Chaetodon reticulatus* (Reticulated butterflyfish), *Chaetodon ephippium* (Saddled butterflyfish) in the Siaton research sites. These cover almost all of the collected Chaetodontidae aquarium species.

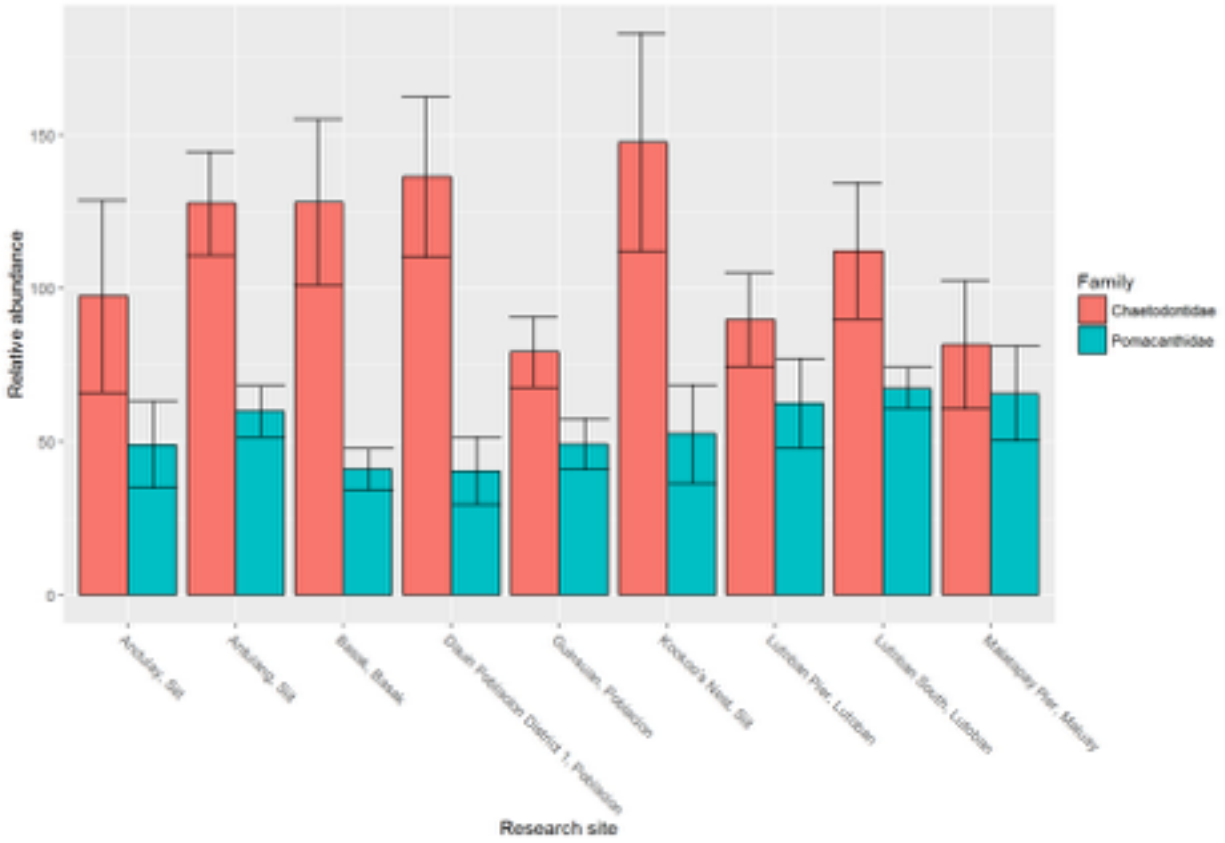

Figure 2: Relative abundance of Chaetodontidae and Pomacanthidae at all research sites.

Pomacanthidae are doing better in non-MPAs compared to MPAs which makes it a unique family. It is possible that because of the fishing pressure Pomacanthidae get an opportunity to flourish and occupy niches that would normally be held by other families in more protected reefs. It would explain the relative abundance and diversity of Pomacanthidae in both Lutoban research sites and Malatapay, see also figure 2 and 3. Two of the three collected aquarium species of Pomacanthidae, *Apolemichtys trimaculatus* (Three-spot angelfish) and *Centropyge nox* (Midnight angelfish) (Nañola et al. 2011) occur on most research sites with the last one in relatively large numbers. Fish collection for aquarium species hardly occurs in this region of the Philippines, implying that the populations of Chaetodontidae and Pomacanthidae are relatively undisturbed. Both families are a bycatch of fishing but in much smaller number compared to other fish families (pers. obs.).

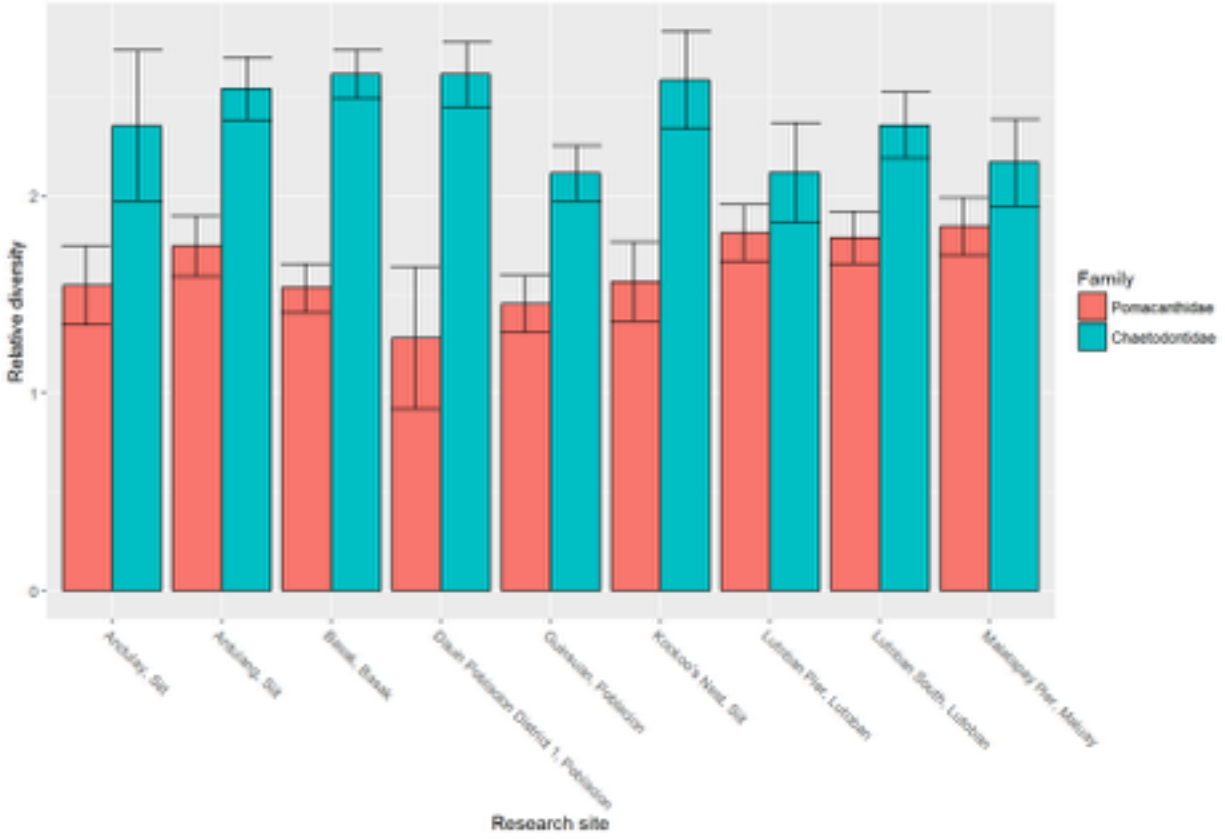

Figure 3: Relative diversity of Chaetodontidae and Pomacanthidae at all research sites.

Herbivorous fish and popular consumable fish: Acanthuridae, Scaridae and Siganidae

The bigger species of Acanthuridae and Siganidae and all Scaridae are commercially interesting fish (Carpenter and Niem 1999).

Acanthuridae are doing extremely well in Dauin, but are also abundant in Kookoo's Nest as can be seen in figure 4, which is explained by the good condition of both reefs, implying there is an abundance of food. The Acanthuridae are slightly less abundant which can be explained by the fishing pressure. Basak scores low, which might be because of the stronger current or the limited amount of food correlating to the lower coral cover percentage. Looking at relative diversity the differences are much smaller.

Scaridae abundance follows more or less the site ranking, with the exception of Basak. However, Basak does have a high relative diversity. The low abundance of Scaridae in Basak might be the same reasons as for the Acanthuridae.

Siganidae occur in much smaller numbers compared to Acanthuridae and Scaridae. They are much more abundant in Dauin than any other site. The commercially interesting species *Siganus corallinus* (Coral rabbitfish) (Nañola et al. 2011) is most abundant in Dauin.

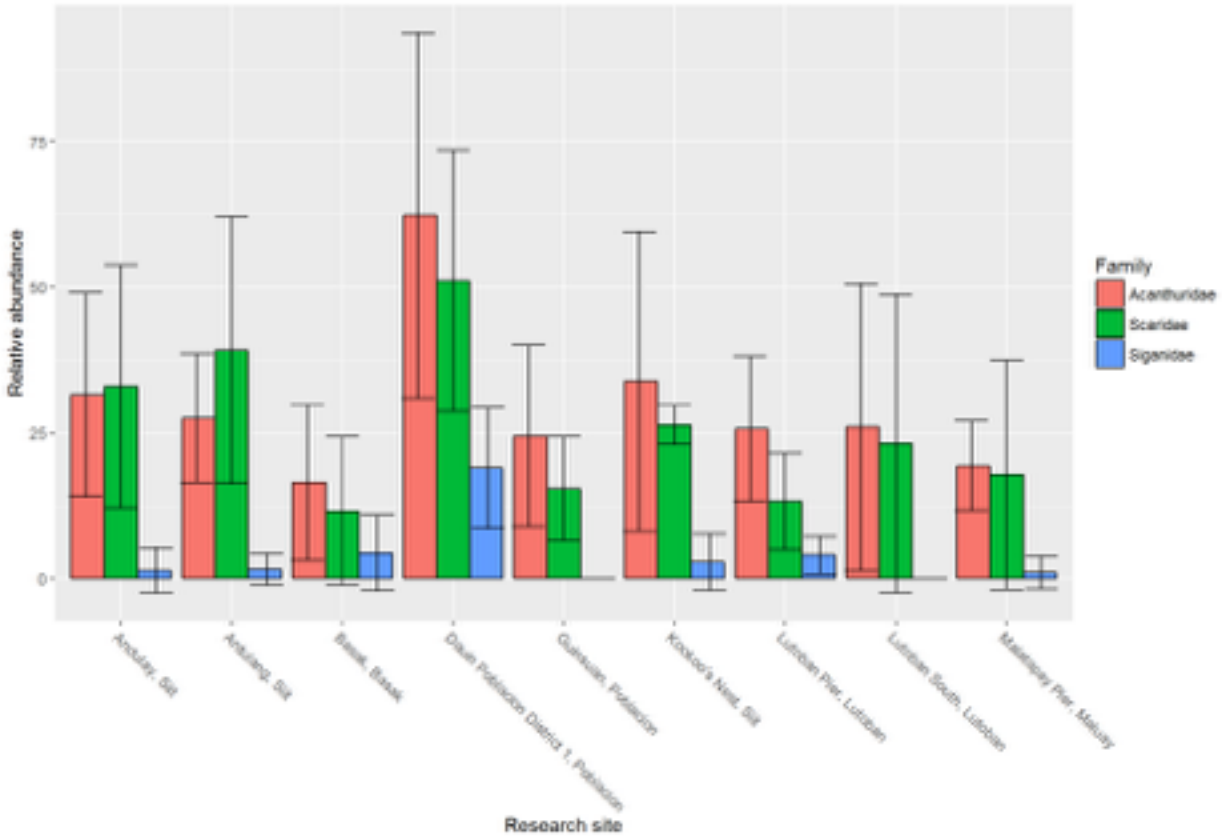

Figure 4: Relative abundance of most important herbivorous fish families at all research sites.

Popular consumable fish: Serranidae and Haemulidae

Serranidae are the most highly priced consumable fish family (Carpenter and Niem 1999). The families' occurrence neatly follows the ranking as can be seen in figure 5, which is to be expected with a higher occurrence in MPAs where fishing is not allowed. Serranidae have several overfished species that still occur in MPAs but are less or non-abundant outside MPAs, like the *Epinephelus fuscoguttatus* (Brown-marbled grouper) and *Variola louti* (Yellow-edged Lyretail). The exception is Basak with a low relative abundance. Serranidae most likely do not prefer the conditions at Basak, such as the patch reef or strong current. Groupers for instance tend to sit on the reef and not in sandy areas.

Most species of Haemulidae were observed at 18 meters or deeper at artificial tire reefs in Lutoban South and Guinsuan and on the edge of the reef in Andulay. Although known to be a commercially interesting family, they occur both inside and outside MPAs and are rare in Dauin as can be seen in figure 6. They often occur on artificial reefs, which might make catching more difficult for fishermen.

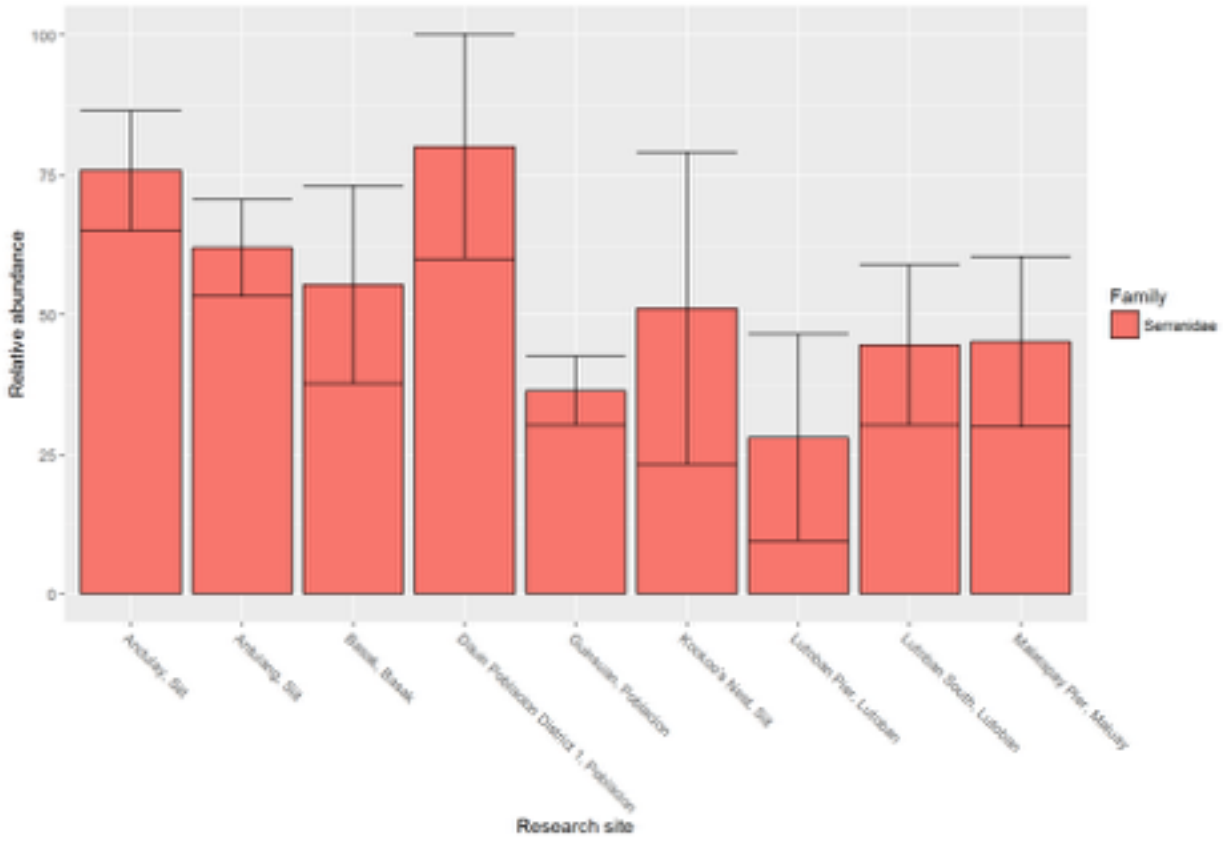

Figure 5: Relative abundance of Serranidae at all research sites.

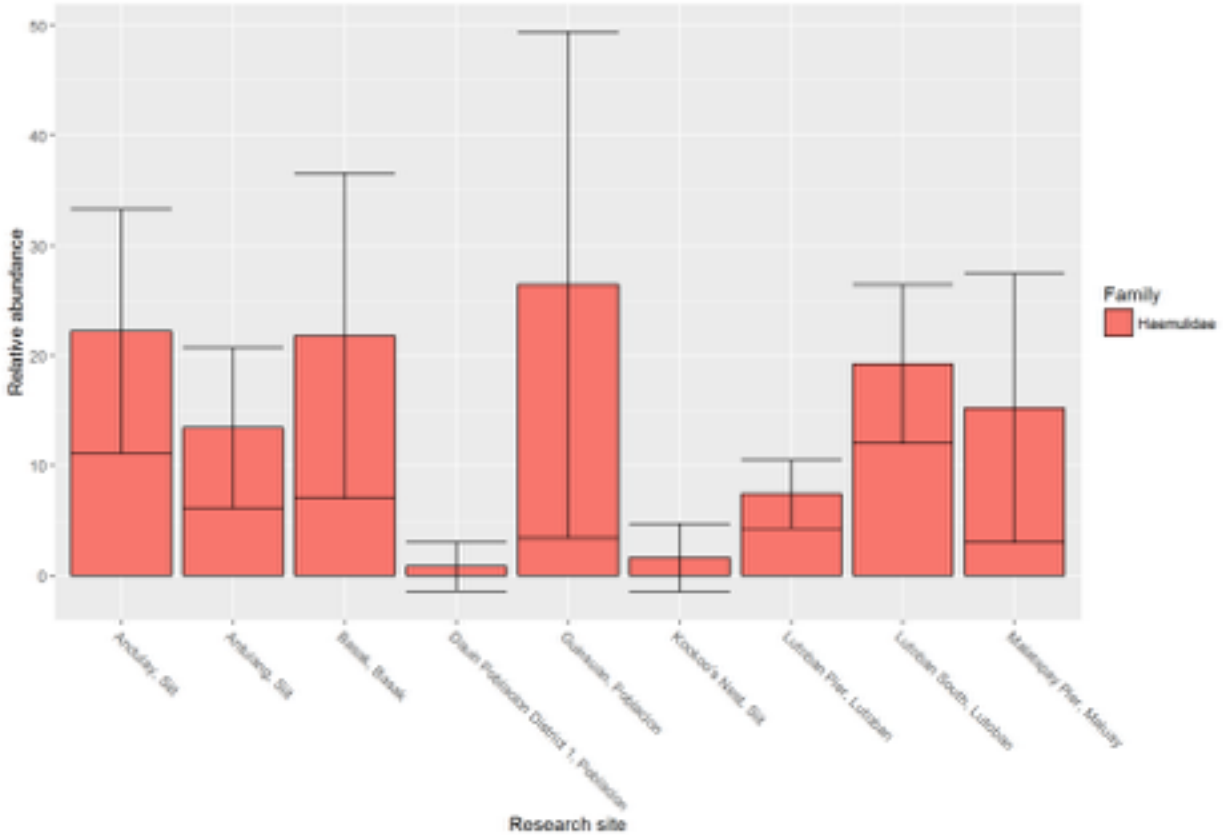

Figure 6: Relative abundance of Haemulidae at all research sites.

Popular consumable fish: Lutjanidae and Caesionidae

Caesionidae are only visitors of the reef and occur in big schools. Interestingly they have a very high relative abundance in Guinsuan and Lutoban Pier (figure 7), which could correlate to the current in Guinsuan, but not Lutoban Pier. The low abundance in Kookoo's nest is most likely explained by the amount of drag netting in which fishermen are able to catch an almost complete school of Caesionidae.

Lutjanidae have a high relative abundance at Guinsuan and Lutoban Pier. The relative diversity is high in Guinsuan, Basak and Malatapay, but low in Dauin, see also figure 7 and 8. They might have a preference for current. Lutjanidae species occur both in schools and singular. At the research sites with high relative diversity the schools of Lutjanidae are often spotted. This does not necessarily reflect the relative abundance, because the schools are often more or less in the same spot. *Lutjanus bohar* (Red snapper) is the species most commercially interesting (Nañola et al. 2011) and is mostly seen in MPAs.

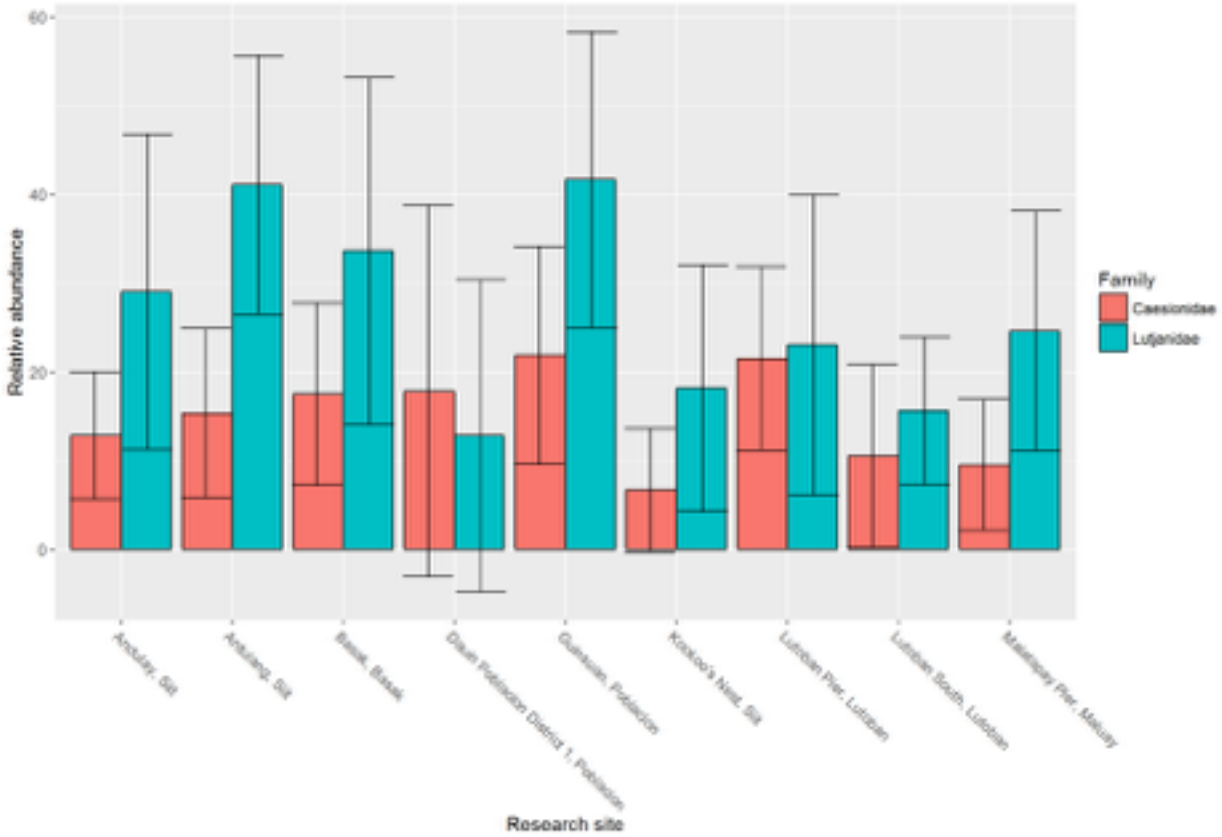

Figure 7: Relative abundance of Caesionidae and Lutjanidae at all research sites.

Labridae and Mullidae

Labridae follow more or less the ranking of the research sites, but generally have a high relative abundance and diversity at all dive sites, suggesting that they thrive in a wide variety of reef conditions. This family has the highest number of different species counted with 77 species.

Mullidae have a low relative abundance at Kookoos Nest, but high at Malatapay which might be explained by their preferred habitat of rubble and sand. Kookoo's Nest has hardly any sand and rubble areas, while Malatapay is much more sandy compared to other research sites.

Other fish families: Balistidae, Nemipteridae, Lethrinidae, Diodontidae, Ostraciidae

With some of the families it is hard to explain why the relative abundance and diversity is higher at certain sites. Some families are not popular for fishing, their diet does not explain their occurrence, nor does the substrate on the reef. Little research is done on the families listed above meaning that much of their behaviour is not well known. All these families except for the Balistidae are minor fish families and not many different species occur in this area.

Balistidae are most abundant at the research sites in Siaton, for which we cannot give an explanation. *Odonus niger* (Redtooth triggerfish) is a commercially interesting species but occurs both in MPAs and non-MPAs.

Nemipteridae prefer sand and rubble habitats, which are present at all research sites. They have a high relative abundance in Basak which correlates to the large areas of sandy bottom but does not explain the low abundance in Antulang which also has a large sandy bottom.

Very little is known about the families of the Diodontidae and Ostraciidae and the data does not show any pattern that can be easily explained when diet and habitat are taken into account, suggesting that other variables determine the occurrence of these families.

Lethrinidae are often found at the deeper part of the reef and are common in Andulay and Kookoo's Nest, but not in Antulang. It might be that Lethrinidae occur even deeper in Antulang because the reef continues up to 35m (pers. obs.).

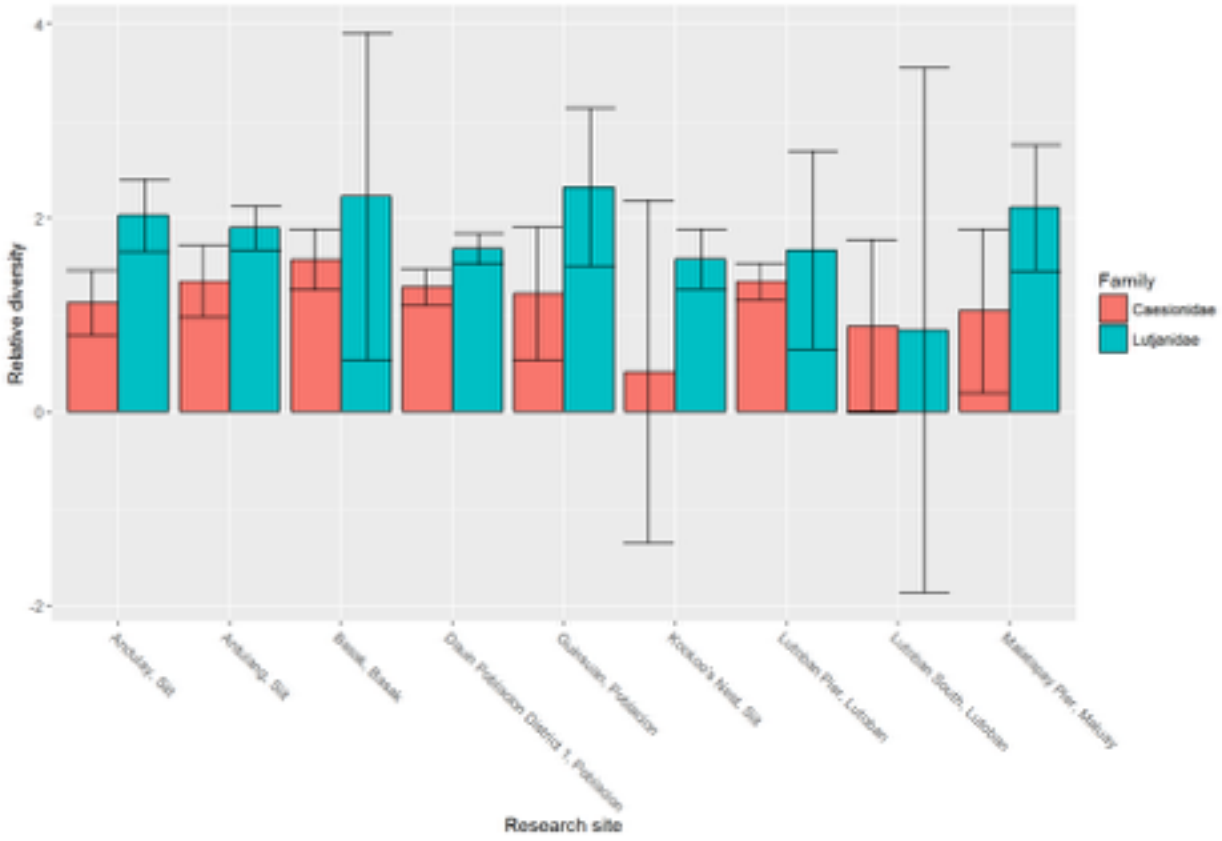

Figure 8: Relative diversity Caesionidae and Lutjanidae at all research sites.

Overall discussion

There are more fish families that spend part of their life on the reef and could have been surveyed, like the squirrelfish, barracuda and other predatory fish and therefore selection might seem a bit random. However, most of the important fish families observed were either commercially important fish species, e.g Acanhuridae, Scaridae, Serranidae, Haemulidae, Lutjanidae, Caesionidae, Nemipteridae, Mullidae and Nemipteridae (Bucol 2014) or herbivorous fish.

Comparing fish at family level is a non-specific method. Fish that are part of the same family can differ greatly in diet, size and habitat. Individual Chaetodontidae species have very different diets and have therefore different requirements. Corallivores such as *Chaetodon trifascialis* (Chevroned butterflyfish) and *Chaetodon unimaculatus* (Teardrop butterflyfish) are observed at sites which have a high percentage coral cover like Kookoo's Nest, while generalists like *Forcipiger flavissimus* (Longnose butterflyfish) can be found at each research site. Serranidae are a popular commercial fish family, but while the *Epinephelus fuscoguttatus* (Brown-marbled grouper) was only observed within MPAs, the small *Epinephelus fasciatus* (Blacktip grouper) was observed everywhere because it is too small to be interesting for fish catch. Balistidae differ greatly in habitat. *Odonus niger* (Redtooth triggerfish) occur high up in the water column, while the *Balistapus undulates* (Orange-lined triggerfish) are found hiding in rock openings. The *Balistoides viridescens* (Titan triggerfish), which grow up to three times bigger than other triggerfish species prefers sandy areas close to the coral.

With a more in depth literature study, interesting details about the reef conditions might have been discovered and fish species occurrence at certain research sites might have been explained. Since very little was known about species occurrences in this study area, this study is a first step in determining the health of the reef and marine life. The indicator fish species list for long term monitoring is derived from the data in addition to data from fishbase and FAO. Results would be more accurate if all fish species are observed simultaneously. However, that is not possible with continuous switching of research assistants. A list of selected indicator fish species is the second best option and long term volunteers will be able to assist in the long term monitoring of the fish.

The use of the RVC method is susceptible to both over- and undercounting. This method only counts species presence or absence, so species that occur individually might end up higher in the total count, while families that occur in schools like Caesionidae are more abundant in numbers but are counted as one. Because the relative diversity has been calculated, instead of the diversity with the Shannon-Wiener, the numbers are even more skewed. There is high variation within research sites with some fish families. During some of the surveys in Kookoo's Nest complete schools of Caesonidae were either present or absent. It is very likely to conclude that at least one of the schools counted on a previous survey have been caught by fishermen.

Conclusion

Fish families are most abundant and diverse in the MPAs of Basak, Dauin and Andulay. Antulang also ranks high. The paper MPA of Lutoban South has the lowest relative abundance and diversity. Visible anthropogenic threats have been observed at various research sites. The fishing pressure outside MPAs is high, resulting in less big fish and a lower number of commercially interesting species. Nets, fish cages and hook and line fishing have been observed outside MPAs. Aquarium trade is unlikely, because of the high numbers of Chaetodontidae and Pomacanthidae and occurrences of other species that are known to be collected for the aquarium trade. Other visible anthropogenic threats are the high siltation rate in Lutoban Pier and around the sand barge in Malatapay, as well as the amount of garbage in the water in Malatapay.

Future studies which combine fish surveys with invertebrate and substrate of the same research sites and include variables like reef rugosity, water temperature, visibility, fishing pressure, sedimentation rate and occurrence of nearby rivers, will give a much better insight in explaining the abundance and diversity of individual fish species. Anthropogenic threats like siltation rate, agricultural run-off and other pollution need to be measured as well to help determine the major threats to the reef and how to protect them.

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