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Dolphin House Reef outer reef flat and reef front (© Patrick Louisy / Peau-Bleue)

MOALBOAL 2013
Peau-Bleue Fish Survey
Preliminary Report

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Warning

The quantitative and statistical results included in this short report are preliminary. For a complete understanding and interpretation, the data will deserve further examination, especially taking into account the recorded environmental parameters.

This fish survey took place in Moalboal, Cebu, Philippines, from July 13th to 27th, 2013. It was part of the "Underwater Biology trips" scientific program of the French association Peau-Bleue. It was organized by the Peau-Bleue scientific team in partnership with Dolphin House Resort (White Beach area), with the support of the Travel Agent Blue Lagoon.

This preliminary document offers a first summary of the main data collected during the survey.

A- THE SURVEYED AREA

Moalboal is located on the west coast of Cebu Island, Central Visayas, in Philippines. It is situated in the waters of Tañon Strait between Cebu and Negros islands.

Philippines are part of the so-called "Coral Triangle": a geographical term that refers to a roughly triangular shape of marine waters between the Pacific and Indian oceans within the territories of Indonesia, Malaysia, Philippines, Papua New Guinea, Solomon Islands and Timor-Leste. The Coral Triangle is unique in being home to the highest concentration and diversity of marine species on the planet.

Within the Coral Triangle, central Philippines are considered a major hotspot of marine biodiversity in terms of coral reefs, invertebrate and fish diversity (Carpenter and Springer, 2005): there is a higher concentration of species per unit area in the Philippines than anywhere else in the area. According to the Coral Triangle Initiative, Philippines are home to about 500 species of hard corals (Scleractinians) and 2724 marine fish species, of which 1658 are reef-associated (CTI, 2011).

The Moalboal Peninsula is surrounded with fringing reefs (with a littoral reef flat, and a reef slope or wall). Our survey took place on three sites along the west coast of the Peninsula, two Marine Protected Areas (MPA) and one site with no specific regulation (most of the information below provided by Mylene M. Panuncial and Rudy Poitiers):

• **White Beach / Dolphin House Reef** (HR on map)
This is the place where was implemented the "Fish Watch" survey (detailed description of fish communities in the various reef habitats). No specific regulation is applied there. Thus, it is subject to the various kinds of human pressures (including sometimes illegal activities).

• **Saavedra Fish Sanctuary**, or"**Marine Sanctuary**" (MS on map) - Area: 8.13 ha. Local, community managed.
Officially established by the Central Visayas Regional Project (CVRP) in 1987, this sanctuary was first implemented by a German NGO in the early eighties, and seemingly continuously monitored and managed since then.

• **Basdiot Fish Sanctuary**, or "**Tongo sanctuary**" (TS on map) - Area: 4.17 ha. Local, community managed.
Established by CVRP in 1988, but long non-functional until the Municipality took over for its revival. Seemingly fully monitored and managed since about 2007 (when buoys were set up).

NB *In the following sections, we will retain the customary names in use in most diving centres and diving maps, i.e.* "Marine Sanctuary" *for Saavedra Fish Sanctuary, and* "Tongo sanctuary" *for Basdiot Fish Sanctuary.*

B- PROTOCOLS

Two different studies were run during this Fish Survey. One was made to estimate the total fish species diversity in one site. The other was focusing on a quantitative assessment of fish subject to fishing or other human impacts in different sites.

• **Fish Watch Survey** on Dolphin House Reef

Aim: describing and comparing fish communities in the different reef habitats.

The Fish Watch protocol has been designed, tested and improved by Peau-Bleue since 2003 (more than ten Fish Watch missions in the Red Sea, Djibouti, Madagascar, North Sulawesi…). It aims at describing and comparing fish communities in different habitats and/or sites. According to this protocol, we made a comprehensive fish species census on the House Reef of Dolphin House Resort. We established fish species lists for the different habitats (inner and outer reef flat, reef front, reef slope), each species being given a semi-quantitative "presence index" value in each habitat.

The survey involved 16 Peau-Bleue amateur divers, 2 Dolphin House Filipino scientists and several dive guides. This team was under the scientific direction of Patrick Louisy, scientific director of Peau-Bleue. The divers spent a total of more than 400 hours recording fish species in Dolphin House Reef. This allowed to assess quite comprehensively the total fish richness and diversity of the 300 meters explored reef section, from the surface down to 25 meters deep.

• **Quantitative census of fished species groups** on 3 sites with different protection status

Aim: quantitatively assess populations of economically important fish groups, and compare them between sites at different depths.

For this study, we used a time transect protocol that was designed by Peau-Bleue in 2012, and tested during a fish survey in Indonesia. Presence-absence of 25 fish categories (with several size classes for each category) was recorded in a series of 5 minutes transects at constant depth. Three sites (Saavedra Fish Sanctuary or "Marine Sanctuary", Basdiot Fish Sanctuary or "Tongo sanctuary", Dolphin House / White Beach) and four depths (5, 10, 15 and 20 m) were sampled. Semi-quantitative data were also recorded, along the same transects, for a number of environmental descriptors.

As indicated before, the three studied sites have different protection or management histories: Marine Sanctuary has been protected since the early eighties, Tongo Sanctuary mostly since 2007. The Dolphin House / White Beach area has no specific management.

A total of 192 transects were made (by the same Peau-Bleue / Filipino survey team as above), equally distributed in the 3 studied sites. These data allow for a comparative assessment of the effect of management and protection measures on commercially important fish. They also provide reference quantitative information about the Dolphin House / White Beach reef section in the prospect of a possible future management program.

C- FISH WATCH SURVEY RESULTS

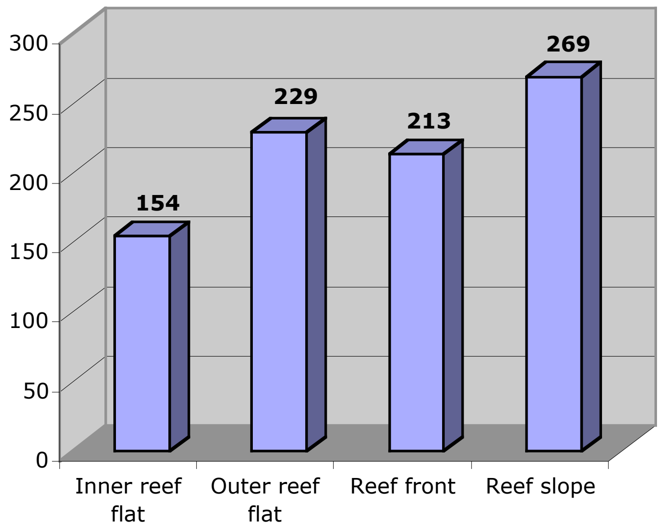
The results presented here remain preliminary: a final check of all the photos taken during the survey may lead to the addition of several more rarely seen species.

At the moment, **397 different fish species have been recorded** from the 300 m long reef section surveyed in front of Dolphin House resort.

The histogram on the right (Fig. **1**) shows the total number of fish species recorded (= species diversity) in each of the different habitats. The reef slope is richest, but it represents a larger reef surface than the reef front and outer reef flat. The species diversity recorded on the inner and outer reef flats can be considered very high for this kind of habitat.

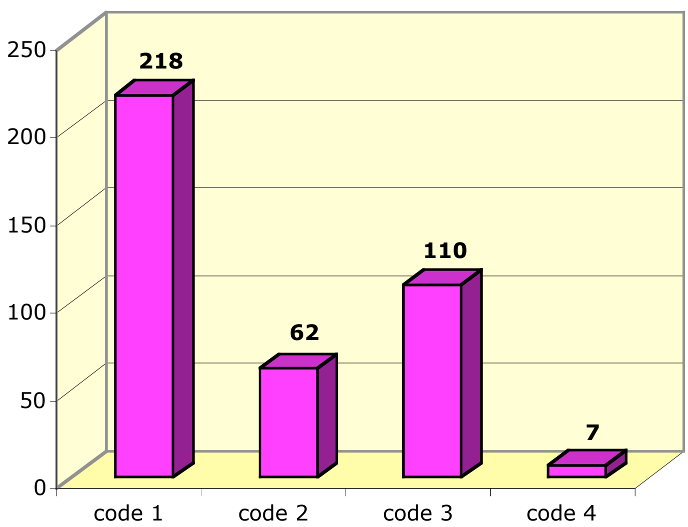
Fig. 1

Number of fish species recorded in each habitat of Dolphin House Reef



The presence index of a species in a given habitat was coded as follows:
1 - Rare or incidental species (one or very few records, not repeated),
2 - Normally present species (more than 3 records in the considered habitat for one observer, or different individuals recorded by several observers),
3 - Typical species (species systematically and repeatedly encountered by any observer exploring the considered habitat).
4 - Abundant species (species abundant in most of the considered habitat, with at least three schools numbering more than 100 individuals).

Fig. 2 **Distribution of fish species according to their Presence Index code**



The figure **2** on the left indicate the number of species that were rated code 1, 2, 3 or 4 in at least one habitat of Dolphin House reef.

7 species of Anthiinae (fairy basslets) and Pomacentridae (damselfish) were abundant enough to be rated code 4. On the other hand, 218 species were rated a maximum of code 1 in any habitat, which means that more than half of the recorded species may not be seen every time one dives on the reef. Thus, only 179 species were likely to be regularly encountered (during the survey period) in at least one of the reef habitats.

D- QUANTITATIVE FISH CENSUS RESULTS

64 census transects were made in each of the three surveyed sites (16 transects per depth, at 5, 10, 15 and 20 m). Only the fish group census results are shown here. The habitat parameters recorded along the same transects will be analysed later in order to better interpret the fish census data.

• Statistical analysis: model and method

We chose to model the number of fish families per transect versus the covariates "site" and "depth". Because the observations are counts, they can be assumed to be distributed as Poisson variables. The logarithm of their expected values is modelled by a linear combination of the covariates. Therefore, if we denote by Y the number of fish families, $E(Y / site, depth) = \mu_{depth,site}$ $= \exp(\alpha_{depth} + \beta_{site} + (\alpha\beta)_{depth,site})$, where α_{depth} and β_{site} represent the main effects of the covariates and $(\alpha\beta)_{depth,site}$ the interaction effects. We first used a stepwise model selection procedure based on the AIC criterion to determine which effects should be kept in the model. Then we used this selected model for estimating the $\mu_{depth,site}$'s and their confidence intervals. All the calculations are done with the package R http://cran.r-pro ject.org/.

The estimated effects, and their standard errors for the selected model will be given in the "Coefficients" tables. The estimated effects should be interpreted by noting that the category corresponding to site=HR and depth=5 is chosen as the reference category. The two last columns of the tables give the test statistic and its p-value for testing the null hypothesis that the considered effect is zero.

• Results: taxonomic diversity

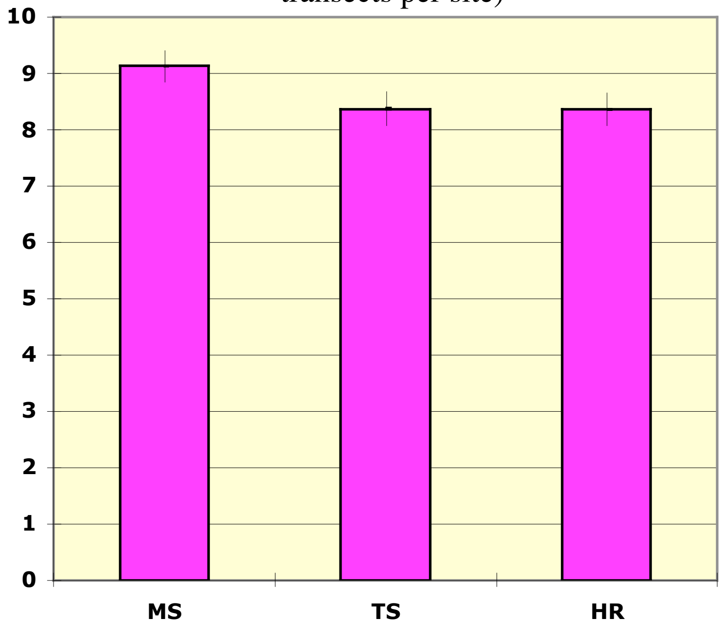
Our measure of biodiversity (or more precisely taxonomic diversity) is the number of fish groups recorded per transect.

The original fish group list included the following 24 categories: Butterflyfish, Angelfish, Wrasses, Goatfish, Rabbitfish, Fusiliers, Surgeonfish, Unicornfish, Parrotfish, Sweetlips, Snappers, Emperors, Groupers, Triggerfish, *Aluterus scriptus*, Batfish (Ephippidae), Jacks / trevallies, Bumphead parrotfish, Napoleonfish, Barracudas, Tunas / mackerels, Sharks, Rays, Squids / cuttlefish. But only 20 categories were actually recorded (Bumphead parrotfish, Napoleonfish, Sharks and Rays were not encountered during the transects).

During the survey dives, we found out that a category "Drummers" (Kyphosidae) would have been useful. These fish were not recorded even though they can be locally significant. This should be corrected if further surveys were to be implemented.

The number of fish categories recorded per transect varied from 2 to 14 (between 8 and 9 in average).

Fig. 3 **"Biodiversity":** Mean number of fish families per transect in the 3 sites (64 transects per site)



The figure **3** on the left (mean fish group number per transect ± standard error) shows that the encountered taxonomic diversity was slightly higher in Marine Sanctuary (MS) than in the two other sites.

In order to better describe the census data, the figures displayed here (Fig. **4**) show the mean taxonomic diversity (mean number of fish groups per transect ± standard error) recorded per depths in the three survey sites.

Marine Sanctuary: Mean number of fish families per transect at different depths (n±SE ; 16 transects per depth)

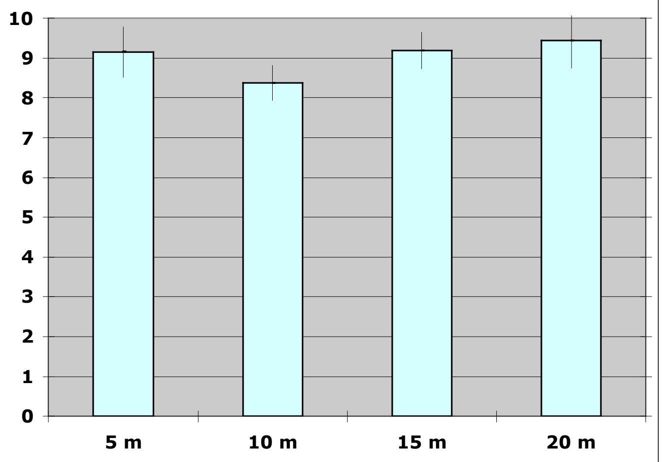
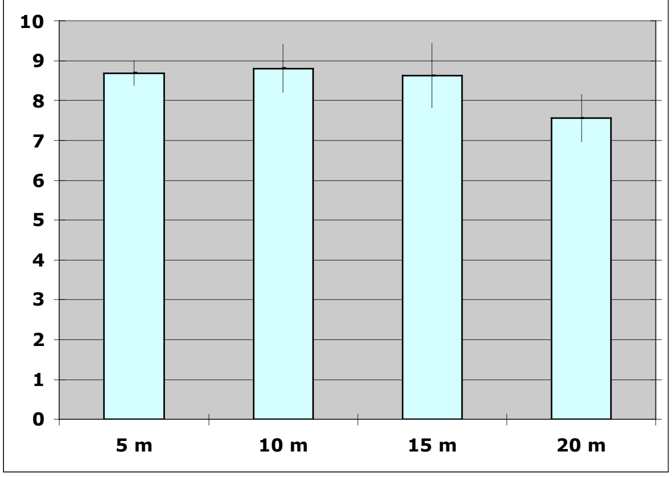
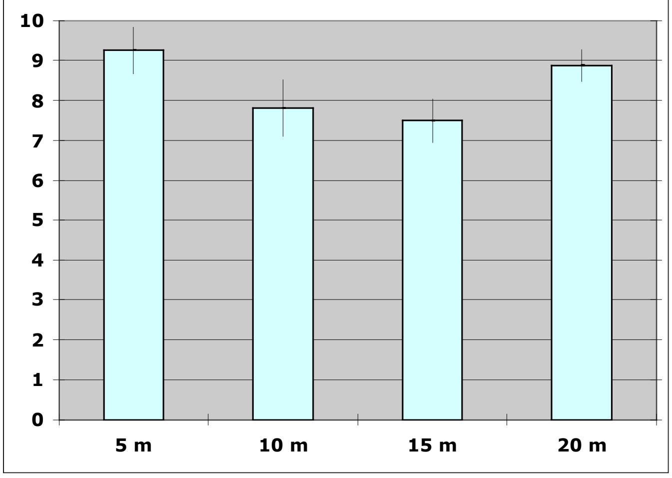


Fig. 4

Tongo Sanctuary: Mean number of fish families per transect at different depths (n±SE ; 16 transects per depth)



Dolphin House Reef: Mean number of fish families per transect at different depths (n±SE ; 16 transects per depth)



Statistical analysis:

The estimated effects, and their standard errors for the statistical model are given in the following table.

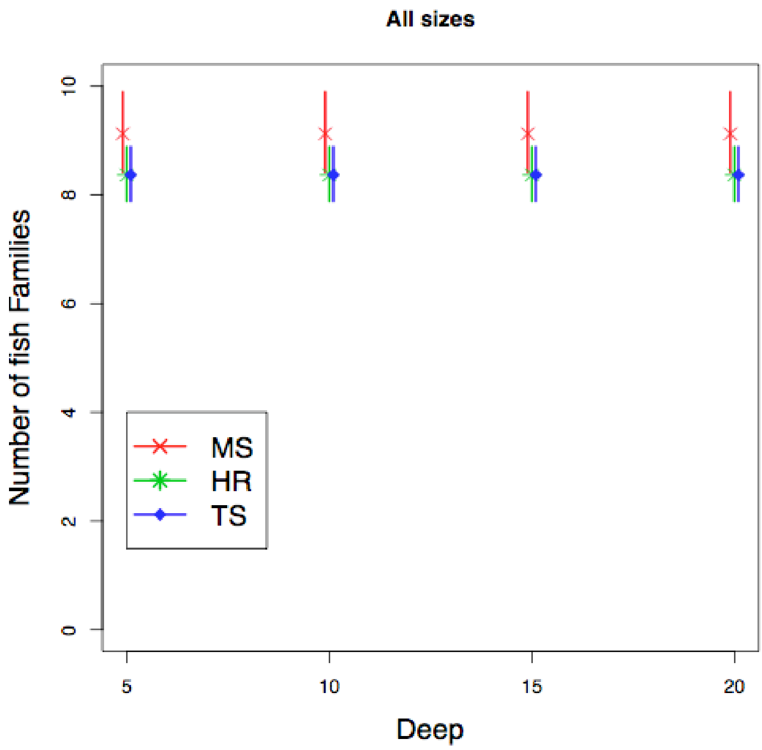
Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	2.12432	0.03056	69.521	<2e-16	***
SiteMS	0.08670	0.05144	1.685	0.0919	.

As could be expected from Fig 3, the model detected a “MS effect” (i.e. global taxonomic diversity is higher in Marine Sanctuary), although not very significant (p value: 0.0919). Further examination of the data will be necessary to check if this difference is best explained by the management status of the sites or by reef structure and ecological features.

On the other hand, no difference was found between TS (Tongo Sanctuary) and HR (Dolphin House Reef), as can be seen on the graph below (Fig. **5**), showing the $\mu_{depth,site}$'s estimated from the model (with 95% confidence intervals).

Fig. 5
Taxonomic diversity estimated by the statistical model per sites and depths. All sizes together.



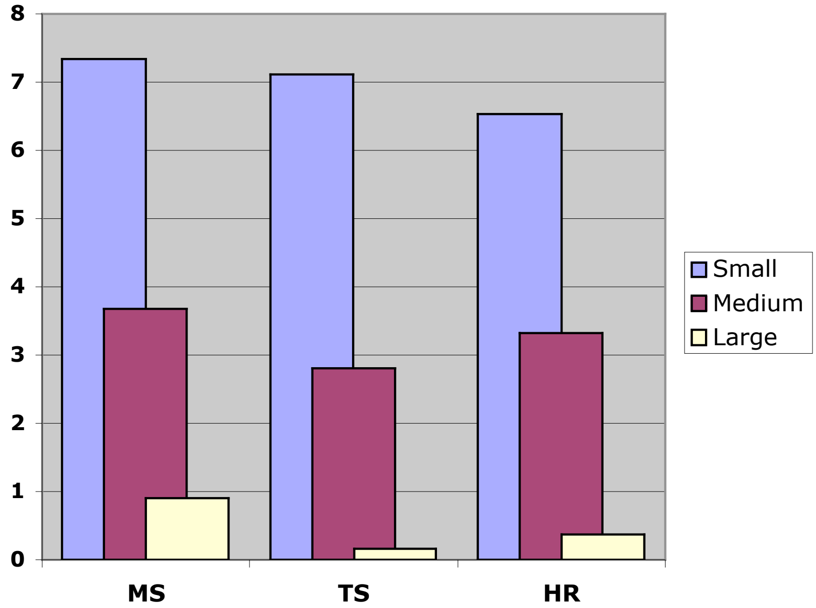
This graph also shows that none of the differences between depths that can be seen in Fig. 4 were retained by the statistical model. This means that the variability between transects at a given depth was higher than the variability between depths.

• **Results: large fish occurrence**

During the census transects, the occurrence of the different size classes was recorded for each of the fish groups. The size classes retained were as follows: XS (<12 cm), S (12-25 cm), M (25-40 cm), L (40-70 cm), XL (70-100 cm) and XXL (>100 cm). For the present analysis, size classes were grouped in three categories: ***Small*** (< 25 cm), ***Medium*** (25-40 cm) and ***Large*** (> 40 cm).

The graph below (Fig. **6**: mean taxonomic diversity for each size range in the different sites) summarizes the observed results for the three studied sites.

Fig. 6 **Mean occurrence per transect of fish group size classes in the 3 sites** (64 transects per site)



The graphs below more precisely show the mean taxonomic diversity for the larger sizes. *Medium* and/or *Large* fish recorded together in Fig. **7**, and *Large* fish only (> 40 cm) in Fig. **8**.

NB: The ordinate scales of the two graphs are not identical.

Fig. 7 **Mean occurrence** per transect of families with **medium or large** specimens in the different sites (64 transects per site)

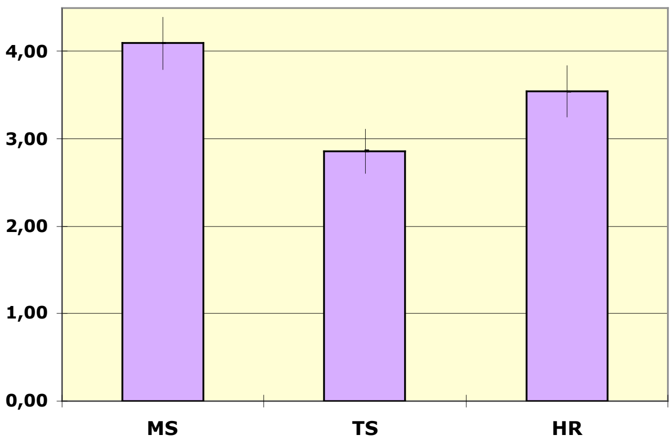
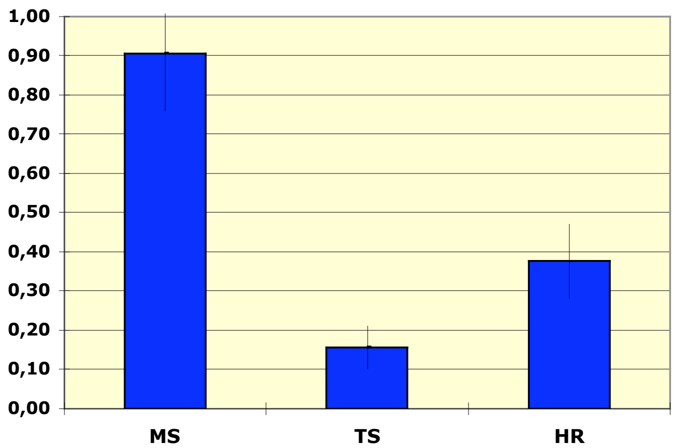


Fig. 8 **Mean occurrence** per transect of families with **large** specimens in the different sites (64 transects per site)



<u>Statistical analysis</u>:

The following table gives the estimated effects, and their standard errors for the statistical model applied to ***Medium* and/or *Large* fish together**.

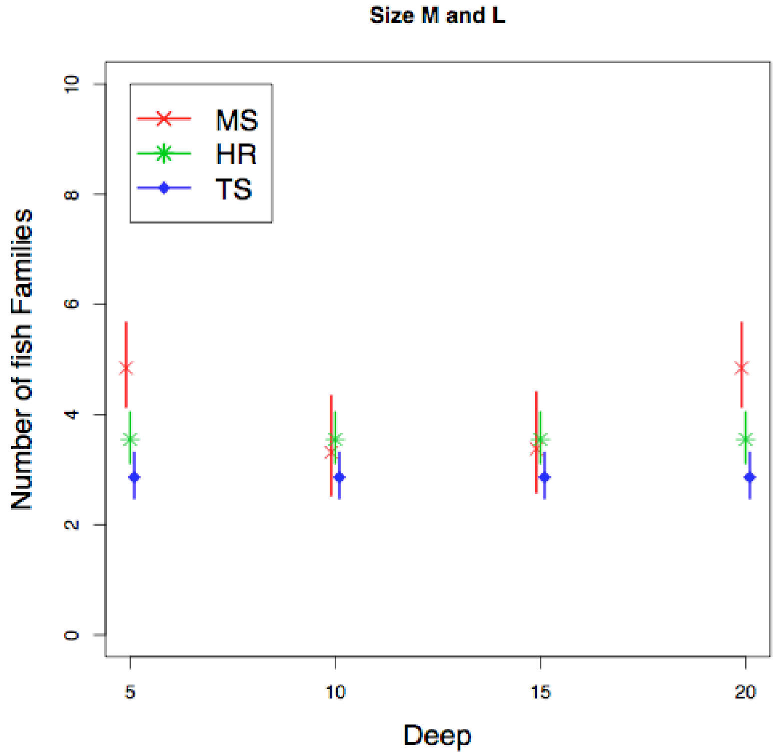
Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	1.26607	0.06637	19.075	< 2e-16	***
SiteMS	0.31162	0.10420	2.991	0.00278	**
SiteTS	-0.21546	0.09935	-2.169	0.03010	*
SiteMS.P10	-0.37999	0.15912	-2.388	0.01694	*
SiteMS.P15	-0.36129	0.15802	-2.286	0.02223	*

There is a clear site effect on *Medium* and/or *Large* fish taxonomic diversity: it is much higher in Marine Sanctuary (MS) than in Dolphin House Reef (HR), while it is lower in Tongo Sanctuary (TS). No global depth effect has been detected by the model. There is however a site-depth interaction: in Marine Sanctuary, *Medium* and/or *Large* fish taxonomic diversity is lower at 10 and 15 m compared to other depths.

These statistically significant effects can be seen on the graph below (Fig. **9**), showing the $\mu_{depth,site}$'s estimated from the model (with 95% confidence intervals).

Fig. 9
Taxonomic diversity estimated by the statistical model per sites and depths. ***Medium and/or Large** sizes together*.



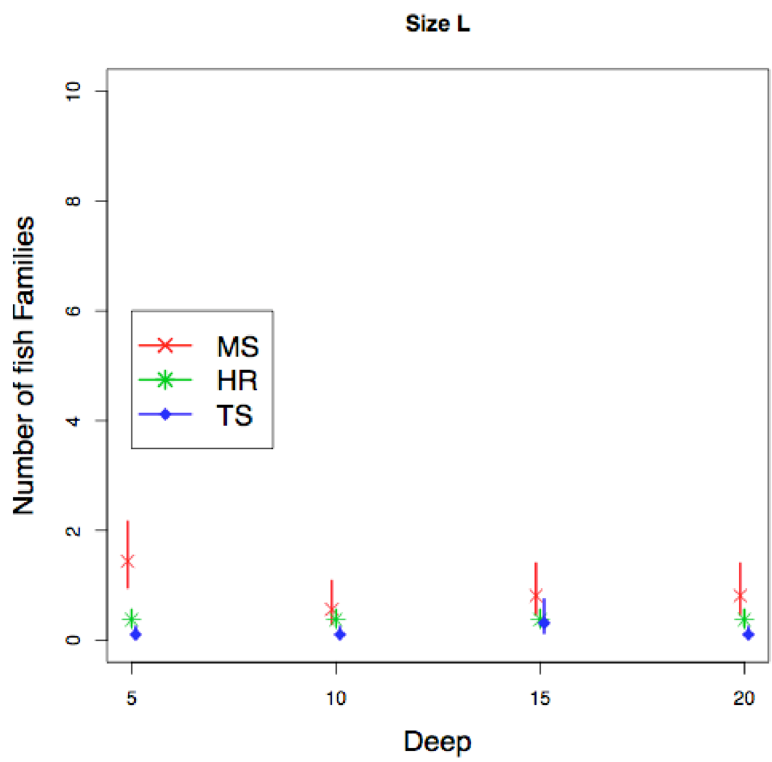
When **only the larger sizes** are considered (> 40 cm), the statistical model gives the following estimates.

```
Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)   -0.9808     0.2041  -4.805 1.55e-06 ***
SiteMS         1.3437     0.2918   4.605 4.12e-06 ***
SiteTS        -1.2809     0.4916  -2.606  0.00917 **
SiteMS.P10    -0.9383     0.3932  -2.386  0.01702 *
SiteMS.P15    -0.5705     0.3470  -1.644  0.10012
SiteTS.P15     1.0986     0.6325   1.737  0.08238 .
SiteMS.P20    -0.5705     0.3470  -1.644  0.10012
```

The effects detected for *Large* fish taxonomic diversity are quite similar to those obtained above for *Medium* and/or *Large* fish, but are even more significant. Thus, *Large* fish taxonomic diversity is very significantly higher in Marine Sanctuary than in Dolphin House Reef, and is significantly lower in Tongo Sanctuary.

The site-depth interactions in Marine Sanctuary indicate lower estimates at 10, 15 and 20 m (compared to 5 m, which is the reference depth in the model). In other words, in Marine Sanctuary, *Large* fish taxonomic diversity is higher at 5 m than at all other depths. This is visible on the graph below (Fig. **10**), showing the $\mu_{depth,site}$'s estimated from the model (with 95% confidence intervals).

Fig. 10
*Taxonomic diversity estimated by the statistical model per sites and depths. Only **Large** fish considered.*



E- DISCUSSION - CONCLUSION

The full analysis and complete interpretation of the fish survey data will necessitate time, and will be continued later. However, some first conclusions and comments can be made at the present stage.

• Dolphin House / White Beach reef: a high fish diversity

With a number of at least 397 recorded fish species, the explored reef section in the Dolphin-House / White Beach area is characterized by a very high fish diversity. In only 300 meters of reef (from 0 to 25 m), one can find more than 12 % of all the marine fish species known from Philippines (about 3200 species according to FishBase, 2013), or almost 24 % of all the reef-associated fish recorded in the country (1658 species according to CTI, 2011). As a comparison, similar surveys made in 2012 in Lembeh Strait (North Sulawesi, Indonesia) recorded 324 and 261 fish species (in Lembeh Resort House Reef and Nudi Falls Reef respectively).

The high fish species diversity in Dolphin House Reef is probably related with the wide local variety of habitats, reef topography, coral cover, and depth range.

However, a high species diversity doesn't necessary imply a high overall abundance. In any case, for a given habitat capacity, the higher the number of species, the lower the number of individual per species. This is illustrated by the strong proportion (55 %) of species that were only incidentally encountered in this Fish Watch survey (presence index code 1).

• Is there a protection effect on fish populations?

Actual recorded data presented in figures 7 and 8, and the statistical models (Fig. 9 and 10) indicate that a significantly higher occurrence of medium to large fish (in the 20 fish groups retained for the survey) can be found in Marine Sanctuary (Saavedra Fish Sanctuary), which has been protected for the longest time (about 30 years). This so-called "Reserve Effect" is even more significant for the larger fish (size > 40 cm). There seems to be also a positive effect of protection on the overall taxonomic diversity in Marine Sanctuary (whatever the size), but less obvious.

However, no reserve effect has been detected for Tongo Sanctuary (Basdiot Fish Sanctuary). Actually, we even observed a higher occurrence of large fish in the unprotected Dolphin House Reef. This paradoxical result could be explained by one or more of the following hypotheses:

- Habitat characteristics at the surveyed depths could be quite different in the three studied sites, and might thus have more influence on fish populations than the management history. To check and understand this, we will examine in detail the fish groups involved, their depth distribution and the environment parameters we measured.

- Tongo Sanctuary has been protected for a relatively short length of time (6 years). This duration might possibly be insufficient to get a reserve effect that could be detected with our protocol.

- There could be some difference of efficiency in the monitoring and control (regulation enforcement) between Marine Sanctuary and Tongo Sanctuary.

- Maybe there is a specific bias in Tongo Sanctuary with the protocol we used. Because the top of the reef wall is quite shallow there, most of the 5 m depth transects happened to be on the outer wall, and not on the reef front like in the two other sites. Our divers could observe a number of large fish in the shallows of Tongo Sanctuary, away from the censused zones.

Anyhow, the goal of the survey was to compare certain features of fish populations, not to specifically assess the efficiency of MPAs. Furthermore, many additional physical and biological variables should be taken into account when dealing with MPA assessment, like the state of the reef prior to the establishment of the MPA, available habitat diversity, water movement, etc.

• Discussion

As already stressed in the introduction, the coastal ecosystems of the Philippines are considered a hotspot of marine biodiversity (Carpenter and Springer, 2005). However, the country experiences a rapid increase in coastal populations along with an increase in fishing pressure (World Bank, 2006). Over-fishing, pollution, coastal development and sedimentation all are possible threats for coastal ecosystems (Wilkinson 2008, Burke *et al*. 2011). Such a global over-exploitation may also threaten the social and economic stability of coastal human communities, where many artisanal fishermen depend exclusively on the marine resources (World Bank, 2006). Thus, addressing the local social dimension is of utmost importance when dealing with coastal preservation. Recently, coastal tourism and diving have become significant economic incomes, and may be an important factor to consider in coastal management and Marine Protected Areas (MPAs) projects (Lucas and Kirit, 2009).

Marine reserves, or MPAs, are a well known tool for coastal resources preservation and management, and have contributed to the development of Integrated Coastal Management (ICM) in the Philippines for more than 30 years (Lucas and Kirit, 2009). The so-called “Reserve Effect”, i.e. the improvement of populations in terms of abundance and size, is especially obvious in fish (Louisy *et al*. 2012). Several comparative studies indicated that small MPAs can be efficient in improving biodiversity and fish production (Francour *et al*. 2001, Halpern 2003), provided that they are parts of a more general network (Varney *et al*. 2010).

With these considerations in mind, it is possible to discuss some specific conclusions we can draw from our results concerning Dolphin House / White Beach reef. This reef section is perceived by divers as one of the nicest dive sites in the Moalboal area. This might be due to its overall topographical and environmental diversity, and to its globally good condition. Indeed, with almost 400 species, the fish diversity we recorded there ranks among the highest one can find in the world. Clearly, such a natural heritage deserves being preserved from deleterious human impacts, so that its richness and diversity are not damaged or spoiled.

Although Dolphin House reef is not a specially protected area, our census yielded a higher occurrence of medium-sized and large fish there than in Tongo Sanctuary (Basdiot Fish Sanctuary). This means that the area has some environmental qualities allowing large fish to settle or transiently inhabit the reef. One possible explanation is the habitat diversity of the reef, that combines a reef flat rich in soft corals, sections of reef front and slope with high hard coral cover and diversity, sand and rubble gullies, slopes and walls with soft corals and gorgonians, diverse cavities, including below the studied depths (where caves and overhangs offer an array of shelters in 25-30 m)… This habitat diversity and the presence of deep shelters make the place a good candidate for management measures aiming at favouring the settlement and growth of large fish, in order to help develop breeding units of commercially interesting species.

The surveys we conducted aimed at providing objective information that could be of interest in the prospect of global coastal management of the Moalboal area. Of course, they are only one element of the overall equation, that includes political and social issues, and may involve many stakeholders, as mentioned in the beginning of this discussion.

Thanks
This scientific survey was made possible by the implication of numerous volunteer divers, with the support of Dolphin House resort and the French tour operator Blue Lagoon. Special thanks are due to Mylene, Ryan and the dive guides who greatly contributed to the underwater survey, and to the whole team of the White Beach Scuba Divers diving centre whose dedication allowed us to run this scientific survey in the best technical and logistical conditions.

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