CORAL RECRUITMENT RATE AND FISH AGGREGATION IN PANDONG BATO PUENTE, CARMEN, CEBU, PHILIPPINES

Joed E. Caballero, Raamah C. Rosales, Anthony S. Ilano, Lea B. Colita, Jay Lord I. Estil and Annabell A. Alimpolos

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Abstract: This study has been to determine the coral recruitment rate and fish aggregation in Pandong Bato Marine Sanctuary, Puente Carmen, Cebu, Philippines. Settlement plates made of clay tiles, marble tiles, and cement blocks were used for the coral recruitment study. A total of 60 sets of settlement plates were installed. Ten sets of each settlement plates were retrieved every month. All the coral recruits found in the settlement plates were recorded. For the fish aggregation study, a fish visual census method was used to identify the species of fish found in the area. Results have shown that the coral recruitment among the type of tiles in terms of coral recruit's clay tiles has the highest number of recruits followed by cement blocks and the least recruits are the marble tiles. For the fish aggregation, we found 18 species of fish in 17 genera which belong to 13 families. Among the families, Labridae displays the highest number of species and is the most abundant in the study area. Indicator species of fish like butterflyfishes that belong to the family Chaetodontidae are present in the area which signifies that the zone is in good condition. The Pandong Bato marine sanctuary needs to be protected and conserved because of its diversity, and it represents the remaining intact coral reef in the northern part of Cebu province.

Keywords: coral recruitment, coral reef, fish aggregation, settlement plates

Introduction:

Coral reef ecosystem is among the most biologically diverse and productive benthic communities in the world (Lewis 1997). Despite the benefits that the coral reef ecosystem provides, coral reefs worldwide are deteriorating due to diverse anthropogenic and natural disturbances (Fishelson 1973; Jackson et al. 2001; McCulloch et al. 2003;

Joed E. Caballero, Anthony S. Ilano, Lea B. Colita and **Jay Lord I. Estil:**
College of Fisheries
Cebu Technological University
R.M. Durano Avenue, 6005 City,
Carmen, Cebu, Philippines

Raamah C. Rosales and **Annabell A. Alimpolos**
College of Arts and Sciences
Cebu Technological University
M.J. Cuenco Ave, Cor R. Palma Street
6000 Cebu, Philippines

E-mail (for all authors):
joed.caballero@ctu.edu.ph

Bellwood et al. 2004; Loya 2004). Coral recruitment is recognized as a key demographic process influencing community structure and the decline and recovery of coral populations (Bak and Engel 1979; Harrison and Wallace 1990; Hughes and Tanner 2000).

Over the last two decades, there has been a growing recognition that the rate of recruitment of larvae back to adult habitats can determine community structure (e.g., Connell 1985; Gaines and Roughgarden 1985; Lewin 1986). Consequently, the pattern and magnitude of recruitment have been suggested to strengthen conservation and management (e.g., Brock 1994; Dunstan and Johnson 1998). The successful recruitment of juvenile corals is an important aspect of the biology population and community structure of coral reefs (Wilson and Harrison 2005; Glassom et al. 2006). Coral populations are dependent largely on sexual recruits for recovery after catastrophic disturbance (Banks and Harriott 1996; Tupper et al. 2007), such as typhoons.

Numerous studies have evaluated relations between the distribution, abundance, and diversity of fishes and living coral cover on shallow tropical reefs (Quinn and Kojis 2005; Martinez and Abelson 2013). Like the adults of most other organisms, they are primarily related to the distribution of food and mating opportunities. The distributions of juvenile reef fishes, however, are more proximally related to the distribution of structurally complex habitats and other factors that directly influence survival under intense predation (Shulman 1985; Hixon 1991; Caley and St. John 1996; Nemeth 1998; Almany and Webster 2006). It is generally accepted that structurally complex coral reefs provide a biologically important physical structure in the form of shelter holes and prey, including small fishes (Gleason 1996; Okamoto et al. 2008; Gringley and Putron 2009). Coral recruitment study and fish aggregation are essential in providing information on substrate preferences of coral larvae to settle, recruitment pattern of coral larvae, and species of fish that inhabit the coral reef ecosystem. The primary aim of the study was to determine the coral recruitment rate and fish aggregation in Pandong Bato Marine Sanctuary, Puente Carmen, Cebu, Philippines.

Materials and methods:

The study was conducted in the marine sanctuary of Pandong Bato, barangay Puente municipality of Carmen, Cebu (Fig. 1). The area is located on coordinates 10.61902ºN and 124.02669ºE. It is a third-class municipality that is around 38 kilometers away from the capital city of Cebu. To the north, it is bounded by the municipality of Catmon, west by the Municipality of Asturias, south by Danao, and east by the Camotes Sea. It belongs to the 5th district of Cebu and has a total land area of about 84.78 km^2. The study site was selected after the conduct of a biophysical survey using SCUBA.

Recruitment study

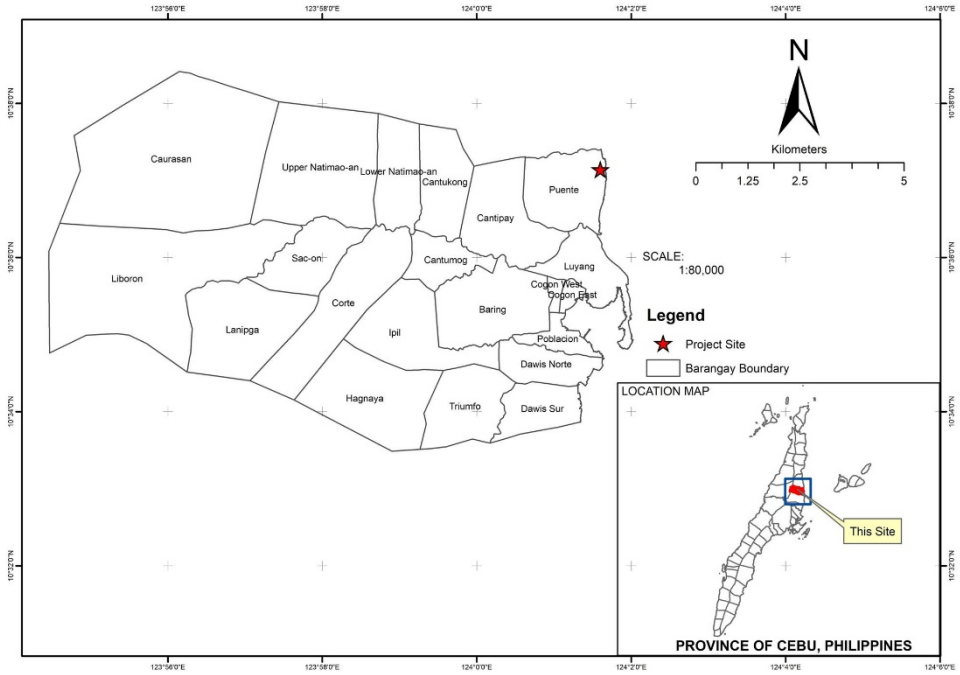
Settlement plates were used to determined coral recruitment rates and recruitment patterns. Three types of settlement plates measuring (12 x 12 x 3 cm) were assembled using marble tiles, ceramic tiles, and cement blocks as a substrate and attached horizontally to a stainless-steel frame with approximately 10 cm between them and anchored with approximately 20 cm above the seafloor. A total of 60 sets of settlement plates was installed. Ten sets of each settlement plates were retrieved every month. To investigate the seasonal pattern of coral recruits, including recruitment rate, all retrieved plates were checked for coral recruits, and all coral recruits were counted. Positions of coral recruits on the plate surfaces (top, bottom, or vertical) were also recorded.

Fish aggregation study

The fish survey was conducted via scuba diving. Fishes found within the coral reef where settlements are deployed were quantified and recorded. The species of corals

where fishes are aggregating were also identified and recorded.

Figure no. 1 Map showing the study site



Data analysis

Comparison of the coral recruit to settlement plates attached using the different configurations was performed using a two-way ANOVA, with planned comparisons. The main effects were 'method' with three substrate types (ceramic plates, marble, and cement blocks). Statistical analyses were conducted using SPSS 16 (SPSS Inc., Chicago, IL, USA) and StatView 5.0.1 (SAS Institute Inc., Cary, NC, USA). The recruitment data were first tested for homogeneity and normality. In the non-normality and heterogeneity of the data, a nonparametric Kruskal-Wallis rank test was applied to examine variations in the number of coral recruits among plate surfaces. Mann–Whitney U test with Bonferroni correction as a post hoc test was used for multiple comparisons since it is an efficient and robust method for heterogeneous data. The relationship between total numbers of coral recruits on different surfaces of settlement plates was examined using correlation and linear regression analyses. For fish aggregation, data on fish were presented in a pie chart to determine the percentage composition of fish in the area surveyed:

$$\text{Percentage composition} = \frac{\text{Total number of individual species}}{\text{Total number of all individuals of all species}} X100$$

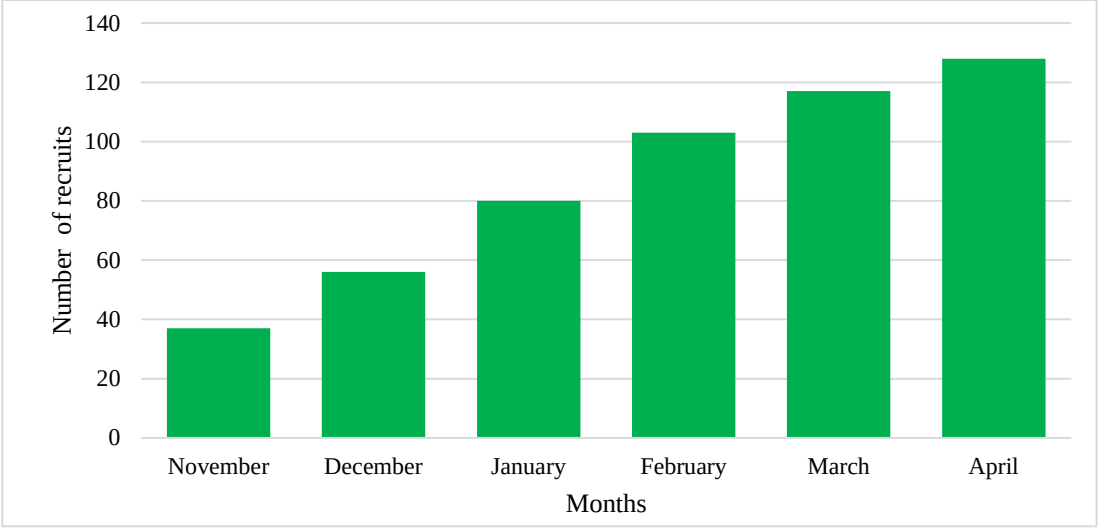
Results and discussion:

Coral recruitment

A total of 520 coral spats were found on settlement plates in six-month survey from November 2019 to April 2020. During the first three months from November to January, there were few coral spats observed, which could be due to the synchrony of species spawn in the area, and in the following three months from February to April, the number of recruits or coral spats increases (Fig. 2). Some studies suggested that Acropora's major spawning occurs early in the season, from March to April (Vicentuan et al. 2008).

Among the substrates, clay tiles have the highest number of recruits, with a total of 199. It may be triggered by the roughness of the tiles in which it is more suitable for the coral larvae to settle. There follow the cement blocks which count a total of 168 recruits while the fewer recruits were recorded with the marble tiles displaying a total number of 153 recruits. Moreover, coral recruits on the tiles were mostly found on the bottom side of the tiles. It is believed that the recruitment rate of coral spats on the top side of the tiles is low. It could be due to grazing and the effect of sedimentation. Therefore, the occurrence of coral spats was mostly observed on the bottom side of the tiles. Studies on shallow tropical reefs demonstrated that coral recruits had a greater preference for the vertical and bottom surfaces (Fisk and Harriott 1990; Harrison and Wallace 1990) (Fig. 3, Annexes).

Figure no. 2 Number of coral recruits per month

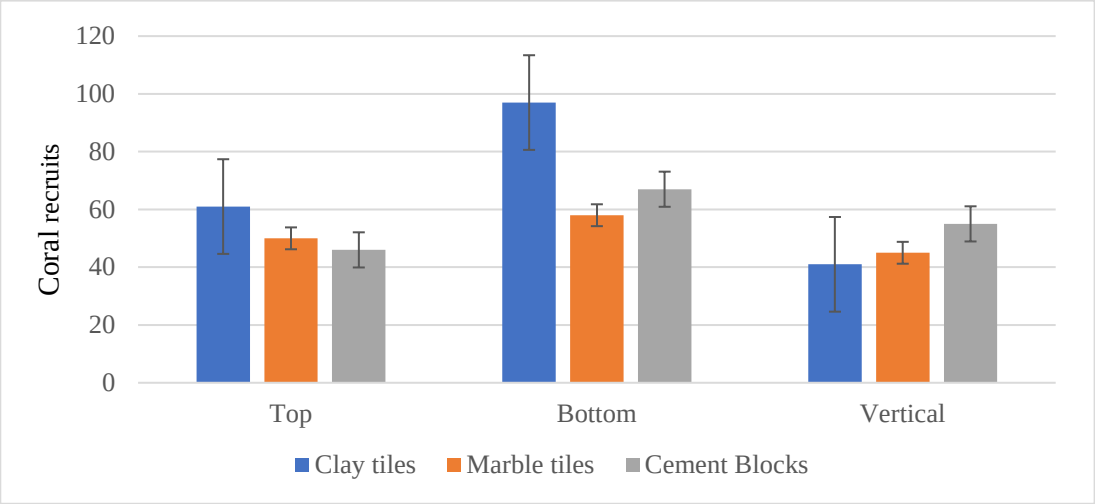


Coral recruitment rate on different surfaces

Coral recruitment on different surfaces shows that more recruits (42.7%, n = 222) were found on the bottom surface, followed by 30.2% (n = 157) on the top surface and 27.1% (n = 141) on the vertical surface (Fig. 4). Studies suggested that coral larvae settle in locations where they can avoid predation by fish or smothering by excessive sediment but still receive adequate light. Other studies also showed a change in orientation of settlement from shallow to deep sites, with corals settling on lower surfaces in shallow sites and increasingly on upper surfaces in deeper sites (Birkeland et al. 1981; Wallace 1985). The result shows that the possibility of coral larvae surviving on the bottom surface is

owed to lower exposure to sediment accumulation and grazing pressure.

Figure no. 4 Number of recruits on top, bottom, and vertical surfaces



Data analysis

There is no significant difference between the recruitment rate in different types of settlement plates (Kruskal-Wallis test, $p > 0.0906$) (Tab. 1). The result shows that coral larvae will settle on the different types of settlement plates, but they differ in the number of recruits per substrate type. This may be due to some coral species' preference on what substrate type they want to settle. According to Golbuu and Richmond (2007), some coral species' larvae are particular regarding where / how they settle and where they metamorphose.

Table no. 1 Correlation analysis between settlement plates

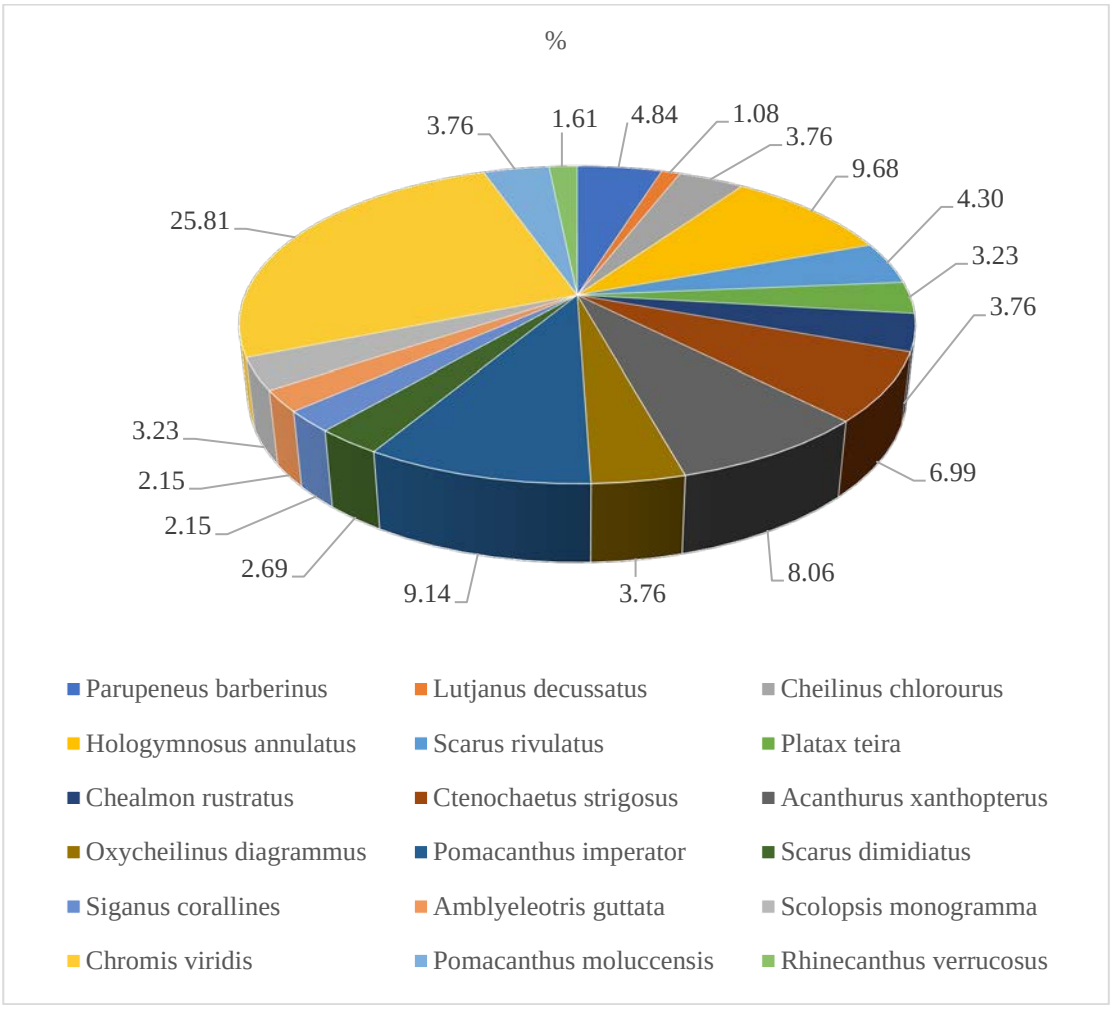
Groups	P values
Clay tiles vs Marble tiles	0.2623
Marble tiles vs Cement blocks	0.8099
Clay tiles vs Cement blocks	0.5745

Fish aggregation

Eighteen (18) species of fish (Fig. 5) in seventeen (17) genera belong to thirteen (13) families, namely Acanthuridae, Balistidae, Labridae, Chaetodontidae, Ephippidae, Gobiidae, Lutjanidae, Mullidae, Nemipteridae, Pomacentridae, Pomacanthidae, Siganidae, and Scaridae. Among the families, Labridae holds the highest number of species and proves the most abundant in the study area. The result reveals that the coral reef of the Pandong Bato Marine Sanctuary is in good condition considering such fish species as the butterflyfishes belonging to the Chaetodontidae family that serves as an

indicator of whether the coral reef is in good or in poor condition (Reese 1981).

Figure no. 5 Percentage composition of fish found in the surveyed area.



Corallivorous fishes have co-evolved with corals on which they feed. The abundance and distribution of these fishes should be directly correlated with the corals' distribution and abundance. If the corals are detrimentally affected by stressful environmental conditions, such as pollution, their health will deteriorate. This deterioration should be detected by the fishes which feed on them. The corals are sessile and cannot avoid the stress, whereas the fishes are motile and can emigrate to healthier regions of the reef (Hourigan et al. 1988).

This study found out that fishes are commonly inhabit branching corals such as Acropora and Porites species. These corals serve as shelter, nursery grounds for juveniles, and protection against predators. On the other hand, Pomacentridae family dominated the area with a percentage composition of 29.57%, followed by Labridae with 17.2%, Acanthuridae 15.59%, and the

rest of the family having less than 10% of the percentage composition.

Conclusions:

The coral cover of Pandong Bato Marine Sanctuary is in good condition, and Acropora species were the most abundant. Possible coral spawning occurs during the dry season from December to May. The results show that the number of coral recruits increases from February to April, compared to the previous months November to January. This possible coral spawning could be due to the rise of sea temperature, which is one of the factors that have influenced coral spawning. For the fish aggregation in the area, 18 species of fish were found in 17 genera and belong to 13 families. Among fish species, indicator species were present, which signifies that the area is in good condition. Branching corals such as *Acropora* and *Porites* species are commonly inhabited by fishes. Coral recruitment rate was determined in a different type of settlement plate was determined, that is among the plates (Clay tiles, Marble tiles, and Cement blocks), Clay tiles has the highest number of coral recruits. In settlement orientation (top, bottom, vertical) bottom side records the higher coral recruits compared to the top and vertical side. This result shows that the possibility of coral larvae surviving on the bottom surface is owed to lower exposure to sediment accumulation and grazing pressure.

Rezumat:

RATA DE REFACERE A CORALILOR ȘI AGLOMERARAREA PEȘTILOR ÎN PANDONG BATO PUENTE, CARMEN, CEBU, FILIPINE

Scopul acestui studiu a fost de a determina rata de refacere a coralilor și aglomerarea peștilor în Sanctuarul Marin Pandong Bato, Puente Carmen, Cebu, Filipine. Plăci de testare din lut, marmură și blocuri de ciment au fost utilizate pentru studiul de refacere a coralilor. Au fost instalate în total 60 de seturi de plăci de testare. Zece seturi din fiecare placă de testare au fost recuperate în fiecare lună. Au fost analizate toate formațiunile de corali găsite pe plăcile de testare. Pentru studiul privind aglomerarea peștilor, a fost utilizată metoda recensământului vizual pentru a identifica speciile de pești găsite în zonă. Rezultatele au arătat că în funcție de tipurile de plăci de testare folosite, rata de refacere a coralilor este mare în cazul plăcilor de testare din lut, urmată de blocurile de ciment, iar cea mai mică pe plăcile de marmură. În ceea ce privește aglomerarea peștilor, au fost semnalate 18 specii de pești din 17 genuri, care aparțin la 13 familii. Dintre acestea, familia Labridae prezintă cel mai mare număr de specii și este cea mai abundentă în zona de studiu. Specii de pești indicatoare, cum ar fi peștii fluture care aparțin familiei Chaetodontidae, sunt prezente în zonă, ceea ce înseamnă că zona este în stare bună din punct de vedere al condițiilor de mediu. Sanctuarul Marin Pandong Bato trebuie protejat și conservat datorită diversității sale și reprezintă reciful de corali intact rămas în partea de nord a provinciei Cebu.

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Annexes:

Figure no. 3 Photos of coral recruits per sampling

1st Sampling a.

b.

Istros – Museum of Braila "Carol I"

c.

2nd Sampling a.

b.

c.

3rd Sampling a.

b.

c.

4th Sampling a.

b.

c.

5th Sampling a.

b.

c.

6th Sampling a.

b.

c.