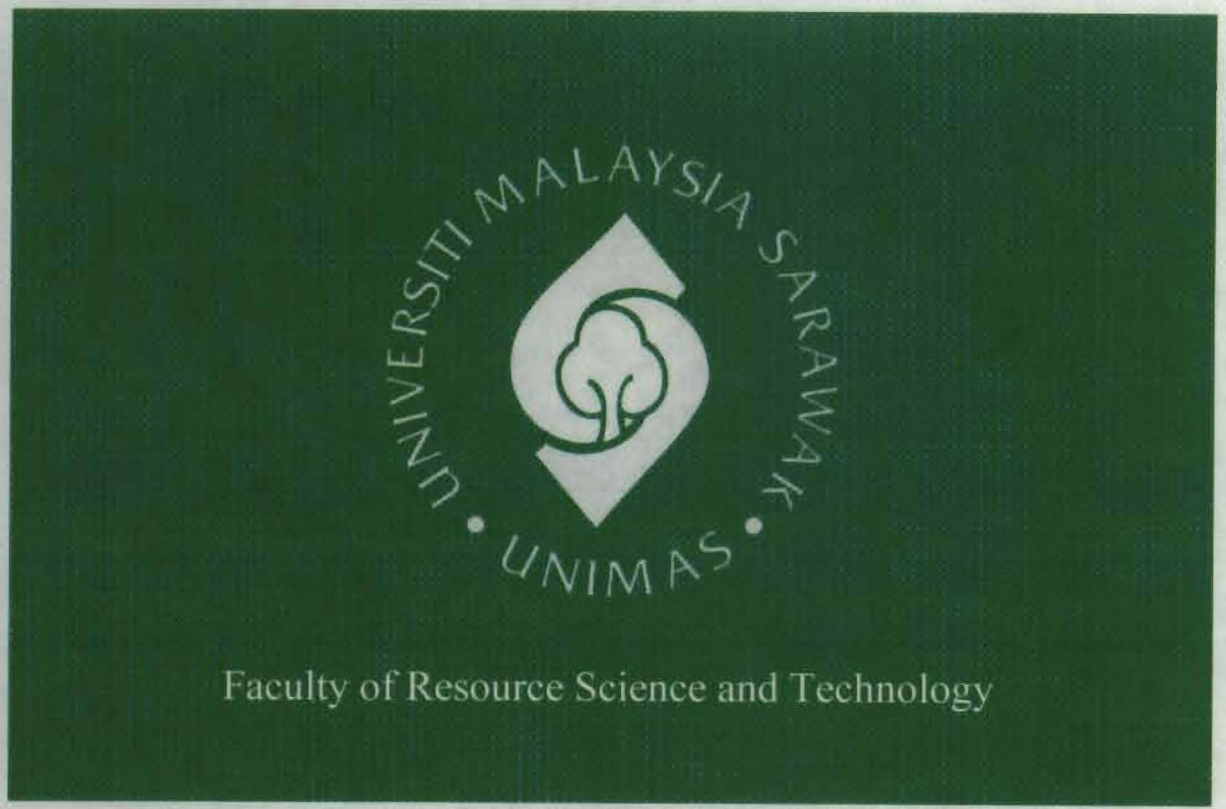


# FISH AND INVERTEBRATE DIVERSITY AT CORAL REEF OF TALANG-TALANG ISLAND, SEMATAN, SARAWAK

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Bachelor of Science with Honours
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# Fish and Invertebrate Diversity at Coral Reef of Talang-Talang Island, Sematan, Sarawak



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## DECLARATION

I, Nurrin Nabilah Teoh Binti Ali Teoh, final year student of Aquatic Resource Science and Management hereby declare that this thesis is my own work and effort with the guidance of my supervisor, Professor Dr. Lee Nyanti. No part of the thesis has previously been submitted for any other degree, university or institution of higher learning.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| MPA | Marine Protected Area |
| SCUBA | Self – Contained Underwater Breathing Apparatus |
| UVC | Underwater Visual Census |
| $m^2$ | Per meter square |
| NTU | Nephelometric Turbidity Unit |
| $mg/cm^2/day$ | Miligram per centimeter square per day |
| mg/L | Milligram per litre |

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# Fish and Invertebrate Diversity at Coral Reef of Talang-Talang Island, Sematan, Sarawak

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## ABSTRACT

This study was carried out in July 2011 and April 2012 to determine the abundance and diversity of fish and invertebrates at the natural reef of Talang–Talang Island. Data were collected using belt transect technique method with the aid of self–contained underwater breathing apparatus (SCUBA) and underwater visual censuses (UVC). Transect lines were laid 100 m parallel to the shore, with depth ranging between 3 - 10 m. Survey carried out covered a distance of 2.5 m from both sides of the transect line or a total area of 250 $m^2$. Data collected were recorded with the aid of underwater slate, underwater flash card to aid in identification, and underwater camera. A total of 73 individuals of invertebrates were recorded at the study area representing 2 families and 3 species. Results show that species richness among the three stations ranged from 0.3899 at station 3 to 0.4969 at station 1. A total of 18 genera and 22 species from a total number of 860 individuals of fish were documented. Results show that species richness among the three stations ranged from 2.2171 at station 1 to 3.2633 at station 2. The assemblages of reef fish in coral reef ecosystem are affected by the percentage of live coral cover and feeding behavior of fishes. The population of invertebrate is affected by the overall condition of the coral reef.

Keywords: Fish, Invertebrate, Coral reef, Talang-Talang Island

## ABSTRAK

*Kajian ini telah dijalankan pada bulan Julai 2011 dam April 2012 untuk menentukan kelimpahan dan kepelbagaian ikan dan invertebrata di terumbu karang semula jadi Pulau Talang-Talang. Pengumpulan data telah dilakukan menggunakan teknik transek tali pinggang dengan bantuan alat penafasan bawah air (SCUBA) dan teknik banci visual (UVC). Tali transek telah sepanjang 100 m diletakkan selari dengan pantai, pada kedalaman air dalam julat antara 3 – 10 m. Kawasan kajian meliputi 2.5 m dari kedua-dua belah tali transek atau kawasan seluas 250 $km^2$. Data telah diambil dengan bantuan papan menulis bawah air, kad warni-warni untuk membantu penceman, dan kamera bawah air. Sebanyak 73 individu invertebrata telah direkod di kawasan kajian dan mewakili 2 famili dan 3 spesies. Keputusan menunjukkan bahawa kekayaan spesies diantara tiga stesen adalah berjulat dari 0.3899 pada stesen 3 sehingga 0.4969 pada stesen 1. Sebanyak 18 genera dan 22 spesies dari jumlah 860 individu ikan telah didokumenkan. Keputusan menunjukkan bahawa kekayaan spesies diantara tiga stesen adalah berjulat dari 2.2171 pada stesen 1 sehingga 3.2633 pada stesen 2. Kepelbagaian ikan di ekosistem terumbu karang dipengaruhi oleh peratusan karang hidup dan kelakuan pemakanan ikan. Populasi invertebrata dipengaruhui keadaan keseluruhan terumbu karang.*

*Kata Kunci: Ikan, Invertebrata, Terumbu Karang, Pulau Talang-Talang*

## 1.0 INTRODUCTION

Coral reefs are termed as unique rainforests ecosystem of the sea as they have an extremely diverse range of species. They are an ecosystem that is high in primary production and transferring energy to the higher trophic level (Robert *et al.*, 2001). These coral reefs also provide a large suitable spot for shelter, source of nutrients, spawning area for reproduction purposes, and coastline protection from shoreline erosion by wave and storm (Hopkins, 2009). The high biodiversity of coral reefs is attributable to higher abundance of reef fishes and invertebrate which live in symbiotic relationship with other reef organisms, especially organism which associate on living coral habitat (Stella *et al.*, 2010).

Reef architecture as topography gives a large surface area for algal and benthic invertebrate colonisation (Davies, 2006). Structure and composition of live coral on tropical reef control the diverse species of coral reef fish assemblages which widely recognized as an example of coexistence. Moreover, the higher the percentage of live coral cover, the higher the density of coral reef fishes assemblages. Hermatypic coral act as foundation contributes of coral community, fish assemblages, species composition, trophic level structure, and other aquatic organisms on patch areas. The condition of coral reef can be monitored from any abiotic or biotic factors that may influence the structure of fish communities (Michele *et al.*, 2011). The abundance of marine invertebrates will influence the health of reefs. Some of the functions of marine invertebrate include removal of detritus material, nutrient cycling and consumption of invading algae. However, destruction cause by marine invertebrate will give negative ecological impacts upon the reefs (Hopkins, 2009).

In this study, Self-Contained Underwater Breathing Apparatus (SCUBA) was used to observe the assemblages of fish and invertebrate. Underwater Visual Censuses (UVC)

method used with belt transects technique were used for collecting data (Valavi *et al.*, 2009). This survey was carried out at three stations, namely Batu Penyu, Talang Besar West, and Talang Besar East. The distribution and diversity of fishes at artificial reef balls at Talang–Talang Island has been reported by Nazzatul (2004). Raymond (2009) carried out a survey on fish composition at natural reef area at Satang Island. However, the diversity of fish and invertebrate at Talang–Talang Island natural reef has not been studied in detailed. The objectives of this research were to:

(i) Determine the abundance, density and diversity of fish and invertebrate at the natural reef of Talang–Talang Island.

(ii) Evaluate the role of fish and invertebrate as indicator species on the condition of coral reef.

## 2.0 LITERATURE REVIEW

### 2.1 Coral reef ecology

Calcium carbonate is the main sources in calcareous formation of coral reefs. The saturation state of calcium carbonate in sea water and sea surface temperature can affect the deposition rate of calcium carbonate by coral and other reef organisms. Coral reefs form ecosystems a most productive and is characterized by a large fauna and flora diversity that provide valuable ecological services such as a beautiful seascape as attraction for tourists, harvestable fishes, and coastline protection from shoreline erosion by wave action and storm (Oliver *et al.*, 2011). Coral reefs support a huge biodiversity of marine organisms which visit reefs periodically for the purpose of feeding and spawning activities that lead to a creation in competing between species and environment (Davies, 2006). In increase in biodiversity, it influences the probability that community members respond differently to variable environmental conditions and perturbations, therefore reducing the risk of species and habitat extinction (Sole and Montaya, 2001).

Davies (2006) mention that healthy reef can be monitored by using percentage of live coral cover and used of biological indicator from indirect observation. This is support by the effect of reef architecture which is mainly about relationship between reef rugosity and reef fish assemblages. Reef rugosity means that there is a variation in reef topography. Moreover, the higher rate of reef rugosity may result in complex coral architecture and multiple levels which provide shelter for a wide range of marine organisms. Rugose reefs also give a larger surface area for algal and benthic invertebrate colonisation which aid in rise of trophic value, resources, supporting more fishes and other marine organisms.

Michele *et al.* (2011) states that patch area on coral reefs have variation in distribution of the fish assemblages, species composition and trophic level structure. Diversity of hermatypic corals which act as foundation contributes to critical habitat for

hundreds of species of corals associated organisms on patch area. Branching corals can give a structural complex and refuge space for large number of reef fishes. For example, branching coral community like Family Acroporidae, play an important role as habitat for reef fishes and other marine organisms. While microhabitat such as holes, crevices and open interior areas between branches are important aspects of habitats structure and can adapt more variation in species richness and total abundance. Changes in the abundance and species composition of fish and availability of shelter and food sources for reproduction will affect the abundance and species richness of fishes. Positively, structure and composition of coral species on tropical reef control the local distribution and abundance of reef fishes.

### 2.2 Coral reef fish communities

Coral reef fishes are typically site-attached with all sizes within restricted home ranges. Reef fishes can relocate to a new home ranges and an association with localized migration between sites used for different vital functions. Most of the reef fishes migrated from feeding sites to specific shelter sites. An adult reef fishes migrated from feeding sites to form spawning aggregations sites (Claydon and McCormick, 2011). Coral reef fishes comprise the most specious assemblages of vertebrates. The variety of shapes, sizes, colours, behaviour, and ecology exhibited by reef fishes are unique (Hixon, 2001). In coral reefs, reef fishes play an important role as predators or grazers in community which have close interaction with corals, algae, and other herbivores (Dillon, 2002). Reef fishes mainly depend on corals for sources of food supply and shelter (Emslie *et al.*, 2011). However, failure in balancing the reef fish assemblages will decrease the coral cover due to rise in abundance of algal (Dillon, 2002). Reef fishes mostly are dominated by the perciform, butterflyfish, angelfish, damselfish, wrasse, parrotfish, gobies, and surgeonfish (Hixon,

2001). Nemeth & Appeldoorn (2009) stated that algal grazing by reef fishes is an important ecological process with practical significance to the management and conservation of coral reefs. Herbivorous play an important role in structuring the benthic community on coral reefs. In coral reef area that have high rate of grazing on benthic algae, the algal assemblage is dominated by coralline algae with cropped algal turfs. This affects the interaction between macroalgae and corals, especially in enhancing coral recruitment and coral reef resilience.

Herbivorous reef fishes are not producing cellulose or other enzymes to digest cell wall component but they have ability of digesting the materials inside plant cells (Tilghman *et al.*, 2003). These fishes also play a role as functional group on coral reef which is central to the capacity of reefs to resist phase shifts and regenerate after disturbance and mediating the competition for space between corals and benthic macro-algae (Hoey and Bellwood, 2008). Moreover, parrotfish from Family Scaridae which act as a community of herbivorous reef fishes can maintain a high proportion of reef area free from macro-algae by their intensive grazing on filamentous algal turfs and lead to a condition where algal communities in a low biomass state (Michelle and Robert, 2006). Abundance of herbivorous reef fishes may be reduced when the physical structure of the reef deteriorates due to coral mortality or anthropogenic nutrient driven phase shifts from coral dominated environments to algal dominated environments (Kathrine *et al.*, 2009).

In an addition, damselfish from Family Pomacentridae which usually can be found in tropical coral reefs are likely to maintain territories to protect food resources and as a substrate on which their eggs mature. These fish maintain on their nursery gardens which have favored algal species and aggressively chase off fish that enter the territory to consume the algae or damselfish eggs (Kemp *et al.*, 2004). Damselfish increase species productivity and thus the rate of energy flow available to them through characteristic

feeding and algal farming behaviors. The cropping action and intermediate feeding intensity of damselfish keeps algae in phase that maximizes growth rates by assuring continuous food supply (Branch *et al.*, 1992). The cropping method of grazing by the damselfish allows and promotes regrowth of coral reefs (Hixon and Brostoff, 1996). Family Pomacanthidae (angelfish) limits its movement to a well defined area close to the shelter of finger coral branches and usually at depths of at least 4.5 m. During day time, it feeds on algae and detritus on dead coral surfaces. At night, these angelfish are inactive but alert with the changes in their surrounding and protected within the corals.

Family of Acanthuridae (Surgeon fish) acts as main group of reef fishes because of the impacts as herbivorous on coral reefs ecology. This Family of Acanthuridae is abundantly in tropical and subtropical waters. Besides that, these fishes also feed on small benthic algae which are generally poorly digested because of the different growth forms of algae. Surgeon fish is a group or school of selective feeding on reefs area (Tilghman *et al.*, 2003).

Corallivorous reef fishes which depend on the live corals for their food sources will increase in density due to high coral cover in a reef area. Majority of species feed mainly on hard corals, soft corals, gorgonians, sponges, algae, polychates and crustaceans (Nicholas, 2007). Nevertheless, corallivorous that have diets containing more than 80 percent on coral shows declination on coral loss, which prove that these species are highly dependent on coral for survival. However, any changes in the environment which will cause stress can be detected through the abundance of these corallivorous fish species. For example, butterflyfish from Family Chaetodontidae that is characterized as diurnally active and bright coloured are easier to detect and living in coral reef for both food sources and shelter (Crosby and Reese, 1996).

## 2.3 Coral reef invertebrate

Marine communities are dynamics systems that can occur in multiple stable states. The ecological processes causing the change from one state to another may begin with a pulse perturbation that leads to a shift in species composition and their relative abundance (Bonaviri *et al.*, 2011). Diversity and abundance of marine invertebrates greatly influence condition of coral reefs. They are a remarkably diverse group of animals due to the variety of functions such as nutrient recycling, the removal of detritus materials, and the consumption of invading algae. Perturbation caused by marine invertebrates can give negative ecological impacts upon the reefs, such as algae blooms and invertebrate plagues leading to a reduction in coral cover and a rise in density of marine invertebrates (Hopkins, 2009).

Macroalgae in coral reef lead to an overall reduction in coral cover. The presence of sea urchin that act as dominant grazing organisms give a positive impacts on growth and settlement of coral as they remove algae which can potentially compete against coral for space. These sea urchins grazing opens up solid substrates upon which coral settle and delicate balance between algae and coral dominated reefs. However, these echinoids can be controlled by abundance of predators in a reef (Hopkins, 2009).

Due to proliferation at larval stages in the presence of increased runoff of nutrients, *Acanthaster planci* (Crown of thorn) is usually used as indicator of disturbance. But, it can kill up to as much as 95 percent of the living coral on severely affected reefs. They consume coral tissue faster than the coral growth rate, and resulted with a condition called outbreak (Hopkins, 2009). Moreover, these A. *planci* are capable of destroying coral reefs when present in large numbers (Valentine and Edgar, 2010).

Holothuriidae, Tridacnidae and Ranellidae are useful indicators of anthropogenic threats as trends in their abundance that lead to intensity of harvesting. Holothuriidae are

macro detritivores and consume organic detritus. Tridacnidae is important filter feeders converting large quantities of organic matter into protein. It is also play role as one of the predator of *Acanthaster planci.*

**2.4 Reef fish survey in Malaysia**

Fisheries Department has done several reef surveys in Malaysia. Some of the studies have been conducted by Fisheries Research Institute of Fisheries Department and local universities. Coral reef fishes were recorded based on few sampling trips and using various techniques, such as underwater visual observation and capturing devices such as gill nets, traps and hand lines. A study by Harding *et al.* (2000) stated that a total of 224 species of reef fish were identified belonging to 38 families at Pulau Banggi, Sabah. The most diverse sites were Red Stick and Pinnacle 3 with 143 and 139 species, respectively. These two sites have the highest number of fish families. The site south and west of Karakit town which includes Patanunam and Pandanan East recorded slightly fewer species and families. The lowest values in terms of species were seven found at Karakit and Otter Reefs. Nazzatul (2004) shows the reef ball that have been deployed in 2002 have the highest number of species (33) compared with natural reef (26). Although the natural reef areas have the highest number of individuals of fish (6640) compared with the reef balls (1631) but natural reef have lower diversity of species. According to Yusuf *et al.* (2005) Kg Tekek, Pulau Tioman shows an abundance of Pomencentridae represented by 39 species from a total of 192 species of coral reef fish that were recorded. From the reef fishes study done by Yusuf *et al.* (2006) at Pulau Layang-layang, Terumbu Layar and Terumbu Ubi, found that Pomancentridae was the most abundant with 53 species recorded followed by Labridae with 35 species and Chaetodontidae with 26 species. The number of

coral reef fish observed at Pulau Layang-Layang and surrounding atolls was higher than other island in Peninsular Malaysia, with an exception of Pulau Tioman.

A study done by Ghaffar *et al.* (2006) at Pulau Redang stated that relationship between the feeding regime of the coral feeding butterflyfish, *Chaetodon octofasciatus* with ranging behaviour, territories size, activity patterns, individual bite rates and types of food consumed were recorded. *C. octofasciatus* is the most common butterflyfish of Redang Island, and feeds on different coral polyps, particularly on genus *Acropora*. The results from the study also found that there were positive correlations between percentages of coral cover against number of fish individuals. Raymond (2009) reported 21 reef associated fish species found at Pulau Satang Besar reefs area. The fish that have been recorded at Satang Besar Island are from eight different families and is dominated by Pomachantidae. According to Yoshida *et al.* (2010), a total of 824 individuals were observed. In Tioman Island, Malaysia the most abundant taxa around the artificial reef are *Caesio caerulaurea* with 233 individuals, followed by *Liza subviridis* with 113 individuals, *Siganus guttatus* with 96 individuals and *Scarus* sp. with 91 individuals.

## 3.0 MATERIALS AND METHODS

### 3.1 Study site

The study site is located at a fringing reefs in Talang-Talang Island which was gazetted as a National Park under the jurisdiction of the Sarawak State Government, through section 19 of the National Parks and Nature Reserves Ordinance, 1998 (*Cap. 27*). Talang-Talang is a part of the first National Park in Sarawak which mainly covers the marine area and has been gazetted since 1999 with the aim as a shelter for marine turtle conservation. This island covers an area of approximately 9,520 ha.

The first field survey was carried out on 25$^{th}$ July – 29$^{th}$ July 2011. Three stations were selected (Figure 1) and the coordinate for each station is shown in Table 1. On this field survey, fish and invertebrate diversity at Talang-Talang Island, were collected and identified until family level for each station.

The second field survey was carried out on 22$^{th}$ April – 24$^{th}$ April 2012. During this field survey, a different and new coordinate for station 1 was set due to the difficulty in finding the previous station. This was because the line transect which was laid out on first survey cannot be found due to strong currents and Northeast monsoon season (November to March) that occurred in between the two survey time. Additionally, line transect have also been deployed each that Talang-Talang Island West (station 2) and Talang-Talang Island East (station 3).While, station 2 and station 3 are still maintained at the same coordinate with previous station. Data were collected and identified untill species level for each station.

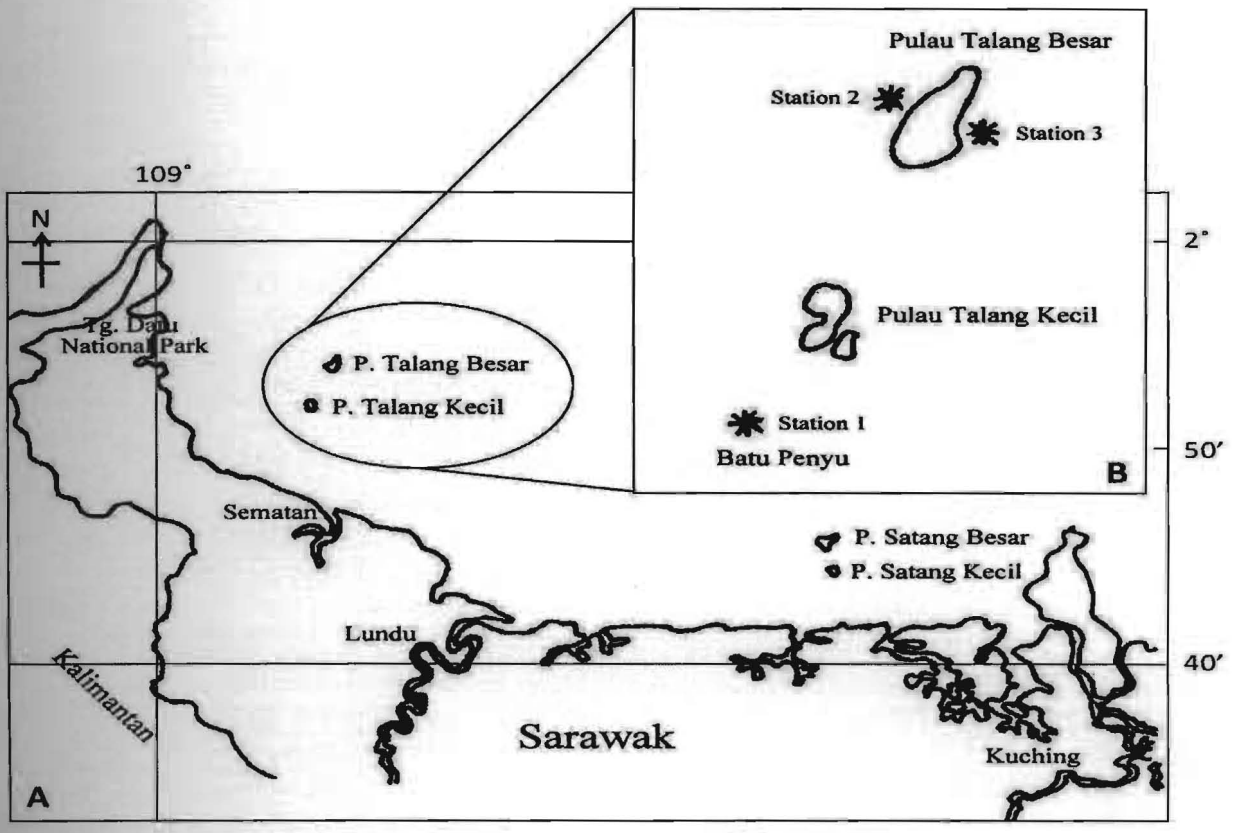


Figure 1: The locality of three stations

Table 1: Three stations of study site for First Field Survey

| Location | Station 1 | | Station 2 | Station 3 |
|---|---|---|---|---|
| Name of the station | Batu Penyu | | Talang-Talang Island West | Talang-Talang Island East |
| Latitude | N 1° 52' 41.0 | N 1° 52' 42.3 | N 1° 54' 57.4 | N 1° 55' 03.3 |
| Longitude | E 109° 45' 35.3 | E 109° 45' 35.3 | E 109° 46' 27.9 | E 109° 46' 27.9 |
| Date of Survey | 26th July 2011 | 23th April 2012 | 27th July 2011 | 28th July 2011 |
| | - | - | 24th April 2012 | 24th April 2012 |

### 3.2 Survey methods

#### 3.2.1 Underwater visual census

Underwater Visual Census (UVC) was used to determine the densities and diversity of coral reef fishes and invertebrates (Dearden *et al.*, 2010). Data collections was carried out between hours of 0900 and 1600 where there were enough light sources and penetration into the water column. Fish and invertebrate were counted and recorded with the aid of underwater slate with designated columns, underwater laminate coloured flash card for easier identification of fishes and invertebrates, and also underwater camera as a reference after finishing the data collections.

#### 3.2.2 Belt transect technique

Transect line was constructed parallel to the shore along the reef flats area at each of the station. A line transect with a total length of 100 m was laid on top of the reef flats with three markers by a team of a pair divers with average depth ranging between 3–10 m. These markers are used to prevent the line transect from floating or moving because of strong wave and current action (Figure 2).

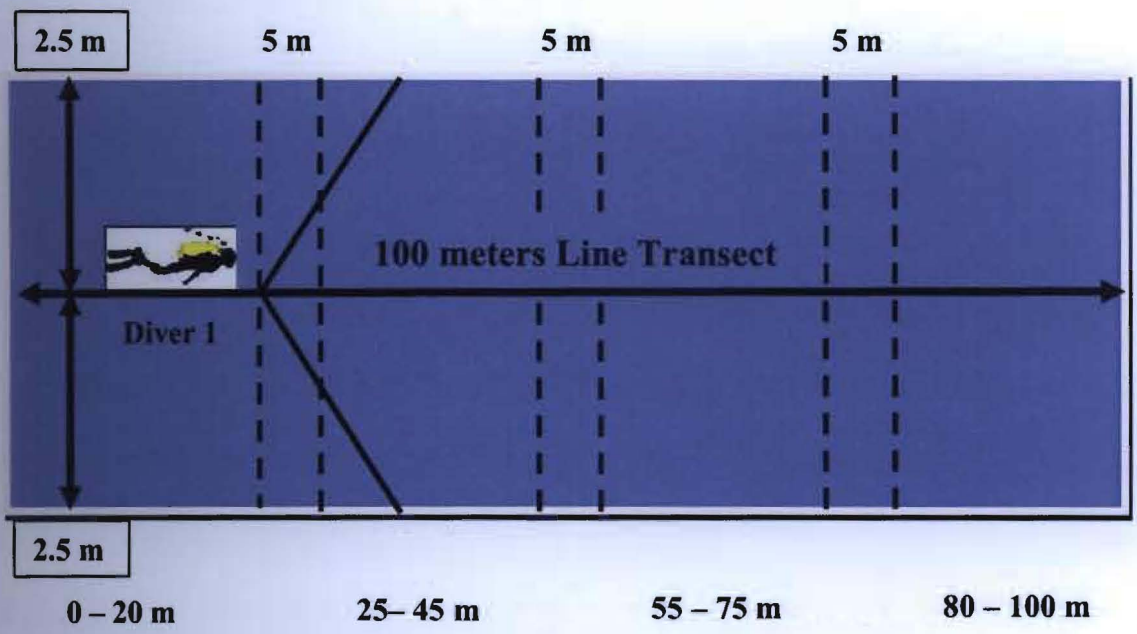


Figure 2: The position of the diver when performing the survey

Maintenance of buoyancy for around 10-15 minutes was done on the starting point of the transect line to allow fishes to enter within the transect areas. Data collection for fish was done first and followed up by invertebrate to minimize the disturbance because fish is sensitive to surrounding environment. The number of fish species present were calculated along a 100 m of line transect with 2.5 m view area away from transect line for both sides. Then, diver stop and maintain the buoyancy for 1 minute at every 10 metres with data collected. Along the transect line and survey, pictures of representative family and species of fish and invertebrate were taken for referring work after doing the field survey.

For invertebrate, diver have to swim in S or U – shaped search pattern starting from the beginning of the transect line and also to observe under the crevices of corals or rocks, and counting the number of invertebrate present along the line transect. This is due to the characteristic of some species of invertebrate which are nocturnal and prefer to hide under the crevices of corals and rocks.

### 3.2.3 Reef Check survey methods

Reef Check Survey is the largest and well known universal method that specialized in monitoring reefs and their relationship with fishes and invertebrates (Valavi *et al.*, 2009). Key indicator species of fish and invertebrate on coral reef condition can be determined and counted easily with the aid of list of indicator fish and invertebrate families from reef check survey guide. Before starting the survey, indicator species of fish and invertebrate were studied to ensure an easier identification works when carrying out the survey. Data were collected for the number of fish and invertebrate which listed under key indicator species, but others than those listed species of fish and invertebrate were not counted.

## 3.3 Identification methods

Identification for fish follows those of Masuda *et al.* (1984), Allen *et al.* (2003), Dieter and Robert (1997). Then, for invertebrate follow those of Humann & Deloach (2002) and Korallen *et al.* (1996).

## 3.4 Data analysis

### 3.4.1 Density

The density at each station was calculated using the following formula below:

$$\text{Density (per station)} = \frac{\text{number of individual in an area}}{\text{Total area (m}^2\text{)}}$$

### 3.4.2 Diversity indices

At each station, the diversity, evenness and richness indices were calculated based on the following formula:

(i) Shannon-Wiener Index (*H*) (Shannon, 1963),

$$H' = \frac{n \log_2 n - \sum f_i \log_2 f_i}{n}$$

where $n$ = total number of individuals
$f_i$ = number of individuals in species i, i=1,2,3,..., n

(ii) Species Eveness

Pielou eveness Index (*J*) (Pielou, 1966),

$$J' = \frac{H'}{\log_2 S}$$

where $H$ = diversity of species
$S$ = total number of species

(iii) Species Richness

Margalef Richness Index (*D*) (Margalef, 1968),

$$D = \frac{S - 1}{\ln n}$$

where $S$ = total number of species
$n$ = total number of individuals

### 3.4.3 Statistical analysis

Statistical analysis was carried out by using Statistical Package for Social Science (SPSS) version 19. Analysis of results was carried out using One-way ANOVA to determine the significance of the number of fish individuals distributed by family present among the stations. The significant of P value is when it is lower than 0.05, ($P<0.05$).