ASSESSMENT OF CORAL REEF FISH POPULATION AT PULAU PAYAR MARINE PARK AND ADJACENT WATERS.

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UNIVERSITI SAINS MALAYSIA

2008

ASSESSMENT OF CORAL REEF FISH POPULATION AT PULAU PAYAR MARINE PARK AND ADJACENT WATERS.

by

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Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

May, 2008

ACKNOWLEDGEMENTS

A lot of people have helped me and supported me during the course of this study. I am indebted to all of them. Here, I would like to distinguish and express my special thanks to the following:

I am very grateful to Mr. Ibrahim Salleh, Deputy Director General, Department of Fisheries Malaysia, and Allahyarham Professor Ahyaudin Ali, Former Dean of Biological School, USM who had initiated the idea of assessing the Pulau Payar Marine Park fish population.

I would like to express my deep appreciation to my supervisor, Professor Madya Dr Khoo Khay Huat, for his skills, enthusiasm, support and patience during the process of this thesis.

I am very grateful to the Resource and Ecology Branch of the Fisheries Research Institute, for providing financial support and staff to carry-out this study. Thanks also to the staff, especially those who had participated in my SCUBA diving, video survey, trap survey and trawl survey trips.

I would like to thank the Marine Park authority (previously under DOF) for allowing this study to be conducted in Pulau Payar Marine Park. Special thanks are due the staff of Pulau Payar Marine Park Centre for providing accommodations and technical assistance during the sampling trips.

Finally, without the love, encouragement and patience of my family, especially my wife Rozima, I would not have been able to complete this task. To my children, Hazim, Alyaa, Haziq and Hazif, this is for you all for been very supportive and patience while I was away from home!

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TAKSIRAN SUMBER PERIKANAN TERUMBU KARANG DI KAWASAN TAMAN LAUT PULAU PAYAR DAN KAWASAN SEKITARNYA.

ABSTRAK

Malaysia, menerusi Jabatan Perikanan telah mewujudkan taman-taman laut sejak 1984 untuk mengatasi kekurangan sumber perikanan akibat penangkapan berlebihan. Sejak ditubuhkan, tidaklah diketahui samada ianya berfungsi sebagaimana diharapkan, kerana tiadanya maklumat tentang status produktiviti ikan dan terumbu karang di dalam taman-taman laut ini. Bagi mengetahui status produktiviti terumbu karang dan sumber ikan di taman-taman laut, satu kajian telah dijalankan di Taman Laut Pulau Payar, Kedah dari 2001 hingga 2005. Di dalam kajian ini, kaedah persampelan mesra alam telah digunapakai bagi menyampel ikan dan terumbu karang di dalam taman laut, manakala pukat tunda diguna bagi menyampel ikan di luar taman laut. Tiga populasi ikan telah dikenalpasti, iaitu populasi ikan terumbu karang di dalam taman laut, populasi ikan berkaitan terumbu karang di luar taman laut, dan populasi ikan pantai. Purata kepadatan ketiga-tiga populasi ikan tersebut masing-masing adalah 29,000 kg/km², 682 kg/km² dan 825 kg/km². Bagi populasi ikan di dalam taman laut, didapati terdapat perhubungan di antara keluasan litupan terumbu karang dengan kepadatan ikan, di mana kepadatan ikan meningkat sebanyak 1,300 kg/km² sejajar dengan peningkatan setiap peratus litupan terumbu karang. Pada masa ini, purata litupan terumbu karang adalah di antara 10-15 peratus. Dengan kepadatan ikan di dalam taman laut yang lebih tinggi berbanding dengan kepadatan di luar, kemungkinan banyak nelayan bertumpu ke kawasan ini, mencari ikan-ikan yang keluar dari taman laut. Untuk memperolehi kebanjiran ikan dari taman laut secara berterusan, adalah penting untuk terus memperbaiki mutu perlindungan taman laut ini. Dengan peningkatan perlindungan ke atas habitat dan sumber perikanan di dalamnya, lebih banyak faedah dapat dijana menerusi peningkatan kuantiti kebanjiran ikan-ikan ke kawasan tangkapan.

ASSESSMENT OF CORAL REEF FISH POPULATION AT PULAU PAYAR MARINE PARK AND ADJACENT WATERS.

ABSTRACT

Malaysia, through the Department of Fisheries, has established marine protected area or marine parks since 1984 to alleviate the problem of low fishery catches due to overfishing. Since its establishment, it is not known whether the marine parks are performing as expected, as there were no information available on the productivity status of fish and coral in these marine parks. To know the present state of coral and fish in the marine park, a study on Pulau Payar Marine Park in Kedah was conducted from 2001 to 2005. In this study, environmentally-friendly methods were implemented to sample fish and corals in the protected marine park, while trawl was used to sample fish in the harvest area or area open for fishing outside of the marine park. Three different fish populations have been identified, they are the coral reef fish population inside the protected area, the coral reef-related fish population just outside of the park, and the coastal fish population near the mainland. The average density of fish for the three fish populations were 29,000 kg/km², 682 kg/km² and 825 kg/km² respectively. For the fish population inside the park, results show that there exists a positive relationship between coral cover and fish density, such that, for every increase in the percentage of coral cover, fish density would increase at the rate of 1,300 kg/km². At present, the average coral cover was between 10-15 percent. With relatively high density of fish in the protected park as compared to the harvest area, it could attract more fishermen to fish nearby, looking for the spillover fishes. To ensure continuous replenishment of the fish population in the harvest area, it is important to improve the protection of the park. With improved protection of the park's habitat and its fishery resources, more benefits could be generated through higher quantity of spillover fishes to the harvest area.

CHAPTER 1: INTRODUCTION

1.1 Coral reefs in relation to fishery management

Coral reefs conservation has been the subject of global interest since 1980s (McManus, 1988; McClanahan & Muthiga, 1988; Sadovy 1989, 1997; Roberts & Polunin, 1993). With the declining trend in the fish stock of major world fisheries due to overexploitation and deterioration of coastal habitats, many countries have opted for other management strategies to support existing conventional management measures. As a result, more conservation efforts were implemented to replenish fish population and to rehabilitate coastal habitats (Roberts & Hawkins, 2000)

In Malaysia, several marine protected areas (MPA) in the form of marine parks and fisheries protected areas have been created since 1983 (Hiew 1998, Najib *et al*, 2002). At the beginning, besides creating the marine parks, more conservation efforts were concentrated on the rehabilitation of coral reef ecosystem, through the construction of artificial reef through out the country (Jothy, 1986). Research on the artificial reef were confined to construction aspects such as better design, suitable material and finding suitable sites for the reef to be launched. The construction of the artificial reefs was then slowed down in the 1990's. Beside discouraging outcomes like coral encrustation, more studies found that the reef acts just like other fish aggregating devices (FAD) that aggregates surrounding fishes rather than generating new fish biomass. It seems that the natural coral reef ecosystems cannot be replaced by the artificial

one, and protecting the natural coral reef ecosystems through the creation and establishment of marine parks as a conservation measure was opted.

Later, more marine parks and fisheries protected areas were created, and more studies were conducted (Najib *et al*., 2002). By 1998, 40 marine parks and 6 fishery protected areas were established. For the coral reefs fish population studies, the common type of data used for diversity analysis was the list of available species, Using SCUBA diving, the coral fish's populations were visually censuses by recording on a waterproof plate (DeSilva and Rahman, 1982; Norhayati, 2000)

Coral reef fish are also sampled using various fishing gears, such as hook-and-lines, traps and drift nets (Ahmad *et al.*, 1996; Ruhana, 1999). The hook-and-lines is the most common method applied. The catch rate is the most popular index used to represent the fish abundance, and the unit of measurement frequently used is the number of fish caught per unit of effort

Although many studies on the coral reefs fish population have been conducted prior to and after the establishment of the marine parks (DeSilva and Rahman, 1982; Ibrahim and Zaharuddin, 1988; Norhayati, 2000), several key issues remain unanswered. One of the key questions is on the effectiveness of the parks in enhancing the biomass of exploited species inside the parks. Diversity analysis based on the species list for example, only shows how diverse an ecosystem is, but does not show how productive the ecosystem is. Research on productivity using fishing gears fails to show changes in the fish biomass inside marine parks.

While the benefits of marine parks in protecting and enhancing the abundance of exploited species inside and outside of the parks are well documented elsewhere (Roberts & Polunin, 1991; DeMartini, 1993; Sladek & Roberts, 1997), these outcomes are yet to be shown here. The key answer to these questions can be obtained through quantitative assessment of the coral reef fishes. As far as Malaysia is concerned, there is no quantitative assessment of the coral reef fishes.

Through the quantitative assessment, the biomass of the reef fishes can be estimated. Just like in the demersal fish stock assessment where the biomass is estimated through demersal resource surveys, the reef's fish biomass can then be monitored over time. As such, any positive or negative effect of creating the marine parks can be ascertained.

1.2 Marine Parks and Marine Protected Areas.

Marine Parks (MP), Marine Reserves (MR) and Marine Protected Areas (MPA) have been created worldwide since the 1980's. Although they are called by various names, the main intended purposes remain the same, which is to protect and conserve the critical marine habitats and its aquatic flora and fauna. This is in line with the approach taken by the International Union for the Conservation of Nature and Natural Resources (IUCN) under the World Commision on ProtecteFd Areas (WCPA) which promotes the establishment and effective management of terrestrial and marine protected areas (IUCN, 1997).

Closed area management in a relatively small area was introduced to supplement the conventional methods in fishery management, which is based on the control of the fishermen's efforts, or their catch, over a much wider area. However, it was noted by IUCN that many natural marine ecosystems are in developing countries which currently have limited institutional capacity and financial resources to manage these ecosystems in a sustainable way (IUCN, 1997).

To be effective, the conventional approach requires the government to be very effective in enforcing the law, and also to provide better job opportunities in other economic sectors, other than in the fishery sector.

Many developing countries in the South East Asia region have introduced various conventional management measures (including closed seasons, closed areas or zoning, mesh-size regulations etc.). However, fishing pressure continues to increase. Increase in human population and the lack of effective enforcement seem to be important contributory factors.

1.3 Fishery Resource

The fishery industry in Malaysia plays an important role in the national economy and contributes significantly towards providing animal protein food and employment opportunities. The total fish production in 2005 of around 1.4 million tonnes valued at RM5.24 billion accounted for about 1.08 per cent of the GDP (DOF, 2005). Coastal fishery is the major contributors to total fish

production, with 87 per cent. The rest comes from aquaculture and offshore fisheries.

Like other countries in the region, fish consumption is quite high among Malaysian, and this has resulted in the high demand for fish. Fish constitutes about 60 per cent of the national animal protein intake, with the annual consumption of about 40kg per capita. As the local fish production is inadequate, the country has to import fish, mainly from Thailand, to meet the local demand. The total import of fishery commodities in 2004 was about 423,093 tonnes, exceeding the amount exported at about 283,385 (DOF, 2004). With the increasing population, the demand for fish is expected to increase from an annual consumption of 630,000 tonnes in 1995 to about 1,600,000 tonnes by the year 2010 (Kamaruzaman, 1998). In term of employment, the fishery sector provides direct employment to more than 79,000 fishermen and 20,000 fish culturists.

Globally, the fish production increased from 19.3 million tonnes in 1950 to more than 100 million tonnes in 1989 and 134 million tonnes in 2002, where marine capture fisheries are the largest contributors to world fish production (FAO, 2005). After reaching about 80 million tonnes in the late-1980s, global marine catches fluctuated between 77 and 86 million tonnes, with a record high of 86.7 million tonnes in 2000 and a slight decline to 84.4 million tonnes in 2002. This suggests that the maximum long-term potential of the world marine capture fisheries has been reached, with some stocks and areas being overfished and some stocks not producing their full expected longterm potential.

The abundance of demersal fish stocks in the Gulf of Thailand in the early 1990s was only one tenth of the 1960s level when the trawl fisheries started. The shrimp resources in the Arafura Sea seem to have experienced increased fishing pressure in the 1990s, with an increase in the number of small trawlers operating in the northern part of the Arafura Sea. The decline in coastal tuna resources in the Philippines waters has encouraged the expansion of tuna fishing into Indonesian waters through bilateral arrangement (FAO, 1997).

Degradation of habitat due to coastal development can contribute to the decline of the spawning stock biomass (SSB) of some important fish species to the critical level, the level that could result in the collapse of the fishery. Land-based activities such as deforestation, agriculture intensification, industrialization and domestic waste disposal have been identified as activities that indirectly affect the water quality of coral reefs, home to many fish species, but coral mining, dynamite fishing and other destructive fishing methods have greater and more widespread impact (Soekarno, 1989; Samoilys, 1988,;Harmelin-Vivien, 1992).

There is a growing concern, globally and regionally, about the failures of the conventional management approaches in dealing with continuous overexploitation and habitat degradation (Roberts, 1997). Then, other means of management were introduced, such as closed areas and community-based management. The International Union for the Conservation of Nature and Natural Resources (IUCN) convinced that marine protected areas represent an important method for conserving marine biodiversity and contributing to the sustainable use of living marine resources IUCN, 1997)

Marine protected areas (MPA) are intended for conservation and protection of commercial and non-commercial fisheries resources, threatened or endangered species or their habitat, especially the areas with high species biodiversity. In term of fisheries, computer simulations have shown that MPA should be installed so that the amount of spillover to the harvest area is maximized (Man *et al*., 1995; Ami *et al*., 2005). Judging from various positive indications, MPA has been accepted by many developing countries as one of their fisheries management tools. By 1998, at least 400 MPAs in more than 65 countries and territories have been created (Bryant *et al*., 1998).

The benefits of MPA are achieved through minimizing the threats from human activities that the coral reefs ecosystems are being exposed to. Coral reefs are under the influence of human activities that will degrade its quality. Depending on the nature of the coral reef, some can withstand the disturbances, but some are very sensitive to human activities, even in the MPA itself. MPA, which is supposed to be a safe haven for the aquatic flora and fauna, might just become a killing field for them. Therefore, before any measurement of the benefits of MPA can comparatively be made, one needs to know its condition and function, prior to the creation of MPA. This will serve as the basis for comparison. Comparison should not be made by comparing one MPA with another, simply because there are no two identical coral reef ecosystems.

Too small the size of MPA will not benefited the effort, and too large will introduce enforcement constraints. MPA under the close area management concept has to be practically small to avoid enforcement constraints. Otherwise,

it will end up being ineffective, just like in the conventional management measures.

The effectiveness of the MPA in protecting and conserving the fisheries resources has been the subject of many coral reefs researchers lately. Naturally, without human activities, not all coral reefs shared the same level of species diversity and productivity. Some are very diverse and productive, but some are neither diverse nor productive. Various factors, such as size, location, habitat type, arrangement and complexity are among the key factors that determined the diversity and productivity of a coral reef ecosystem.

Coral reefs is the most complex ecosystem but not very well studied. Until recently, almost nothing was known about the extent and condition of coral reefs. Unlike the change in rainforests, that in coral reefs is difficult to assess from satellites, and information on their status has been scattered, anecdotal, and relatively inaccessible (Bryant *et al*., 1998).

1.4 Coral reef ecosystem studies.

The coral reef ecosystem studies has gone through many development processes. It evolves around the objectives and research methodologies that are subjected to improvements and changes. Different objectives require different tools. These can be seen from the trend or stages it has gone through.

Previous objectives were confined to obtaining basic biological information for taxonomic purposes. The introduction of scuba diving technique in 1950s for

mobilization underwater has resulted in more studies of coral reef fish with a much wider coverage (Sladek and Friedlander, 2004). Studies on species distribution, species diversity and species richness in relation to various type of substratum were a common research objective in the past.

With the introduction of the MPA concept, quantitative assessment to obtain fish biomass in the coral reef ecosystem has becoming a necessity. Using visual census technique, experience SCUBA divers can identify, count and measure the coral fish, so that an estimate of biomass can be performed. Due to limitations, better quantitative assessments have been searched to replace diver's visual census. Today, using stereophotography technique, a more reliable biomass estimate can be obtained.

The focus of the fisheries research in the past was to obtained information on the fishery resources for exploitation purposes. Now, with the declines in the fishery resources, research agenda has become increasingly more challenging. When the concept of MPA was introduced, there was an urgency to identify suitable area to be protected. At this phase, habitat or substrate analysis is given priority, and research tools were developed to meet this need. The rationale behind studying and mapping the habitat using rapid assessment method so as to cover a much wider area is the pressing need to find and protect pristine habitats for conservation purposes.

1.4.1 Research tools and area of coverage

Apart from scuba and visual census, other tools and techniques were applied at different scale. Tools or techniques that are more practical, economical and reliable are usually preferred. The coral reef fishes and their habitat can be observed and recorded from the surface using CCD camera attached to poles and cables. Apart from no requirement of diver, this technique also allows for a much longer observation. Remote controlled camera, such as Remotely Operated Vehicle (ROV) was introduced for observation in much deeper waters.

Data collection has evolved from capture to non-capture method, as sampling technique changed from that using sampling gears to that based on visual census. With the advancement in camera technology, a diver's visual census can now be replaced by camera census, from single to stereo camera, from still photo to video, and from film or tape to digital format. The image analysis has evolved from single to stereo prints, from analogue to digital. Thousands of video images can be captured using a frame grabber and faster analysis can be performed via computer.

In terms of subject of study and area coverage, the method has evolved from studying substrate to studying fish, from wider area coverage to a more confined or small area, from using remote to direct observation and from low to high resolution sampling.

Later, when essential habitats have been identified and MPAs are created, there is a need to do detailed monitoring work for quantitative assessment of the

substrate and coral reef fishes (Roberts and Hawkins, 2000). This is done especially to assess the role of MPA in protecting and enhancing the coral reef fish inside it.

To assess whether MPA can protect and enhance the fish stock within its boundary, the non-capture technique is preferable (Harvey *et al*.,2001a and 2001b). To meet this need, appropriate tools were then designed and improved, from diver census to camera census, from slow to a more rapid assessment, from less to a more practical method, and from expensive to more economical equipment.

1.4.2 Study on coral reef fish population.

The high diversity of fish species and complex nature of the coral reef habitat which vary from one coral reef ecosystem to another make it almost impossible to establish a general correlation between habitat and fish, that can be applied to any coral reef ecosystem. Therefore, a more detailed study on the multispecies fish assemblage in various types of habitat, on a much smaller scale in term of area coverage is more appropriate.

Although there were claims that the highest quality of habitat supports the highest concentration of fish, the details remain unclear, especially when a rapid and remote assessment method is applied. For example, using an acoustic method may calculate the total fish biomass, but the abundance by species cannot be provided.

Application of fishing gears such as traps, hooks and drift nets as the sampling gears can only catch a few selected species from the very diverse coral reef fish community. Traps for example catch more siganids and labrids, while hook-and-lines catch lethrinids (Acosta and Turingan, 1991).

Visual census techniques (English *et al*., 1994) have many advantages, compared with other sampling techniques. This rapid quantitative method is non-destructive and repeatable. However, the disadvantages of this technique is that the observers undertaking the sampling need to be trained and must have experience to identify, count, and estimate the length of reef fish accurately. Using scuba, this technique is restricted to shallow waters due to decompression constraints.

Using diver's visual sampling, the error in measuring objects underwater is that the objects look bigger and nearer. Using a single camera, the same size objects look different in size, as their distance from camera is different. The far away fish looks smaller than the nearer fish. All these errors are related to object's distance, which can be overcome if the object's distance from the diver or the camera is known. This is achieved through the application of the stereophotography technique, where a 3D positioning of an object can be established. The technique is explained in CHAPTER 3.

Stereophotography involves the use of two or dual cameras, parallelly arranged either horizontally or vertically. Apart from calculating the position of an object in relation to the horizontal and the vertical axes, its distance from the stereo cameras can also be calculated. This gives 3D position values such as x, y and

z, where x and z can represent the geographical position such as longitude and latitude, and y represents the depth.

The stereophotography technique for remote measurements has been applied in various fields such as in remote sensing and underwater works in offshore oil platform. Recently, this technique was applied to measure the size of free-swimming fish underwater (Klimley and Brown, 1983; Beddow *et al*.,1996 and Harvey *et al*.,2001a and 2001b).

The stereophotography method for remote measurement of fish has evolved from a small-scale and slow measuring technique to a rapid assessment method such as measuring large fish in small numbers using SLR camera (Klimley and Brown, 1983) to measuring small fish in large numbers using video camera and frame grabber image processing technique (Beddow *et al*.,1996, Harvey *et al*.,2001a and 2001b).

The present rapid video-assessment method can be done using CCD cameras (small in size) and the recording can be done above water using poles and cables. Hence a diver may not be needed. The future of stereo-video system will probably incorporate the application of neural network and fuzzy logic in the image analysis (Harvey *et al*.,2001a).

Visual census technique has been applied to various coral reef fish population studies in Malaysia (DeSilva and Rahman, 1982; Ibrahim and Zaharuddin, 1988; Yusri, 2005). However, as far as fish biomass is concern, no quantitative assessment of the fish stock in the marine park has ever been made. Although

biomass can be estimated using diver's census (English *et al*., 1994) through conversion to weight from estimated length, sampling difficulties, diver's inexperience and inadequcy of proper tools, hinder such assessment. Such a difficult assessment method is now being improved by a more reliable, practical and economical technique, suitable and affordable for monitoring and assessment of coral reefs fish by any country (Harvey *et al*., 2001a and 2001b).

Until a reliable and economical method for coral reef fish stock assessment is found, the function of the coral reef ecosystem and the MPA remain unclear (Sladek and Friedlander, 2004). We are still unable to predict the responses of organisms inside and outside of newly created reserves. We should know about the distribution and movement of adult fishes and juveniles as this is a key factor that determines the function of the reserves. Monitoring is the key answer for all these issues, and reliable and economical sampling methods need to be developed before any biomass and productivity of coral reef fishery resources can be estimated. Proper methods for data analysis and interpretation are also needed to be searched. Based on the present trend in the coral reef population studies, the stereophotography and photogrammetry technique are very promising techniques for future use in quantitative sampling.

1.5 Objectives

The abundance of fish in a specific location can be attributed to many factors. Habitat arrangement and complexity, depth or distance from shore, seasonality and exploitation are among the important parameters. In term of seasonality, the abundance of fish in Malaysia is known to be different from the pre and the

post northeast monsoon season, while the abundance and diversity of demersal fish are known to be different from sandy to muddy bottoms. Coastal habitats are also known to be more productive than open water habitats (Alias, 2003).

Fish dies due to two main reasons, the natural and fishing mortality. In a protected habitat, natural mortality will be the prime factor for fish to die, but in the open areas, fishing is the factor to be considerd together with the natural mortality. Without fishing, the abundance of fish in a marine park should be much higher than in the areas open for fishing.

The evaluation of the effectiveness of MPAs in sustaining fisheries was among the key activities described by IUCN in order to ensure that MPAs were given sufficient time to re-establish viable fish stocks (Williams, 1998). For better understanding of how a local coral reef marine park ecosystem is functioning (or not functioning) in protecting and enhancing the fish population, the primary objective of this study was to do quantitative assessment on the Pulau Payar Marine Parks (PPMP) coral reef fish population and its habitat.

The main objectives of this study were to:

- Evaluate the status of the coral reef ecosystem within PPMP, through the assessments of its live coral cover and its fish population.
- To map the habitat and its water quality parameters

- To identify key parameters such as distribution and movement of adults and juveniles fish that affect the overall abundance of PPMP fish population.

- To relate the distribution and abundance of fish with spatial and temporal variations.

- To formulate management strategies to achieved maximum benefits from the marine protected areas in PPMP.

It is hoped that by the end of the study, the existing knowledge and information on our marine park can be further improved and enhanced. It must be noted that different sites would behave differently. Although the study focused specifically on the PPMP as the study site, this can be used as the basis for future works in other areas.

CHAPTER 2: MATERIALS AND METHODS

The productivity assessment of PPMP was achieved through three activities:

a. Coral reef habitat sampling and analysis
b. Coral reef fish population sampling and analysis
c. Coral reef fish community analysis

The coral reefs habitat analysis focused on the spatial arrangements of substrate, and involved mapping of the various type of substrate. Through the coral reefs fish population analysis, quantitative assessment yielded the fish density by different type of substrates of the total area observed. The fish community analysis further enhanced the understanding of the habitat preferences of the fish assemblage.

This study gathered new information as well as making use of all other available related information. Description of the study area for example, will not be possible without using the information from the past studies. Besides providing new data, existing information were updated, improved and enhanced.

2.1 Description of the Study Area

PPMP was selected as the study site because of its geographical, fishery and tourism importance.

2.1.1 Geography

PPMP is located on the Northwest coast of Peninsular Malaysia, in Kedah State waters. Figure 2-1 shows the map of the study site. It is located between Pulau Langkawi in the north and Pulau Pinang in the south.

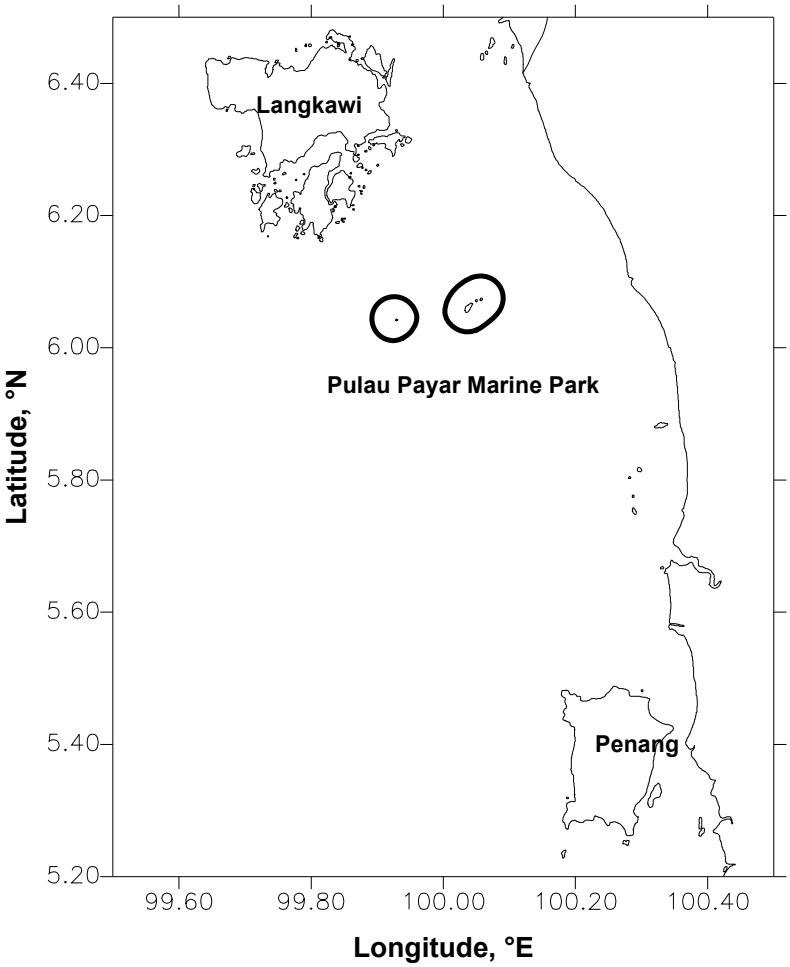

Figure 2-1: Location of Pulau Payar Marine Parks, with its 2Nmi boundary of protected reef areas (circled).

PPMP comprises of four islands, which are Pulau Payar, Pulau Lembu, Pulau Segantang and Pulau Kaca (Figure 2-2). The study focused on Pulau Payar

(Figure 2-3), which is the largest and the most diverse (DeSilva and Rahman, 1982; Sarala and Wong, 1994).

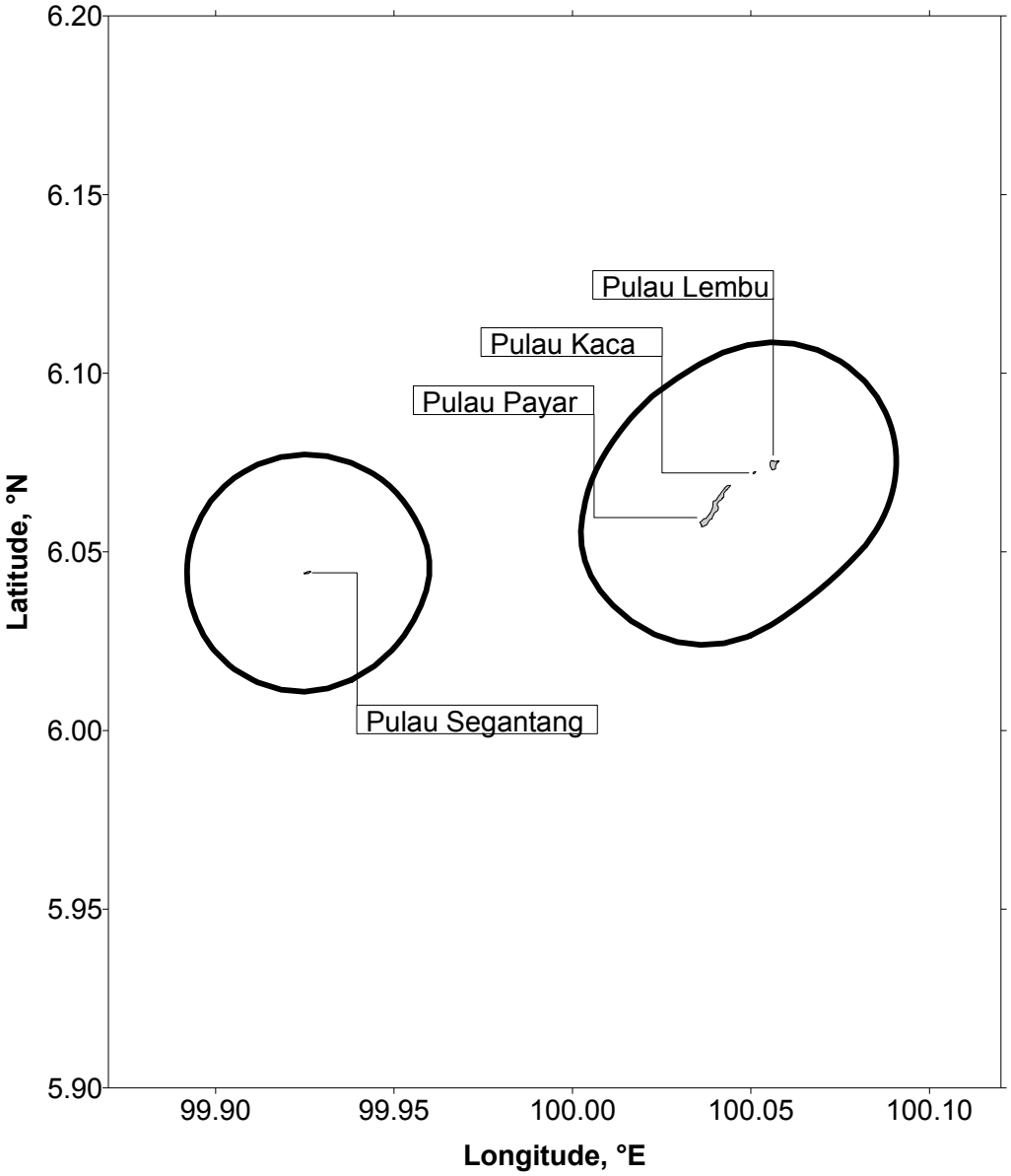

Figure 2-2: Pulau Payar Marine Parks with its 2Nmi boundary, comprising of Pulau Payar, Pulau Lembu, Pulau Kaca and Pulau Segantang

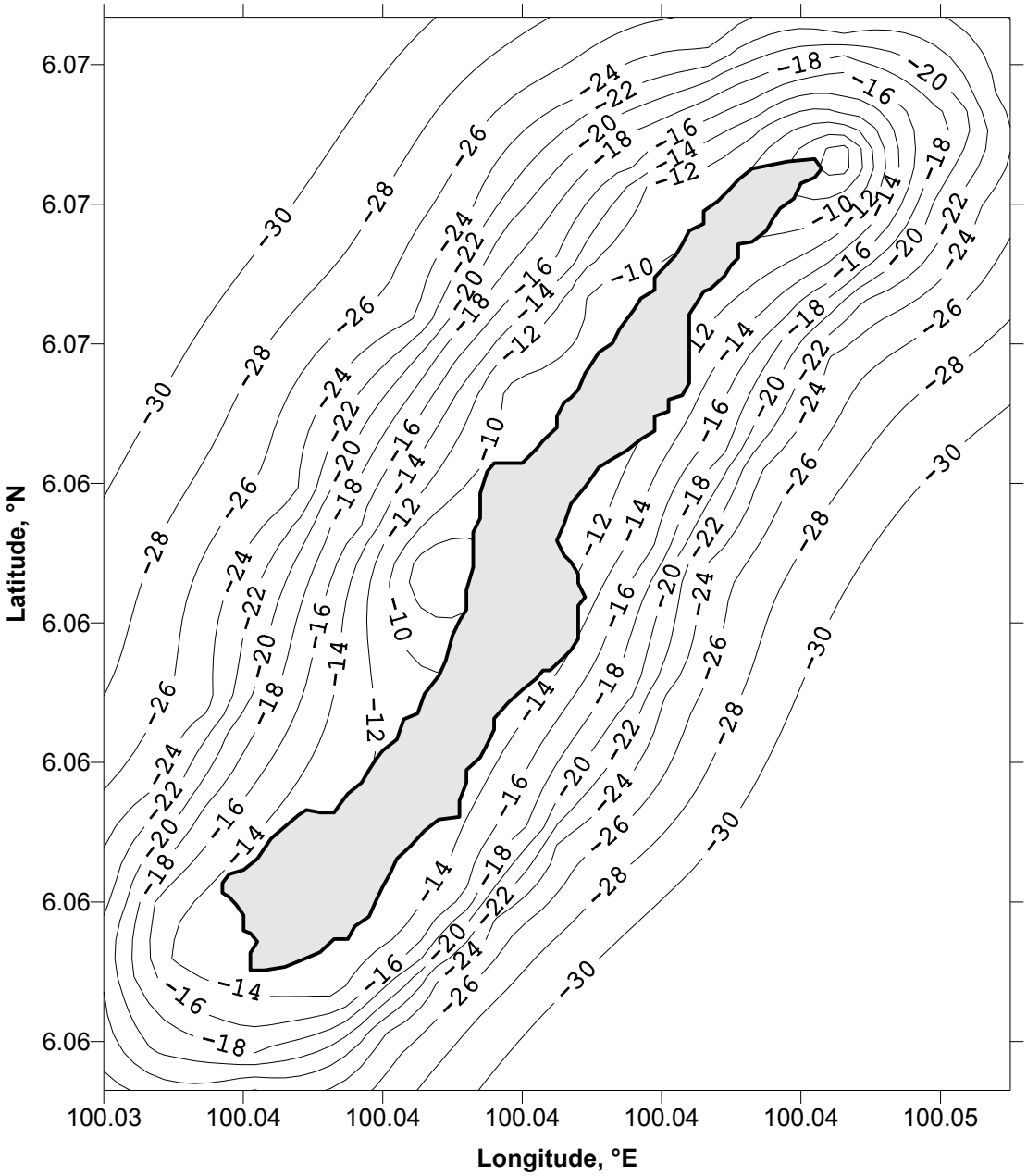

Figure 2-3: The study site, showing Pulau Payar with 2-m depth contour.

2.1.2 Fishery

PPMP is located on the west coast of peninsular Malaysia. It is located at the centre of fishing activities of various fishing methods, eg. anchovy and handline fisheries, where yield of fishes were reported to have improve after the

establishment of the MPA (Alias & Saupi, 2000). As one of the earliest MPA and located in one of the most important fishing ground in the country, its selection as the study site would provide useful information about the impact of MPA on the fishery. It could be treated as the case model of a functioning marine park to justify the need for more MPAs.

In term of fishing gear, there are two types of fishery, namely traditional and commercial. Traditional fishery operates in the coastal waters, using traditional gears such as anchovy purse seine, drift nets, barrier nets, handlines, pots, and push nets. Commercial gears such as trawl and fish purse seine operate in waters further than 5 nautical miles from shore. The most important fisheries operating in waters surrounding and close to PPMP are the anchovy purse seine and the prawn trawl fishery (<40 GRT). Other fisheries include handlines and drift nets.

Kedah was one of the important fishing states in the west coast of Peninsular Malaysia in the eighties. The fishery production for Kedah grew from about 30,000 tonnes in 1970 and attained its highest in 1982, where it landed about 149,600 tonnes or 39% of total west coast production (Alias & Saupi, 2000). After 1984, its contribution has dropped to only about 20% of total west coast production. Today (2005), the landing was only about 63,703 tonnes or 12 % of the total west coast production (DOF, 2005). This is an indication that Kedah's fishing ground has been extensively exploited and its habitat has been turned to unproductive fishing ground.

2.1.3 Tourism

In term of tourism, PPMP is one of the most frequently visited marine parks in the country. The islands known for their diverse coral reefs, have long been a popular picnic destination for many visitors (Sarala and Wong, 1994). With the rapid development of Langkawi, and being situated between Penang and Langkawi, PPMP has been receiving a tremendous increase in the number of visitors, both local and foreign. In 1988, it received a total of 1373 visitors, and in 2001 the number of visitors has increased dramatically to over 100,000, the highest among all marine parks in Malaysia. Therefore, an assessment of PPMP ecosystem could generate knowledge on the impact of tourism on this very small island.

2.1.4 Logistics and facilities

Other than its importance to fisheries and tourism, Pulau Payar was selected for study because of logistic reason. Being close to Penang and Langkawi, and connected through reliable services of boat, the Marine Park authority on the island also provides good research facility for SCUBA diving, accommodation and assistance while carrying out research activities on the island. The Park's Centre is located on the sheltered eastern side of Pulau Payar Island. It is equipped with facilities like jetty, chalets, and most important, the diving facility.

2.1.5 Oceanography

In general, the torpedo-shape of Pulau Payar, which is pointing toward the Northeast, lies on the edge of 25-m seabed before it suddenly drop to 30-m in

the south. The water in the north, bounded by Pulau Kaca and Pulau Lembu, is shallower than in the south.

The littoral and longshore currents flow in the direction southerly and northerly. Southerly current appears during the north-east monsoon season and northerly during the south-west monsoon.

From an oceanographic survey around Langkawi (JKR, 1993), tidal current are generally not higher than 0.36 m/s during the spring and 0.10 m/s during the neap tide. Flood tide flows generally in the south-east direction and the north-west during the ebb tide.

2.2 Habitat Sampling

The objective of the habitat sampling was to obtain the distribution of habitat type and environmental parameters, and to relate them to the fish density-distribution. This information later on will be use in the community assessment of the ecosystem.

There are two main types of habitat, one is the rock and coral bottom ground, which is close to the island, and next to it, is the sandy and muddy bottom ground. For the outside area of the marine park, based on the previous trawl surveys, the area was assumed to be of the muddy bottom type. To study the extent, type and distribution of the rock-coral bottom in the park, a video survey was conducted. Apart from that, a topographic survey and hydrographic survey

were also conducted to collect information on bathymetry and other environmental data.

2.2.1 Topographic survey

Present information on the study area and its bathymetry based on previous study (Lee *et al*., 2000) will be upgraded and improved by conducting a topographic survey. A topographic survey was conducted in February, 2002, using a small boat along a zig-zag tract in the marine park areas, where bathymetry data were collected using echo-sounder, and the position were obtained using GPS. Pulau Segantang was excluded from the topographic survey as it is too far away from the other three islands (Figure 2-4).