Assessment of Species Composition and Abundance of Selected Marine Invertebrates in Pulau Layang Layang, Malaysia

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Abstract: Marine invertebrates were surveyed at eight sites at Pulau Layang Layang Malaysia on May 2009. The purpose of this study was to establish a list of selected marine invertebrate species found in Pulau Layang Layang waters as well as to rank those species according to abundance. Data on sighting frequency, species composition and abundance of the selected invertebrate species were collected using a roving diver technique. A total of 37 invertebrate species were recorded. The top five most frequent species sighted were *Tridacna* sp. (giant clams), *Acanthaster planci* (crown-of-thorns starfish), *Trochus* sp. (top shells), *Choriaster granulatus* (granular sea stars) and *Phyllidia* sp. (nudibranch). Species richness, according to the number of species sighted during each survey, was found to be highest at the Tunnel site and lowest at the Reefball site. This study also examined species distribution across different depth ranges. The majority of the species (33 out of 37) could be found between the depth of one to ten metres. It is hoped that these results can be utilised to produce a proper monitoring and better conservation management plan for Pulau Layang Layang.

Keywords: marine invertebrates, Pulau Layang Layang, abundance, Roving Diver Technique

Abstrak: Pemantauan invertebrata marin telah dijalankan di lapan kawasan di Pulau Layang Layang, Malaysia pada bulan Mei 2009. Tujuannya adalah untuk menyediakan senarai invertebrata marin di pulau ini mengikut kekerapan penglihatan, komposisi dan kepadatan spesies. Data kekerapan penglihatan, komposisi spesies dan kepadatan spesies terpilih ini dikutip menggunakan teknik *roving diver*. Sejumlah 37 spesies invertebrata telah direkod. Lima spesies yang paling kerap dilihat adalah *Tridacna* sp. (kima gergasi), *Acanthaster planci* (mutiara berduri), *Trochus* sp. (top shells), *Choriaster granulatus* (tapak sulaiman) and *Phyllidia* sp. (nudibranch). Kepadatan spesies berdasarkan jumlah spesies yang dilihat pada setiap kali survei adalah paling tinggi di kawasan Tunnel manakala terendah di kawasan tapak tukun tiruan (reefball). Kebanyakan spesies (33 daripada 37) ditemui pada kedalaman satu hingga sepuluh meter. Keputusan yang didapati dari kajian ini, diharap dapat digunakan untuk menghasilkan program pemantauan dan pemuliharan yang lebih berkesan untuk Pulau Layang Layang.

Introduction

Pulau Layang Layang Malaysia is located in the midst of South China Sea, about 300 km north-west of Kota Kinabalu, Sabah (Nichols and Stachels, 2002). It is a ring-shaped atoll made up of 13 reefs with coral walls that plunge more than 1,800 metres to the ocean floor (Malaysia Airlines, 2009). The atoll is surrounded by clear water with underwater visibility that may exceed 200 m (Zaidnuddin *et al.*, 2000). Pulau Layang Layang is the only true coral atoll in Malaysia. The clear, nutrient-rich waters permit dense coral growth to a depth of more than 50 metres (Svrcula, 2008). This is also one of the unique diving sites in Malaysia. Besides hammerhead sharks and migratory birds, the atoll is home for thousands of fish, corals, and marine invertebrate species such as giant clams (Asnawi *et al.*, 2004). It has been reported by Svrcula (2008) that some of the giant clams (*Tridacna gigas*) in Pulau Layang Layang reached a diameter of over one metre and are reputed to live up to 200 years.

'Invertebrate' is a term used to describe any animal without a vertebral column (backbone). They are an extremely diverse group and represent 95% of species belonging to the animal kingdom (Colin and Arneson, 1995). In the sea, coral reef invertebrates are comprised of single-celled animals, principally foraminifera (Protozoa), and multicellular species such as sponges, cnidarians (hydroids, jellyfish and corals), various worm-like animal, molluscs (nudibranchs and sea shells), crustacean arthropods (barnacles, shrimp and crabs), echinoderms (starfish, urchins, crinoids and sea cucumbers) and the ascidians (seasquirts) (Colin and Arneson, 1995).

Reef invertebrates are one of the major components that make the complex coral reef ecosystem (Kee Alfian *et al.*, 2005). They are important components of the ecosystem on many different levels. Many, such as lobsters, clams and scallops, are resource species. Many more are vital food species, which support the fisheries sector in Malaysia (Mohamad Saupi and Ahmad Adnan, 2005). Others like sea cucumbers have commercial values whereby they are farmed and harvested, particularly in the waters of Sabah, to be exported and/or used as medicine or food which makes this group of invertebrates' equally important (Forbes *et al.* 1999; Kee Alfian *et al.* 2005). Marine invertebrates are critical to most ecosystem functions especially in coastal regions. Their activities influence and often control basic physical, chemical, geological and biological processes in marine ecosystems.

Prior to this study, resource surveys on the marine invertebrates of Pulau Layang Layang were only done on a single group of the invertebrate such as sponges (Zaidnuddin *et al.*, 2000); giant clams (Asnawi *et al.*, 2004); and sea cucumbers (Zaidnuddin *et al.*, 2004). For this study, the selected invertebrates represent the major groups of marine invertebrates, i.e.: crustaceans (crabs and shrimps), molluscs (gastropods and bivalves), echinoderms (sea stars, sea urchins and sea cucumbers), and sea anemones. The almost similar groups of invertebrates have also been studied by Kee Alfian *et al.* (2005) in Pulau Tioman.

Human activities such as scuba diving and sea-ranching are increasing in this area, as is interest in conserving the biological diversity that is found here. One of the conservation tools that has increasingly become more important is the ability to conduct rapid species assessments (Schmitt *et al.*, 2002).

The purpose of this study is to establish some baseline data on the abundance and species richness of selected groups of marine invertebrates at Pulau Layang Layang, Malaysia. Monitoring of species abundance, composition and distribution is essential for management and conservation of marine invertebrate populations. Thus, baseline data on Pulau Layang Layang's marine invertebrate populations can be useful for decision making as well as future scientific studies.

Materials and Methods

Study sites

Marine invertebrate surveys were conducted at eight study sites at Pulau Layang Layang in May 2009. The atoll has two significantly different types of wall; walls with a short, gently sloping edge and walls with a sheer vertical drop (Zaidnuddin *et al.*, 2000). Thus, study sites were spread over the atoll to get a rough idea of the distribution of its marine invertebrates. Listing from the easternmost to the westernmost, were Gorgonian Forest, Navigator Lane, Tunnel, Reefball, Runway, D'Wall, Shark's Cave, and Wrasse Strip (Fig. 1).

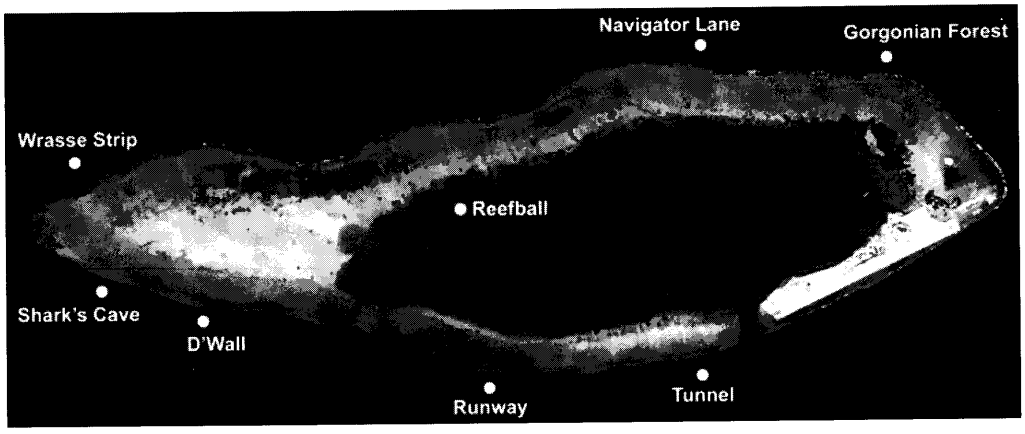

Figure 1: Survey sites in Pulau Layang Layang

Survey methodology

Species abundance was estimated using a visual scoring system, based on the Roving Diver Technique (RDT), used by the Reef Environment Education Foundation (REEF, 2007). Earlier surveys on targeted marine invertebrates of the island were also conducted using this RDT method (Asnawi *et al.*, 2004; Zaidnuddin *et al.*, 2004). Each recorded species was assigned a visual abundance score between 1 and 4 based on how many of each species were seen during the survey. The logarithmic-based categories of the visual scoring system were as follows:

1 =	Single (S)	= Only one individual seen
2 =	Few (F)	= Between 2 and 10 individuals seen
3 =	Many (M)	= Between 11 and 100 individuals seen
4 =	Abundant (A)	= > 100 individuals seen

Surveys were carried out using SCUBA equipments. A team of three (occasionally two or four) divers conducted a 45-60 minutes RDT survey at each site. The survey was also supported by underwater photography. Stratified surveys were carried out at depth intervals of 30, 20, 10, and if possible at 4 m. All surveys were undertaken between 10.00 am and 4.00 pm.

Three parameters i.e. percent sighting frequency, density score, and abundance score were calculated for each species. The sighting frequency (% SF) was obtained by taking the number of surveys in which the species was sighted and dividing it by the total number of surveys. An estimate of abundance was calculated as:

$$\text{Abundance score} = D \times \% \text{ SF},$$

Where, the density score (D) for each species is a weighted average index based on the frequency of observations in different abundance categories (S, F, M, and A). Density score is calculated as:

$$D = [(S \times 1) + (F \times 2) + (M \times 3) + (A \times 4)] / (\text{No. of surveys in which species was observed})$$

Due to lack of expertise and time constraint, only eight groups of invertebrates are chosen for this survey i.e. anemones, bivalves, crabs, gastropods, sea cucumbers, sea stars, sea urchins, and shrimps. Field identifications were based on Allen (1997), Colin and Anerson (1995), Fiene-Severns *et al.* (2000), Forbes *et al.* (1999), Gremli and Newman (2001), Oliver (2004), and Wood and Aw (2002).

Results

A total of 37 invertebrate species comprising of eight different groups were recorded during this survey (Table 1). All species were identified, at least up to the genus level. The 20 most common species, according to % SF, are listed on Table 2. The five most frequent species sighted, ranging from highest to lowest, were *Tridacna* spp. (giant clams), *Acanthaster planci* (crown-of-thorns starfish), *Trochus* sp. (top shells), *Choriaster granulatus* (granular sea stars) and *Phyllidia* sp. (nudibranch). However, more than half of these recorded species (20 out of 37) had density score values of 1.0 or less.

Table 3 shows the classification scheme used in mapping species abundance by REEF (2007). Only three species (*Tridacna* spp., *Acanthaster planci*, and *Trochus* sp.) were classified as "highly frequent", while 23 species were considered as "uncommon". As expected, all the species with density score values of 1.0 or less were categorised as "uncommon". Out of the "highly frequent" species, only *Tridacna* spp. can be found in every survey sites, while *Acanthaster planci*, and *Trochus* sp. were not presence at site 4 (Reefball) and site 2 (Gorgonian Forest) respectively (Table 1).

Table 1: The presence and abundance of each species at the eight sites surveyed

Species	Survey Sites 1	2	3	4	5	6	7	8
Acanthaster planci	○	⊙	⊙		●	⊙	●	⊙
Actinophyga lecanora			○					
Bohadschia argus			○					
Bursa sp.			⊙		○		○	⊙
Cantharus sp.			○					○
Choriaster granulatus	⊙	○		○	○		○	○
Chromodoris lochi					○	⊙	○	
Chromodoris quadricolor								○
Conus sp.						⊙		⊙
Culcita novaeguineae	○	○						
Cypraea tigris			○	⊙		○		⊙
Dardanus sp.								○
Diadema sp.		○	⊙		○		○	
Echinaster callosus						○		○
Epitonium sp.	○							
Fromia sp.								○
Fryeria sp.						⊙		
Holothuria atra	○	⊙	○			○		○
Lambis sp.						⊙		
Linckia multiflora				⊙			⊙	
Linckia sp.	⊙		●			○	⊙	
Majidae sp.							⊙	
Mitra sp.			○			○		
Opheodesoma sp.			○					
Pachycerianthus sp.						○		
Pearsonothuria graeffei						⊙		
Pedum sp.	○	⊙						
Phyllidia sp.	○	⊙	⊙			○		⊙
Pinctada margaritifera	○	⊙				○		
Stenopus hispidus							⊙	
Stoichactis sp.	○		○				⊙	
Terebra sp.			○					
Tonna sp.		○						○
Trachycardium sp.		○						
Trochus sp.	○		⊙	○	○	⊙	○	⊙
Tridacna spp.	●	●	●	⊙	●	●	●	●
Turbo sp.						⊙	○	○

Notes:

Site 1: D'Wall, 2: Gorgonian Forest, 3: Navigator Lane, 4: Reefball, 5: Runway, 6: Tunnel, 7: Shark's Cave, and 8: Wrasse Strip

● = Many, ⊙ = Few, ○ = Single

Table 2: Twenty most frequently sighted marine invertebrates on the Pulau Layang Layang

Rank	Scientific Name	Common Name	Sighting frequency (%SF)	Density Score
1	*Tridacna* spp.	Giant clam	100.0	2.88
2	*Acanthaster planci*	Crown-of-thorns	87.5	2.14
3	*Trochus* sp.	Top shell	87.5	1.43
4	*Choriaster granulatus*	Granular sea star	75.0	1.17
5	*Phyllidia* sp.	Nudibranch	62.5	1.60
6	*Holothuria atra*	Sea cucumber	62.5	1.20
7	*Linckia* sp.	Blue linckia	50.0	2.00
8	*Bursa* sp.	Toad shell	50.0	1.50
9	*Cypraea tigris*	Tiger cowry	50.0	1.50
10	*Diadema* sp.	Sea urchin	50.0	1.25
11	*Stoichactis* sp.	Giant sea anemone	37.5	1.33
12	*Chromodoris lochi*	Nudibranch	37.5	1.33
13	*Pinctada margaritifera*	Pearl oyster	37.5	1.30
14	*Turbo* sp.	Turban shell	37.5	1.33
15	*Linckia multiflora*	Sea star	25.0	2.00
16	*Conus* sp.	Conus shell	25.0	2.00
17	*Pedum* sp.	Coral clam	25.0	1.50
18	*Culcita novaeguineae*	Cushion star	25.0	1.00
19	*Echinaster callosus*	Sea star	25.0	1.00
20	*Cantharus* sp.	Goblet	25.0	1.00

Table 3: Classification scheme used in mapping species abundance (REEF, 2007)

Sighting frequency (%SF)	Classification	No. of Species
76 - 100	Highly Frequent	3
51 - 75	Frequent	3
26 - 50	Common	8
1 - 25	Uncommon	23

Results on sea cucumber population show that *Holothuria atra* is the sixth most frequent marine invertebrate species found in Pulau Layang Layang. This finding is in agreement with Zaidnuddin *et al.* (2004) who reported that *H. atra* was found to be the most dominant species of sea cucumber in Pulau Layang Layang. They also reported that the density of sea cucumbers in the island was relatively low compared to densities reported in other areas. As indicated on Table 2, no other species of sea cucumber managed to be in the top 20 of most dominant invertebrate species in Pulau Layang Layang.

Species richness, according to the number of species sighted during each survey, was found to be highest at the Tunnel (17 species present) and lowest at the Reefball with only five species present (Figure 2). The high number of species recorded at the Tunnel maybe due to the fact that this area is not the most popular dive sites at Pulau Layang Layang. Thus, it has lesser human activities in this area compared to other popular dive sites, as mentioned by Svrcula (2008); Nichols and Stachels (2002), such as Gorgonian Forest, Shark's Cave, D'Wall and Wrasse Strip. Gremli and Newman (2001) stated that the sheer number of SCUBA divers in the water has a deleterious effect on the reef population. Meanwhile, the low number of species recorded at the Reefball may be due to the fact that this area was used to be an open space of sandy seabed with a few patches of seagrass, until the artificial reefs were placed on its floor a few years ago.

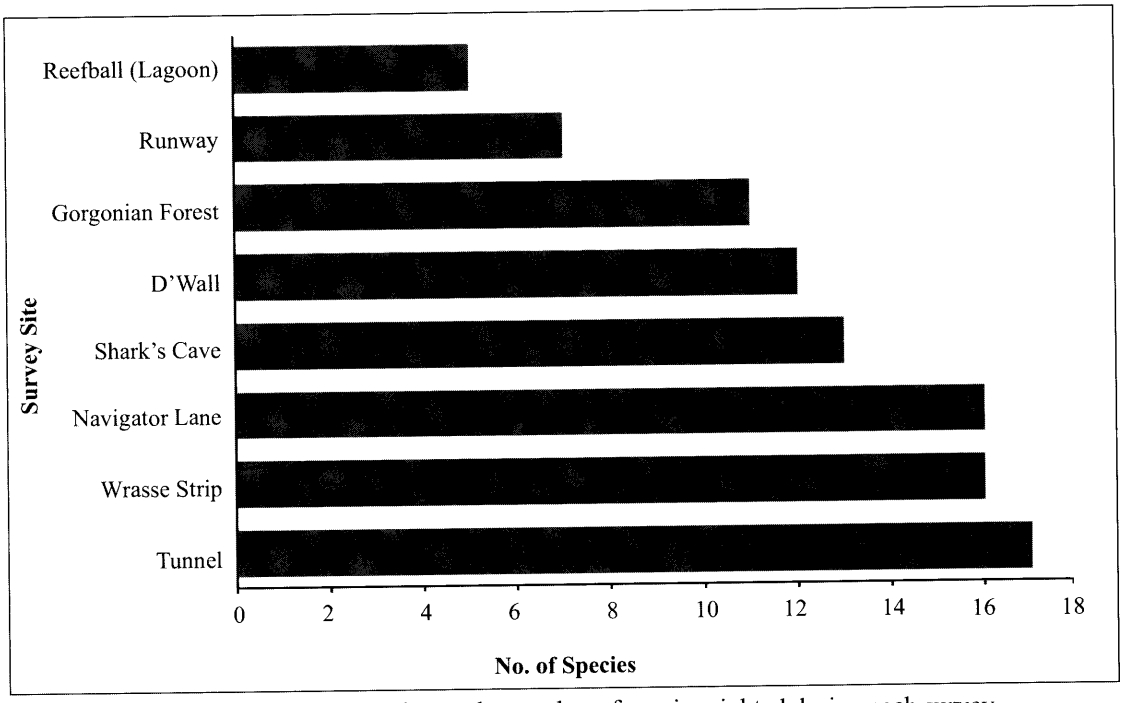

Figure 2 : Species richness according to the number of species sighted during each survey

Table 4 shows the species recorded according to the depth intervals of 1-4 m, 4-10 m, 10-20 m, and 20-30 m. The result shows that the majority of the species (33 out of 37) can be found between the depths of one to ten metres. Nudibranch (*Chromodoris quadricolor*) and tube anemone (*Pachycerianthus* sp.) were solely found at depths between 10-20 m, while Alabaster sea cucumber (*Opheodesoma sp.*) and coral clam (*Pedum* sp.) can only be found at deeper depth of more than 20 m. Granular sea star (*Choriaster granulatus*) and nudibranch (*Phyllidia* sp.) were the only two species observed at all four depth intervals.

Discussion

The results presented in this paper are only intended to serve as a baseline data on Pulau Layang Layang marine invertebrate populations. The list presented, although represents most commonly sighted invertebrate species, should not be considered comprehensive as more surveys and different techniques might reveal even more species. The findings of this study were limited by the fact that only three persons were conducting the field surveys. Future studies could be improved through a combination of more surveys and multiple surveyors.

Table 4: Species sighted at depth intervals from 1-30 m

Species Name	Common Name	Depth Interval			
		1 - 4	4 - 10	10 – 20	20 - 30
Acanthaster planci	Crown-of -thorns	✓	✓	✓	
Actinophyga lecanora	White patch sea cucumber	✓			
Bohadschia argus	Leopard sea cucumber	✓			
Bursa sp.	Toad shell	✓	✓		
Cantharus sp.	Goblet	✓			
Choriaster granulatus	Granular sea star	✓	✓	✓	✓
Chromodoris lochi	Nudibranch		✓	✓	
Chromodoris quadricolor	Nudibranch			✓	
Conus sp.	Conus shell	✓	✓	✓	
Culcita novaeguineae	Cushion star	✓	✓		
Cypraea tigris	Tiger cowry	✓	✓		
Dardanus sp.	Hermit crab		✓		
Diadema sp.	Sea urchin	✓			
Echinaster callosus	Sea star		✓	✓	
Epitonium sp.	Wentletrap		✓		
Fromia sp.	Peppermint sea star		✓		
Fryeria sp.	Nudibranch		✓		✓
Holothuria atra	Sea cucumber	✓	✓	✓	
Lambis sp.	Spider conch		✓		
Linckia multiflora	Sea star	✓	✓		
Linckia sp.	Blue linckia	✓	✓		
Majidae sp.	Crab	✓			
Mitra sp.	Miter	✓		✓	
Opheodesoma sp.	Alabaster sea cucumber				✓
Pachycerianthus sp.	Tube anemone			✓	
Pearsonothuria graeffei	Sea cucumber		✓		
Pedum sp.	Coral clam				✓
Phyllidia sp.	Nudibranch	✓	✓	✓	✓
Pinctada margaritifera	Pearl oyster		✓		✓
Stenopus hispidus	Banded boxer shrimp	✓			
Stoichactis sp.	Giant sea anemone	✓		✓	✓
Terebra sp.	Auger shell		✓		
Tonna sp.	Tun shell	✓			
Trachycardium sp.	Enode cockle	✓			
Trochus sp.	Top shell	✓	✓	✓	
Tridacna spp.	Giant clam	✓	✓	✓	
Turbo sp.	Turban shell	✓	✓		

This study indicates that giant clams (*Tridacna* spp.) are the most frequent and abundant marine invertebrate species found in Pulau Layang Layang. The result is supported by Asnawi *et al.* (2004) who claimed that the island is rich in giant clams, compared to other area in Malaysia. This result is indeed a good indication, ever since Kee Alfian *et al.* (2005) reported that the population sizes of giant clams in Pulau Layang Layang, in particular *T. maxima*, is still recovering from heavy fishing pressure in the past. Wood and Aw (2002) reported that giant clams occur throughout the South China Sea region but has been drastically over-exploited and tends to be seen only in protected areas. Shockingly, crown-of-thorns starfish (CoT) has emerged as the second most abundant and frequent species found in this island. It can be found at every survey sites except the inner lagoon. This phenomenon is alarming as the presence of ravenous crown-of-thorns starfish and sea urchins are normally associated with coral reef degradation as well as a direct result of pollution and contamination (Svrcula, 2008). The threat of CoT to coral reefs is imminent. Thus, something needs to be done in order to control the existence of this predator in the island.

Apart from that, the most serious threat to the condition of coral reefs, in terms of their overall structure as well as in the growth and population of the reef organisms that inhabit and visit them, is human intervention of one sort or another (Gremli and Newman, 2001). From 1995 to 2006 some 16,000 people, many of whom were divers, have visited the island (The Star, 2006). The number has definitely grown up ever since.

The number of marine invertebrate species recorded was quite low (only 37 species). This is possibly due to the surveys being conducted during day time. Thus, only species that are active during the time were able to be observed and recorded. Nocturnal species such as emperor shrimps, hermit crabs, and stalking octopuses (Svrcula, 2008) were hardly found or not found at all. Another possibility was because only species that were exposed on the sea floor were recorded. The population of marine invertebrates that hid among the rocks, crevices, holes and other rocks substrates could be higher than the one that were observed.

Although the number of recorded species was low, there is, however, a few unique and interesting species have been found at Pulau Layang Layang. For instance, Alabaster sea cucumber (*Opheodesoma* sp.) was not recorded during the study by Zaidnuddin *et al.* (2004), but has been observed in this survey. Another species found at Pulau Layang Layang that is worth mentioning here is *Echinaster callosus* (sea star). This species is indeed very special, thus it has become one of an iconic image, along with Pulau Layang Layang, in one of the 17th collection of 2005 Malaysian postal stamp.

While the abundance data does seem to provide a good picture of the actual population, it is important to note that the roving diver techniques used in this study have known advantages and disadvantages when compared to other survey techniques such as belt transects. Roving diver techniques are more likely to record rare species, resulting in greater number of species being recorded, than belt transects. However, unlike transect surveys, roving diver techniques are not able to provide information such as length (biomass) and actual density measures (Schmitt *et al.*, 2002). Schmitt *et al.* (2002) have also concluded that both methods were complementary and should be used together to provide a more complete overall species assessment of reef species than does either method in isolation as a result of specific biases and limitations inherent to each individual method. Thus, the data presented here could be used as a starting point for conducting future studies that employ both methods. All in all, it is hoped that these data can be used to produce a proper monitoring programme and a better conservation management plan for Pulau Layang Layang.

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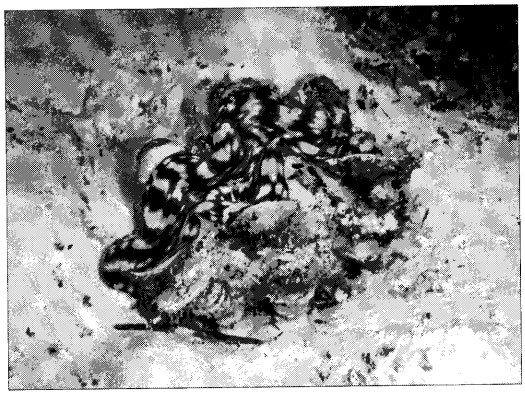
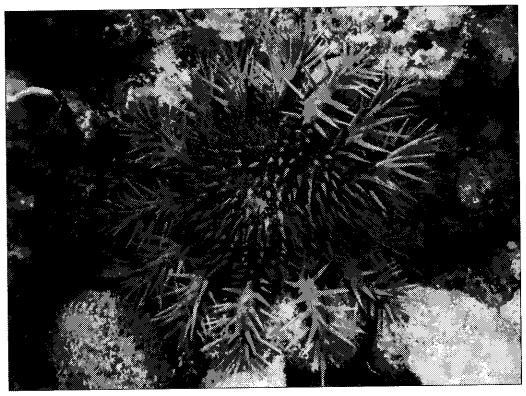
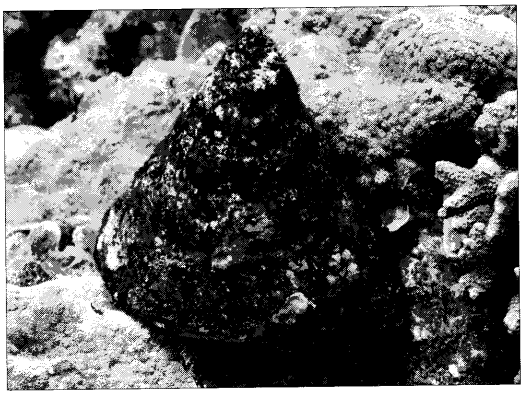
Appendix 1: Marine invertebrates observed during the survey



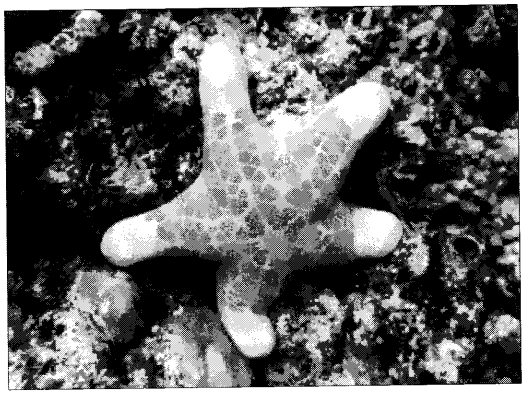
Tridacna sp. (giant clams)



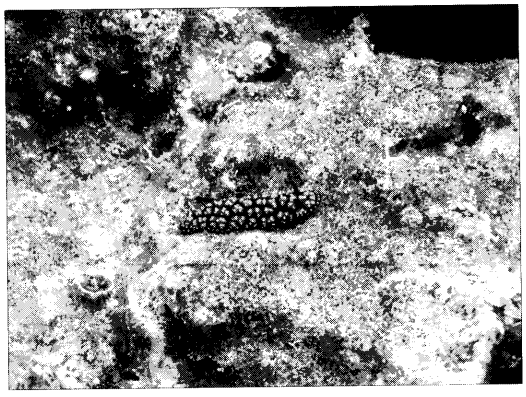
Acanthaster planci (CoT)



Trochus sp. (top shells)



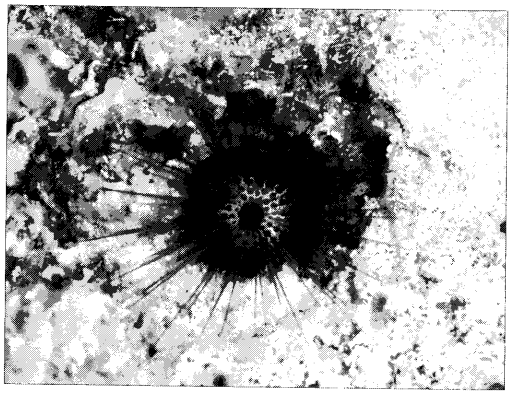
Choriaster granulatus (granular sea stars)



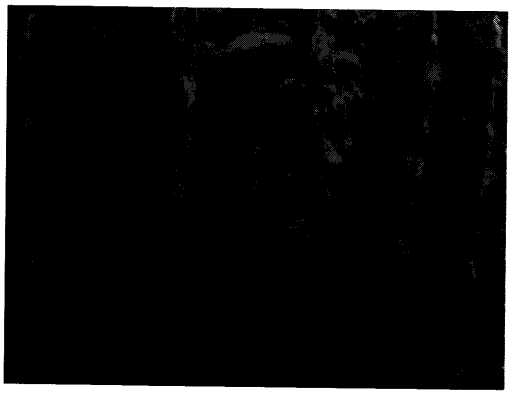
Phyllidia sp. (nudibranch)

Holothuria atra (sea cucumber)

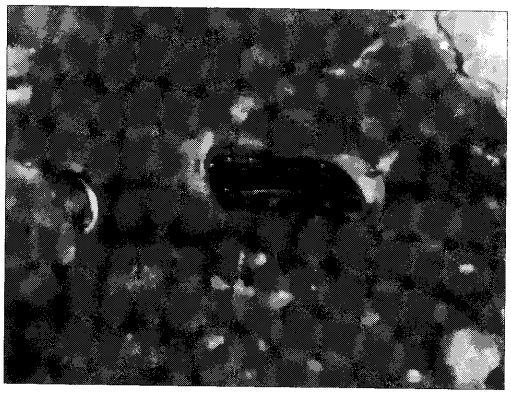
Chromodoris quadricolor (nudibranch)



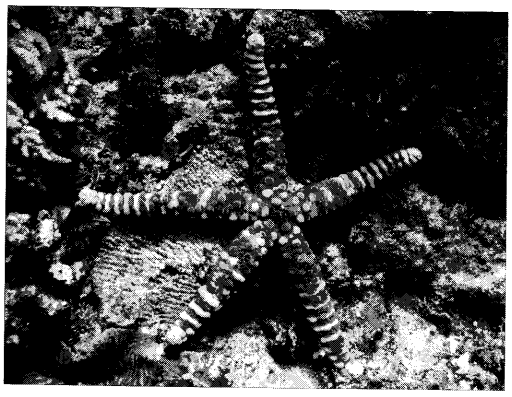
Pachycerianthus sp. (tube anemone)



Opheodesoma sp. (Alabaster sea cucumber)



Pedum sp. (coral clam)



Echinaster callosus (sea star)