REEF CHECK MALAYSIA ANNUAL SURVEY REPORT 2010

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EXECUTIVE SUMMARY

1. A total of 93 Reef Check surveys were completed in 2010, 46 in peninsular Malaysia and 47 in East Malaysia. Although slightly fewer than 2009, the surveys are a continuation of a successful National Reef Check Survey Programme that has now run for four years.

2. The surveys were carried out by volunteers trained and certified in the global standard Reef Check method. 42 people were trained during 2010, adding to the base of volunteers who are participating in Reef Check Malaysia's programmes. A third of trainees were upgrading their certification to Trainer level, reflecting growing interest from participants. Surveys were carried out on several islands off Peninsular Malaysia's East coast inside established Marine Protected Areas, and in various parts of East Malaysia, both Sabah and Sarawak.

3. The results indicate that the reefs surveyed have a relatively high level of living hard coral, some 10% above the regional average.

4. The level of recently killed corals indicates continuing recovery from the 1997-8 global bleaching event that killed 10% of the world's reefs. However, many of the surveys were carried out before another major bleaching event, which started early in the second half of 2010. It is likely that post-bleaching surveys will register higher levels of recently killed corals.

5. Low levels of abundance of high-value species of fish (such as grouper) and shellfish (such as lobster) were recorded, indicating slow recovery from past overfishing and possible continuing problems with poaching inside Marine Protected Areas.

6. Continuing – and in some cases increasing – high incidences of algae at some reefs indicate that some reefs are suffering from an ecosystem imbalance due to elevated nutrient inputs, possibly from sewage and agriculture activities (particularly plantations), coupled with low herbivory by fish and sea urchins.

7. A series of recommendations is provided with a focus on better education and enforcement of existing laws. In particular, the government is asked to support further survey programmes, to take steps to build resilience of coral reefs and to establish a comprehensive Bleaching Response Plan, to enable it to better respond to future mass coral bleaching events.

8. While tourism is a valuable source of income, the government is asked to require hotels and dive facilities to follow best practices including careful attention to sewage treatment and discharge, and education of clients so as to avoid damage to reefs.

9. Coral reefs are a valuable economic and biological resource in Malaysia, where they are a major attraction for the tourism industry, serve as a protein source for millions of people and are a major source of biodiversity. One estimate puts the economic value of well-managed coral reefs in South East Asia at around US $ 12.7 billion per annum. Coral reefs are threatened due to global warming, overfishing, pollution and sedimentation.

10. Reef Check is a coral reef monitoring methodology used worldwide to assess the health of coral reefs in over 82 countries worldwide, and in Malaysia since 2001. The non-profit Reef Check Malaysia Bhd (RCM) is available to oversee training and surveys in Malaysia.

1. Introduction

1.1 Why Are Coral Reefs Important?

Coral reefs provide a number of valuable services to society, so called “Eco System Services”, among which are:

- **Food:** coral reefs are a key source of protein for coastal communities in Malaysia and around the world
- **Fisheries:** reefs are nurseries and breeding grounds for an estimated 25% of all marine animals, and home to one third of all fish species found worldwide
- **Tourism:** reefs attract millions of tourists annually, creating jobs and bringing revenue to local economies
- **Coastal protection:** reefs form a natural barrier for coastal protection, reducing erosion of land.
- **Medicine:** drugs from the sea are currently on the market to combat illnesses including cancer and many more are undergoing trials.
- **Aesthetic, spiritual and religious**: the beauty of reefs is well known, and many religions including Christianity, Buddhism and Islam recognize the value of living organisms other than humans.

The complexity of the economic, social and biological systems surrounding the use of coral reefs makes it difficult to put a value on these services. However, three estimates serve to demonstrate just how important coral reefs are:

- The Global Coral Reef Monitoring Network report, “Status of the Coral Reefs of the World: 2004” suggests that the potential economic value of well managed coral reefs in South East Asia is some US $12.7 billion per annum.
- Coral reefs provide economic goods and ecosystem services worth about $375 billion each year to hundreds of millions of people (Costanza, Robert et al., 1997, *The Value of the World's Ecosystem Services*).
- The World Resources Institute report “Reefs at Risk in South East Asia (2002) indicates that sustainable coral reefs fisheries alone are worth some US $ 2.4 billion per year in the region. The coral reefs of Indonesia and Philippines provide annual economic benefits estimated at US $ 1.6 billion and US $ 1.1 billion per year, respectively.

Protecting these resources to ensure that they continue to provide these benefits in the future is important to the well being of hundreds of millions of people around the world who rely on coral reefs for their livelihoods.

1.2 Background to Reef Check

Founded in 1996, Reef Check is the world's largest international coral reef monitoring programme involving volunteer recreational divers and marine scientists (Hodgson 2001, Hodgson et al, 2006). The Reef Check Foundation supports the use of a suite of monitoring methods to survey coral reefs and rocky temperate reef ecosystems. First carried out in 1997, Reef Check monitoring of coral reefs provided the first solid evidence that coral reefs have been damaged on a global scale. The survey raised the awareness of scientists, governments, politicians and the general public about the value of coral reefs, threats to their health and solutions to coral reef problems (Hodgson, 1999).

In August 2002, Reef Check released its five-year report, *The Global Coral Reef Crisis – Trends and Solutions* (Hodgson and Liebeler, 2002). Based on data collected in over 80 countries, the report was the first scientific documentation of the dramatic worldwide decline in coral reef health over the previous five years. The rate of decline and the global extent of the damage are alarming. There is virtually no reef in the world that remains untouched by human impacts, such as over fishing, pollution and climate change. Yet the success stories discussed in the report show that, with proper monitoring, management and protection, our coral reefs can recover. It is up to us.

Today, Reef Checks are conducted annually at hundreds of sites around the world, in order to continually monitor the state of the world's reefs. Reef Check teams have been sponsored by a number of large corporations and have worked with many businesses in tourism, diving, surfing and the marine aquarium trade, to develop mutually beneficial solutions - including the creation of self-funding Marine Protected Areas.

A non-profit organization, Reef Check's mission is to:

- **Educate** the public and governments about the value of coral reefs and the crisis facing them;
- **Create** a global network of volunteer teams, trained and led by scientists, that regularly monitor and report on reef health using a standard method;
- **Facilitate** collaborative use of reef health information by community groups, governments, universities and businesses to design and implement ecologically sound and economically sustainable solutions;
- **Stimulate** local action to protect remaining pristine reefs and rehabilitate damaged reefs worldwide.

Reef Check is now active in over 90 countries and territories throughout the world. Reef Check promotes reef education and "citizen science" for students and adults through the EcoDiver certification program that is also a self-funding mechanism for dive shops and resorts.

1.3 Reef Check in Malaysia

Malaysia is part of the "Coral Triangle", the area of the world's oceans recognized by scientists as having the highest marine biodiversity. Coral reefs represent an economically important ecosystem and are the foundation of a significant percentage of the country's tourist industry. There are some 4,000 km^2 of reef around the country, including fringing reefs and offshore islands. It is estimated that there are over 550 species of coral in Malaysian waters (source: "Reefs at Risk in South East Asia").

However, a lack of comprehensive management programmes is leading to degradation of this important economic resource. This situation is exacerbated by inadequate information on the status and location of the reefs, further hindering management efforts.

In 2001, the Reef Check Foundation appointed a National Coordinator for Malaysia, to promote Reef Check and carry out training and surveys. While surveys were carried out in several parts of the country, a lack of funding and support limited the growth and positive impacts of the programme.

In 2006, the British Government provided funding for a one year project to establish a more sustainable Reef Check programme in Malaysia. That project culminated with the registration of Reef Check Malaysia Bhd as a non-profit company in August 2007.

At the end of 2007, Reef Check Malaysia published its first annual survey report, covering 33 surveys at 21 sites on the East coast of Peninsular Malaysia. During 2007, Reef Check Malaysia trained 15 EcoDiver Trainers and 58 EcoDivers. In 2008, almost 100 divers completed the EcoDiver programme, and 58 surveys have been completed. A further 61 people were trained in 2009 and 115 surveys completed. In 2010, RCM certified 35 new EcoDivers and 13 EcoDiver Trainers who assisted in the completion of 93 surveys throughout the year.

1.4 Goals of Reef Check Malaysia

The goals of Reef Check Malaysia are consistent with the global program and are to educate Malaysians about the value of coral reefs and to build up a constituency of citizens who are knowledgeable and supportive of marine conservation. RCM seeks to do this by training "citizen scientists" – from students to business people, to help monitor these critically important natural resources and to obtain reliable scientific data that will help the general public and the government to understand the health of Malaysia's coral reefs. RCM seeks in particular to bring together academic scientists, businesses, government staff and non-profit organizations in a united effort to sustainably manage coral reefs.

This report is the fourth annual report, and details the results of Reef Check surveys carried out during 2010. It represents a continuation of the reef monitoring effort started by RCM in 2007. The information shown highlights key concerns and identifies steps that need to be taken to contribute to the conservation of Malaysia's coral reefs.

2. Threats to Coral Reefs

According to "Reefs at Risk in Southeast Asia" (Burke *et al*, 2008), the coral reefs of Southeast Asia are the most threatened in the world. The damage caused by occasional natural phenomena is far outweighed by growing human impacts in the region.

The "Reefs at Risk" report identifies the following key threats to coral reefs.

2.1 Coastal Development

Growing populations and expanding industrial economies, combined with developing tourism markets, drive demand for new infrastructure in coastal zones. This results in both direct and indirect pressures on reefs:

- direct pressure: physical damage to the reef as a result of construction (e.g. damage to substrate, sedimentation, dredging), land reclamation activities, and use of corals as a source of lime for cement production

- indirect: development in coastal areas usually results in increased sedimentation and nutrient runoff; destruction of mangroves, an important part of the marine ecosystem, adds to the problem. High levels of sediment mean that corals are unable to photosynthesize, causing coral bleaching; poor waste water treatment leads to high nutrient loads, resulting in algal blooms which also smother coral.

These pressures combined can have significant negative impacts on coral reefs. Irresponsible development of tourist facilities in particular can destroy the very ecosystems tourists come to see.

2.2 Marine-based Pollution

The sea lanes around South East Asia are among the busiest in the world. The volume of sea traffic threatens coral reefs in a number of ways:

- pollution from ports: pollutants can accumulate in these semi-enclosed areas

- oil spills: both large spills and frequent minor spills release oil which can cause significant damage to coral reefs

- ballast and bilge discharge, which can result in release both of pollutants and exotic species

- garbage and solid waste dumping.

2.3 Sedimentation and Pollution from Inland Sources

Corals depend on photosynthetic zooxanthellae for nutrients and therefore thrive in clear tropical waters. High levels of sedimentation can significantly affect coral growth and can even result in coral dying. Logging, river modifications, road construction and other upland activities are causing high rates of soil erosion in South East Asia, which then enters rivers to eventually find its way to the sea.

In addition to sediment, nutrients and fertilizers that are not absorbed by soil also flow into the sea, contributing to algal blooms that smother and kill reefs.

2.4 Overfishing

Coastal populations are growing throughout South East Asia, and over 80% of the populations of Malaysia, Indonesia, the Philippines and other countries live within 50km of the coast. Many rely on marine resources for their food and livelihoods. As a result, coastal resources are increasingly being exploited beyond sustainable limits.

The resulting overfishing causes a variety of impacts:

- many fish species are overexploited, either as a food source or for the marine aquarium trade, resulting in reduced breeding populations
- the mix of fish species can change, reducing the resilience of coral reefs to natural and anthropogenic disturbances
- algal-grazing fish are removed from the coral reef resulting in algal blooms which smother reefs.

2.5 Destructive Fishing

Destructive fishing techniques, particularly poison fishing and blast fishing, contribute to over-exploitation of economically important species and cause damage to other species and the coral reef itself.

Poison fishing is used to stun fish that are subsequently caught for the live fish food trade. Other fish and corals are affected, and repeated applications of cyanide may cause coral death. Blast fishing uses explosives to kill fish, which are subsequently harvested. However, the process causes severe damage to reefs, and can kill up to 80% of coral in the area.

2.6 Physical Impact from SCUBA diving and Snorkelling Activity

The tourism industry has grown significantly over the past decade, resulting in development of new resorts to cater for the increasing numbers of tourists visiting the islands each year. With the increase of numbers of tourists on these islands, recreational activities such as SCUBA diving and snorkelling have also been gaining popularity.

The increasing number of new and inexperienced divers and snorkelers has been identified as one of the threats causing physical damage to the coral reefs around these areas.

2.7 Status of Threats to Reef Corals

In 2008, the International Union for the Conservation of Nature (IUCN), with the assistance of Reef Check, organized a review of the threats to reef building corals. As a result all hard corals were listed on the IUCN Red List with a high percentage considered threatened (Carpenter *et al.* 2008).

3. Survey Methodology and Sites

Coral reefs are complex ecosystems. Changes to one part of the ecosystem (e.g. over fishing of a particular species for food) can have a significant impact on other parts (e.g. growth of reef-smothering algae), resulting in damage to the entire ecosystem.

3.1 Reef Check Survey Methodology

Reef Check surveys are based on the philosophy of "Indicator Species". These are marine organisms that:

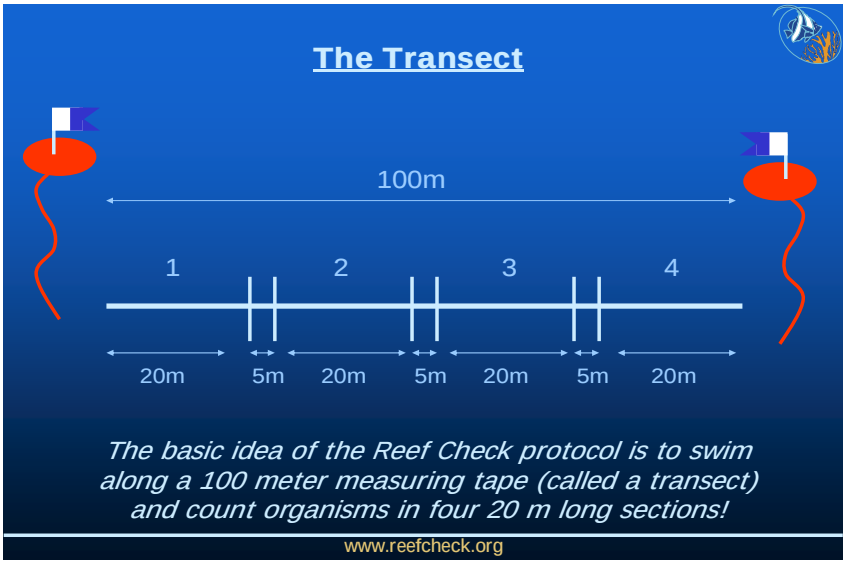
- are widely distributed on coral reefs
- are easy for non-scientists to identify
- provide information about the health of a coral reef.

Using a standardized methodology, data from surveys in different sites can be compared, whether it be on an island, regional, national or international basis (see www.reefcheck.org for more details).

The Reef Check monitoring methodology allows scientists and managers to track changes to coral reefs over time. By surveying reefs on a regular basis, deleterious changes can be highlighted early, before they become problems. This gives managers the opportunity to intervene, carry out additional more detailed studies and/or initiate management actions to try to reverse the change before permanent damage is done to the reef.

Reef Check surveys are conducted along two depth contours (3 m to 6 m and 6 m to 12 m depth). A 100 m transect line is deployed and along it four 20 m transects are surveyed, each separated by 5m, which provides four replicates per transect (8 per complete survey) for statistical analysis (see Figure 1).

Figure 1: The Transect



Four types of data are collected:

- the first is the fish survey which is carried out by swimming slowly along the transect line counting the indicator fish within each of the four 20 m long x 5 m wide x 5 m high corridors
- second is the invertebrate survey during which divers count the indicator invertebrates along the same four 20 m x 5 m belts
- an impact survey involves the assessment of damage to coral from bleaching, anchoring, destructive fishing, corallivores such as *Drupella* snails or crown-of-thorns starfish, and trash.
- data on the substrate is collected by the Point Intercept method whereby the substrate category such as live coral is noted every 0.5 m

3.2 Survey Sites

During 2010, a total of 93 surveys were completed, 46 in Peninsular Malaysia (2009: 50) and 47 in East Malaysia (2009: 65):

- In Peninsular Malaysia, some 75% of sites surveyed in 2009 have been re-visited in 2010, and some new sites were added

- In East Malaysia, the 2009 Expedisi Perdana (a collaboration between a number of universities and government departments) visited a large number of previously un-surveyed, remote sites. These have not been revisited this year due to lack of resources and manpower, so a number of sites remain un-surveyed, and the total number of surveys for East Malaysia is lower for 2010.

In Peninsular Malaysia, the surveys conducted at sites around the five main islands off the East coast (Aur, Perhentian, Redang, Tenggol and Tioman) were carried out as a continuation of the monitoring programme started in 2007. New sites on the islands of Kapas, Bidong and Yu were added into the survey programme this year as an extension of RCM's effort to cover more sites around Malaysia.

In East Malaysia, a large percentage of the surveys were conducted together with a number of dive operators, notably in Lankayan, Mataking and Kapalai in Sabah as well as Miri, in Sarawak. This is one of the successful stories of getting local stakeholders, especially dive operators and local community, to be involved in monitoring and management of their own local reefs.

The list of sites at which Reef Check surveys have been conducted over the last four years is shown in Appendix 1.

4. 2010 Survey Results and Analysis

This section presents the results of Reef Check surveys carried out during 2010. Although 46 sites were surveyed in Peninsular Malaysia, data is only available for 20 sites, due to data loss. Data from 47 sites in East Malaysia is also analysed below.

As this is the fourth year of an on-going, extensive survey programme, many sites were repeated from previous years. However, new sites are still being added to the list of sites surveyed as part of the overall initiative to monitor the reefs around Malaysia more extensively.

4.1 Status of Coral Reefs in Malaysia

In this section, the results from all 67 surveys for which data are available have been compiled to provide an overview of the status of coral reefs for the whole of Malaysia. Many of these sites are popular dive sites which are frequently visited by divers and snorkelers. However, there are still many areas, especially off the coasts of Sabah, which are unexplored, but are facing threats from destructive fishing methods such as fish bombing.

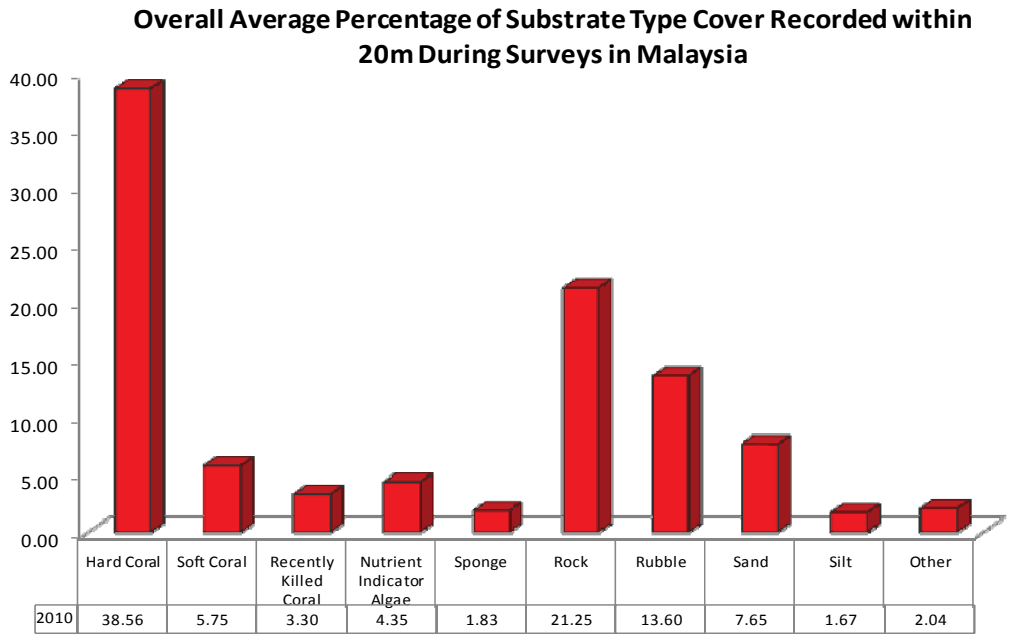
4.1.1 Substrate

The table below shows the Coral Reef Health Criteria developed by Chou *et al*, 1994.

Percentage of live coral cover	Rating
0-25	Poor
26-50	Fair
51-75	Good
76-100	Excellent

According to these criteria, the general condition of Malaysia's coral reefs is categorised as "fair", based on the average live coral cover (Hard Coral + Soft Coral) from all the surveys of 44.31%, (see chart 1).

Chart 1: Substrate Cover – Malaysia



2010 saw a mass coral bleaching event that affected coral reefs in the whole of South East Asia. The percentage of Recently Killed Coral (RKC) detected by the surveys was still low at 3.3%, indicating that damage to reefs in the last year due to natural or human factors was relatively low. However, a large proportion of the surveys were conducted before the full effects of the bleaching event were felt, and it is likely that post-bleaching surveys (to be conducted in 2011) will show a higher level of RKC.

The percentage of Rock is relatively high (over 21%), a large proportion of which is old dead corals. This is considered to be an acceptable level, given that most of the reefs surveyed are in areas affected by monsoon and strong waves during certain times of the year.

It is also encouraging that the average level of Nutrient Indicator Algae (NIA) is relatively low at 4.35%, although it has increased 0.6% from 2009. It is important to continue to monitor NIA levels as a continuous trend of increasing NIA coverage would indicate a consistent increasing influx of nutrients into the water, which in turn can lead to a proliferation of algae to a level that is above the ability of herbivorous organisms to keep it in check. This results in algae smothering and killing corals, and reduces the surface for potential recruitment of new corals on rock and old dead corals, hindering the recovery of reefs over time.

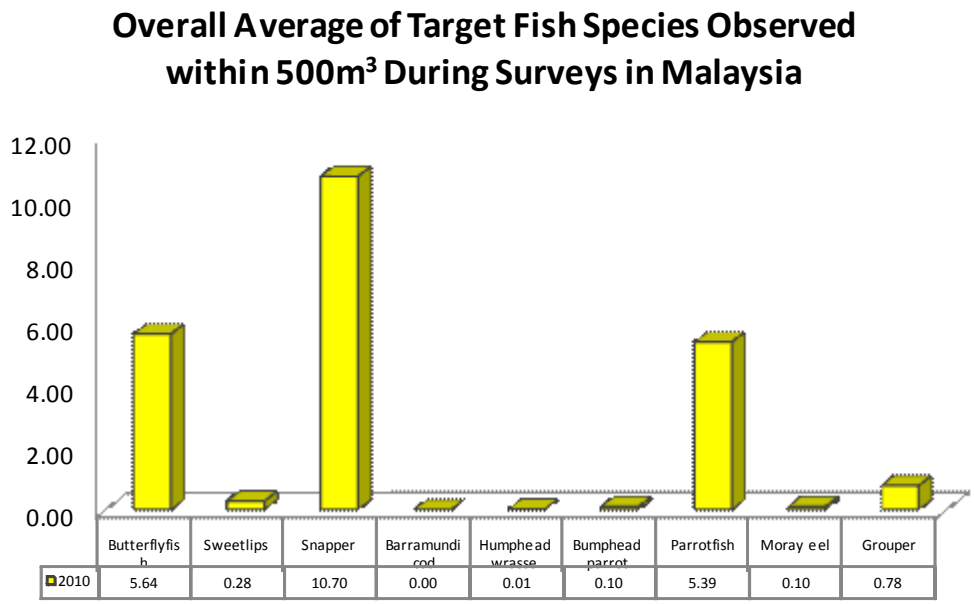
Even though the average live coral cover of the reefs from the surveys indicates that the reefs in Malaysia are in “fair” condition, there is still room for improvement. A range of issues such as development, sedimentation, pollution and tourist activities need to be managed so that impacts on coral reefs are minimised, creating the conditions for improvements in the future.

Furthermore, as most of the survey sites are easily accessible dive sites, many other unexplored sites around Malaysia need to be surveyed to provide a better overall picture of the condition of reefs in Malaysia.

4.1.2 Fish

The abundance of indicator fish counted during the surveys is shown in Chart 2 below.

Chart 2: Fish Abundance - Malaysia



One criterion used to select Reef Check indicator fish species is their desirability for various types of fishing. Abundance of those varieties that are targeted for the food trade is low in most of the areas where surveys have been conducted. These include groupers and parrotfish, of which only adult-sized fish are counted during the survey (over 30cm and 20cm long respectively). The low figure of less than 1 grouper observed per 20 m long replicate transect (500 m^3 of water volume surveyed) indicates heavy fishing pressure for such fish.

The numbers of prized fish such as Barramundi cod, Sweetlips and Humphead wrasse were also very low and rarely sighted, with the Barramundi cod only spotted once in all the 67 surveys.

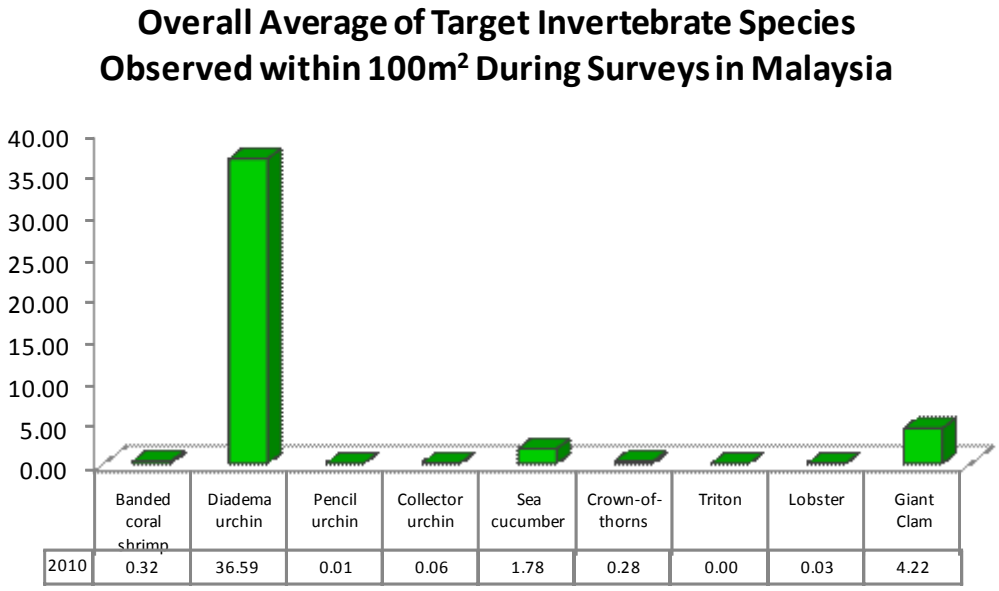
In particular, the high value of a single large Humphead wrasse (which can be worth up to US$ 10,000 on live fish markets), results in targeted fishing effort for this particular species. Greater enforcement of Marine Park regulations will be necessary to aid recovery of populations of this iconic species, and on-going monitoring will help to track recovery in populations.

On a more positive note, the presence of butterflyfish and parrotfish in most survey sites is a good indication that there is low collection pressure for these fish, a popular item in the aquarium (butterflyfish) and food (parrotfish) trades. Furthermore, the high numbers of butterflyfish at some survey sites also reflects the fairly healthy status of reefs around Malaysia, as they thrive on reefs with healthy corals, feeding mainly on coral polyps. Parrotfish will also act as a control for any algae proliferation as they are herbivores.

4.1.3 Invertebrates

The invertebrate indicators have been selected on the basis either that they are high-value target organisms for fishing and/or collection, or indicators of an imbalance of, for example, nutrients in the water. Highly sought after invertebrates such as collector urchin, triton shell, lobster and pencil urchin were largely absent from all the surveys we have conducted (see chart 3). These invertebrates are prized either as food, as decorative "curio" pieces at home or for the aquarium trade. Older fishermen in survey areas tell stories of previously high numbers of lobster on some reefs now being substantially depleted due to over-harvesting.

Chart 3: Invertebrate Abundance - Malaysia



The abundance of long-spined sea urchins *(Diadema sp.)* at some sites, particularly Tioman Island (see section 4.2.3) and a few sites in Sabah, is a concern. When the reef ecosystem is in balance, the numbers of *Diadema* urchins, in combination with herbivorous fish, keep algal growth in check. However, these urchins can reproduce rapidly in conditions in which their main food source (micro- and macroalgae, which proliferate in nutrient rich water) is abundant. Thus, high or increasing numbers of *Diadema* could indicate above normal levels of nutrient, causing algae to grow.

High numbers of *Diadema* can cause a particular problem. The spines which the urchins use to move scrape living corals as they move over the surface of the reef. Very high numbers of *Diadema* can damage the reef structure, degrading the reef if the bioerosion rate exceeds the rate of coral growth. Having a balance of *Diadema* and herbivorous fish such as parrotfish, surgeonfish and rabbitfish is important as a control for algal growth. Even with this balance, the fertilizing effect of nutrient pollution is something that needs to be addressed to prevent further degradation of reefs from algal proliferation.

Crown-of-thorns starfish (COT) feed on corals and can cause significant damage to coral reefs, destroying large areas in a short period of time. According to CRC Reef Research Centre (Australia), a healthy coral reef can support a population of 20-30 COT per hectare (10,000m^2), or 0.2-0.3 per 100m^2. The abundance of COTs found during surveys (0.28 per 100m^2)is within this range, suggesting that COT numbers are within acceptable limits. On some of the islands off the East coast of Peninsular Malaysia, considerable efforts have been made by Marine Park authorities and local dive centres to control COT numbers by organising COT removal activities to reduce the threat posed by these creatures. Continued monitoring is essential to prevent significant outbreaks of this dangerous coral predator.

4.2 Status of Coral Reefs in Peninsular Malaysia

The results below summarise the health of coral reefs on the islands surveyed off the East coast of Peninsular Malaysia. The results highlight the different problems each island is facing.

4.2.1 Substrate

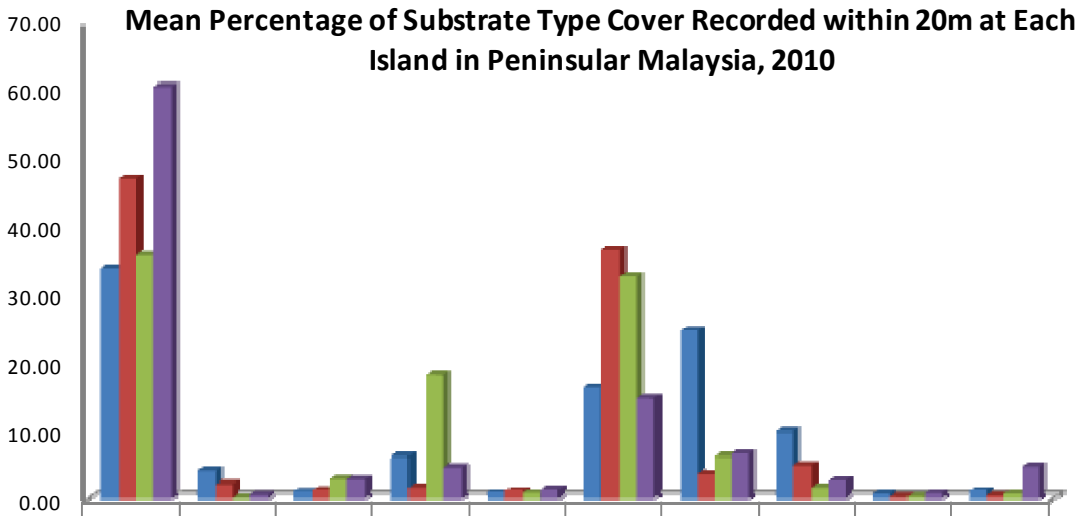
The results from the surveys show that Tioman has the highest LCC (61%), which is "good" under the Coral Reef Health Criteria described earlier. The other three islands are in the "fair" category, with Kapas Island having 49.2%, Aur Island, 38.1% and Perhentian with 35.9% of Live Coral Cover. All these islands have reefs mainly consisting of hard corals and they provide a healthy reef system as the hard structure, with holes and crevices, provides habitat for many reef organisms.

Sites in Kapas and the Perhentian Islands have a significantly higher Rock cover at 36.6% and 32.7% respectively. As some survey sites are more rocky in nature than others, these percentages only show part of the picture of the condition of the reefs. However, observations during surveys clearly show some sites have been damaged by diving activities as well as strong waves during monsoon.

With high Rock cover on all islands providing a suitable platform for new corals to attach to and grow on, recovery of reefs will be possible with effective management and proper enforcement to protect these islands.

The very high level of Rubble at sites around Pulau Aur (24.7%, compared to an average of 5% on other islands) is a cause for concern and should be investigated. Anecdotal observations show that trawling and poorly supervised diving activities are the main causes of the damage. Both of these impacts can be reduced through improved management interventions.

Chart 4: Substrate Cover – Peninsular Malaysia



	Hard Coral	Soft Coral	Recently Killed Coral	Nutrient Indicator Algae	Sponge	Rock	Rubble	Sand	Silt	Other
Aur Island	33.91	4.22	1.25	6.25	1.09	16.41	24.69	10.00	0.78	1.41
Kapas Island	46.88	2.34	1.41	1.88	1.41	36.56	3.75	5.00	0.31	0.47
Perhentian Island	35.78	0.16	2.97	18.28	0.94	32.66	6.25	1.88	0.31	0.78
Tioman Island	60.47	0.55	2.89	4.69	1.56	14.69	6.64	2.81	0.86	4.84

On a more worrying note, the level of Nutrient Indicator Algae (NIA) in Perhentian is significantly higher than other islands, with over 18% cover. This is an increase of 8% from the previous year which only had 10% NIA cover. The proliferation of these algae is likely to be caused by an influx of nutrients into the water. Anecdotal observations suggest that one source of nutrient is from resorts, as most of the resort operations are small scale and do not have properly maintained sewage systems. These observations are supported by the results of water quality testing in Perhentian in 2009, which indicate the presence of fecal coliforms in water samples from the island. Nutrients from soil flowing into the water as a result of land-clearing activities is also a likely cause for such increase in algal growth.

The high levels of NIA on these islands needs to be kept in check as further proliferation could result in corals being smothered by algae. This will not only kill the corals due to competition for space and sunlight, but will also reduce the amount of suitable surface for new coral recruitment. This is an issue that needs to be addressed jointly by Marine Park management, resort operators and state governments.

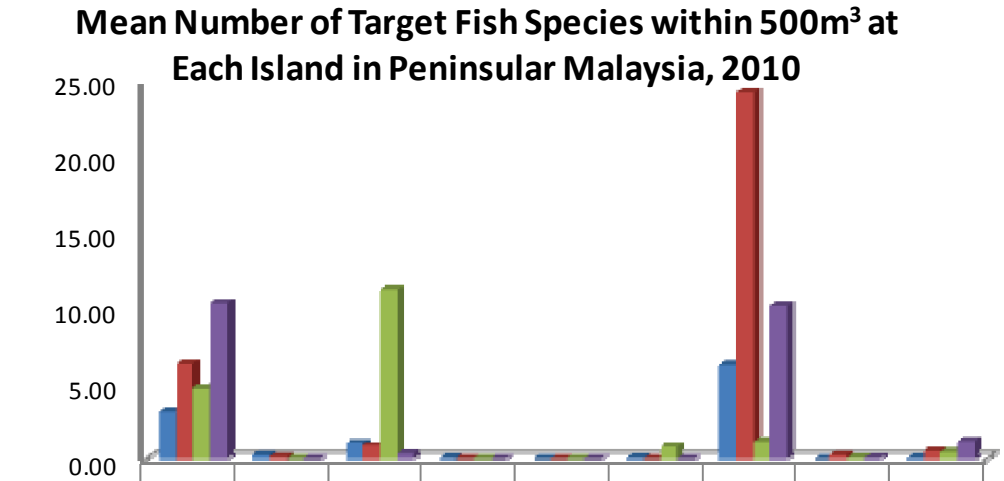
4.2.2 Fish

Abundance of most fish indicators is low, particularly for prized food fish such as Sweetlips, Barramundi cod and Humphead wrasse (see chart 5).

Other food fish, such as grouper, were observed less than once within a survey area at all islands, except for Tioman Island. This is an indication that these fish may have been overfished, especially before the islands were gazetted as Marine Parks. However, observations during the surveys noted the presence of many juvenile groupers (<30cm) at most sites. This suggests that the fish population is recovering and with proper enforcement, there is a chance for the population to fully recover. This can be seen in Tioman where in previous years, many juvenile groupers were observed during surveys and the adult-sized groupers are now recorded during the surveys this year.

Another type of fish which is sought after for food is parrotfish. The presence of parrotfish is important as these fish are part of the mechanism for controlling the growth of algae on reefs, the main diet of these fish. Observations from the surveys also show that parrotfish populations have the potential to grow further as many juveniles (<20cm) were observed during the surveys on several islands. As with Groupers, the increase in abundance of parrotfish in Tioman in 2010 compared to previous years is probably due to the growth of juveniles that were observed in previous years. The number of parrotfish in Kapas Island is significantly higher than other islands, and this is due to large schools of parrotfish at two survey sites, a good indication that fishing activities on this island are minimal.

Chart 5: Fish Abundance – Peninsular Malaysia



	Butterflyfish	Sweetlips	Snapper	Barramundi cod	Humphead wrasse	Bumphead parrot	Parrotfish	Moray eel	Grouper
Aur Island	3.13	0.25	1.06	0.06	0.00	0.06	6.25	0.00	0.06
Kapas Island	6.31	0.13	0.88	0.00	0.00	0.00	24.31	0.25	0.50
Perhentian Island	4.75	0.00	11.19	0.00	0.00	0.75	1.19	0.06	0.44
Tioman Island	10.31	0.00	0.34	0.00	0.00	0.00	10.16	0.06	1.22

4.2.3 Invertebrates

Abundance of indicator invertebrates is shown in Chart 6.

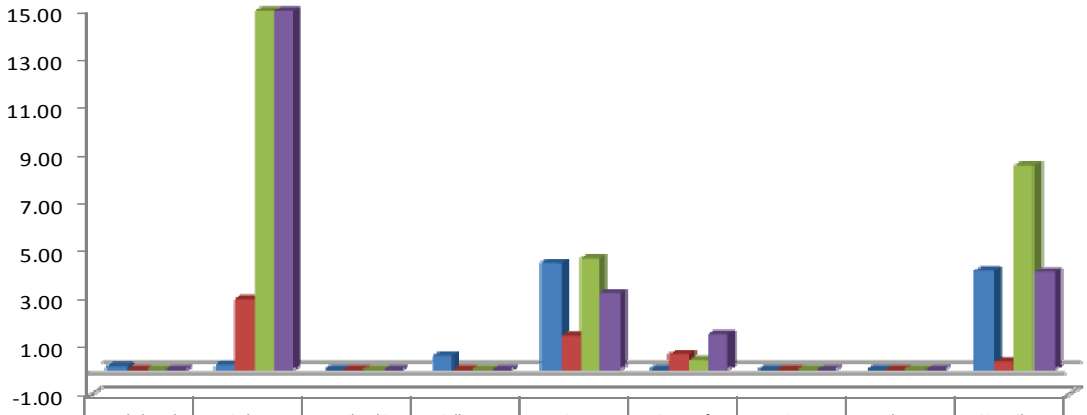
Three invertebrate indicators – Triton shell, pencil urchin and lobster - were totally absent from the surveys conducted over the four islands (see chart 6). Although known to be uncommon around the Peninsula, the small populations previously present could have been over-harvested and it will take a very long time for populations to recover.

The presence of edible sea cucumbers and giant clams on a number of the islands is good news, as it suggests that there has been minimal harvesting for food and curio trade of both types of invertebrates. Continuous monitoring and enforcement should help these populations recover in other islands.

The number of *Diadema* urchins is very high in Tioman and Perhentian compared to the other islands. Although populations could be naturally high in Tioman, this abundance was not recorded in Perhentian previously and is likely to be an indication of nutrient pollution that is in turn causing excessive algal growth, an important food source for these urchins. While these urchins are important to control the amount of algae on the reefs (as reflected in the low NIA cover in Tioman), it is equally important to find solutions to the problems that are causing the pollution in the first place. As mentioned in section 4.2.1, the issue of proper sewage management in resorts needs to be addressed to prevent further degradation of the reefs around Malaysia caused by proliferation of algae.

Chart 6: Invertebrate Abundance – Peninsular Malaysia

Mean Number of Target Invertebrate Species within 100m² at Each Island in Peninsular Malaysia, 2010



	Banded coral shrimp	Diadema urchin	Pencil urchin	Collector urchin	Sea cucumber	Crown-of-thorns	Triton	Lobster	Giant Clam
Aur Island	0.13	0.19	0.00	0.56	4.44	0.00	0.00	0.00	4.13
Kapas Island	0.00	2.94	0.00	0.00	1.38	0.63	0.00	0.00	0.31
Perhentian Island	0.00	72.63	0.00	0.00	4.63	0.38	0.00	0.00	8.50
Tioman Island	0.00	90.88	0.00	0.00	3.19	1.44	0.00	0.00	4.06

4.3 Status of Coral Reefs in East Malaysia

The 47 surveys conducted in East Malaysia are divided into five areas: Miri, Lankayan, Pulau Gaya, Kapalai and Mataking. Most surveys were conducted in Miri and Lankayan.

4.3.1 Substrate

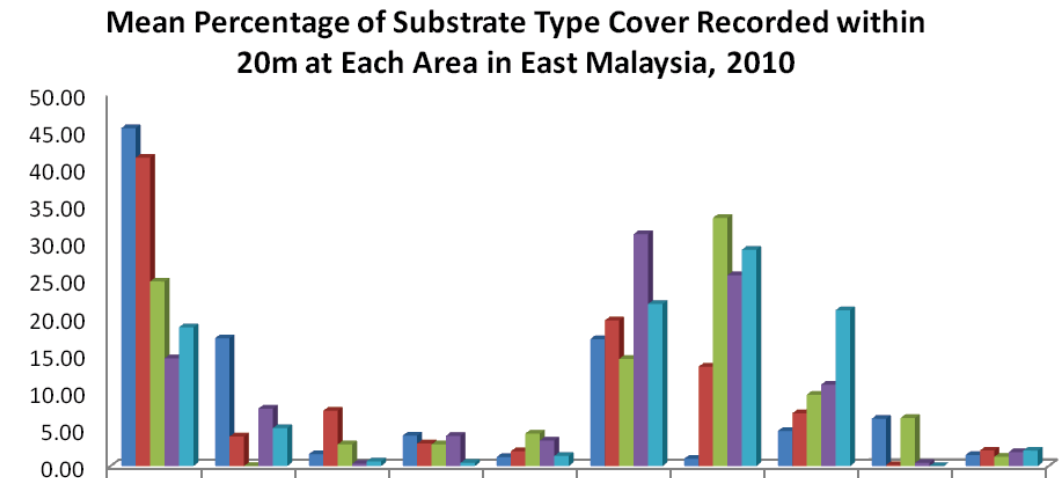
According to the survey results, only the reefs around the Miri area are categorised as "good", under the Coral Reef Health Criteria, with total LCC of 62.5% (see chart 7). Reefs around Lankayan are in "fair" condition, with LCC over 45%. Reefs around Pulau Gaya, Kapalai and Mataking are categorised as "poor" with LCC below 25%.

The very high percentage of Rubble (RB) in Pulau Gaya and some sites in Kapalai and Mataking is a cause for concern as these are areas where fish bombing activities have been reported (though this is largely historical in the case of Pulau Gaya). The issue of destructive fishing is not new to Sabah waters and can be seen in these areas, and to a lesser extent around Lankayan, which has 13% RB cover. This compares to less than 1% in Miri, where fish bombing is less common. Action to reduce fish bombing is required.

Several sites around Lankayan also recorded over 15% of Recently Killed Corals (RKC), which was mainly caused by predation from the Crown-of-thorns Starfish. Continuous efforts to control these predators are necessary to reduce the damage from these predators.

As mentioned previously, the levels of Rock (RC) at all five areas are consistent with providing good solid surfaces for new coral recruitment in the future, contributing to reef regeneration.

Chart 7: Substrate Cover – East Malaysia



	Hard Coral	Soft Coral	Recently Killed Coral	Nutrient Indicator Algae	Sponge	Rock	Rubble	Sand	Silt	Other
Miri	45.40	17.17	1.59	4.09	1.19	17.04	0.97	4.72	6.36	1.48
Lankayan	41.42	3.96	7.43	3.02	1.98	19.55	13.33	7.08	0.14	2.08
Pulau Gaya	24.79	0.00	2.92	2.92	4.37	14.38	33.33	9.58	6.46	1.25
Kapalai	14.48	7.71	0.31	4.06	3.44	31.14	25.62	10.94	0.42	1.88
Mataking	18.65	5.10	0.63	0.42	1.36	21.77	29.06	20.94	0.00	2.08

The level of silt recorded in the reefs around Miri and Pulau Gaya also needs to be monitored to track changes in siltation. Additional silt and sediment load will reduce sunlight penetration to coral, resulting in poor coral health that can lead to mortality. Thick layers of silt on rocks and other hard surfaces will also prevent new coral recruitment. Therefore, it is very important to find the cause of silting and, where possible, reduce silt load on these reefs before it damages more corals, particularly around Miri where the reefs are still in quite good condition.

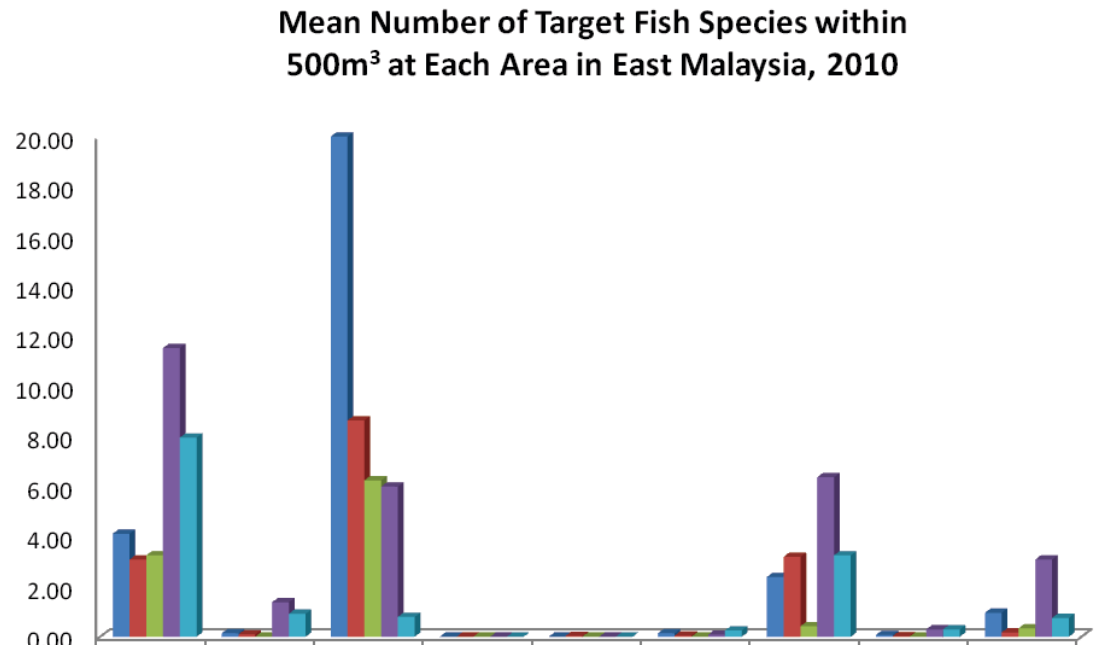
4.3.2 Fish

The survey results show that most of the food fish that are highly sought after such as Sweetlips, Barramundi cod, Humphead wrasse, groupers and the large Bumphead parrotfish were rare or absent during most of the surveys in all the islands (see chart 8).

On a more positive note, sites around Kapalai and Mataking have higher abundance and diversity of fish, having the widest range of indicator species found during the surveys. Groupers, which are popular on local fish markets, were observed in very low numbers in Lankayan and Pulau Gaya, with less than 2 fish sighted in one whole survey. The number of groupers is higher around Miri, Kapalai and Mataking Semporna, with average sightings of about 4 groupers per survey in places. This is surprising, since both Lankayan and Pulau Gaya are within marine protected areas, but the other sites are not, suggesting that enforcement needs to be stepped up in the former areas.

The numbers of butterflyfish recorded during the surveys within all five areas were high compared to most other indicator species. This suggests a minimal impact on these fish from fishing activities for the aquarium trade. The abundance of snappers, another food fish, especially in the Miri area, is a good indication that fishing pressure is low around the reefs there.

Chart 8: Fish Abundance – East Malaysia



	Butterflyfish	Sweetlips	Snapper	Barramundi cod	Humphead wrasse	Bumphead parrot	Parrotfish	Moray eel	Grouper
Miri	4.11	0.14	37.52	0.00	0.00	0.14	2.39	0.07	0.95
Lankayan	3.08	0.09	8.65	0.00	0.03	0.05	3.19	0.02	0.17
Pulau Gaya	3.25	0.00	6.25	0.00	0.00	0.00	0.42	0.00	0.33
Kapalai	11.54	1.38	6.00	0.00	0.00	0.08	6.38	0.29	3.08
Mataking	7.96	0.92	0.79	0.00	0.00	0.25	3.25	0.29	0.75

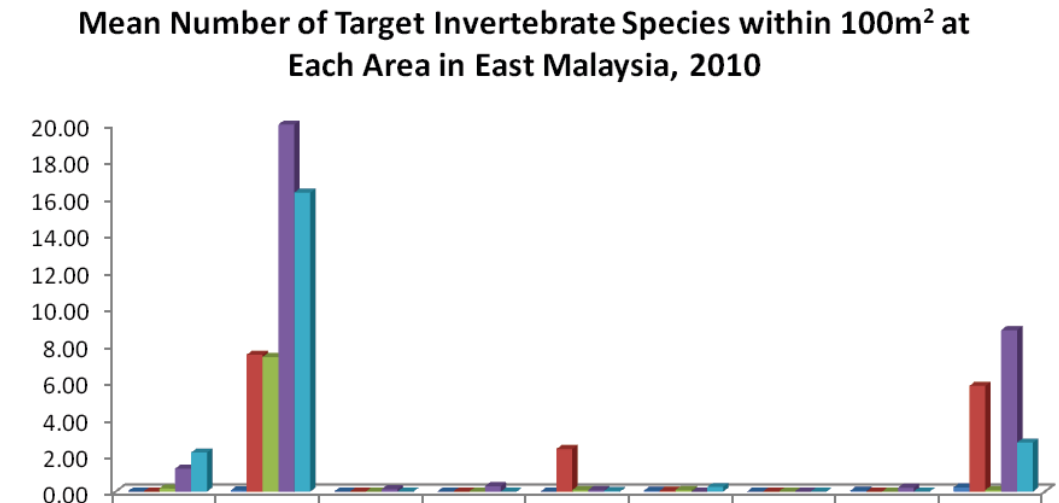
The surveys also show the presence of parrotfish equally distributed in all areas except for Pulau Gaya. It is important to track changes to these numbers to ensure the parrotfish populations are not in decline, as they play a significant role in controlling algal growth through their dietary pattern. There is a need for continuous enforcement to prevent further degradation of fish population around these areas.

4.3.3 Invertebrates

Data from surveys in East Malaysia show that numbers of those invertebrates that are highly sought after for the aquarium trade (such as Banded coral shrimp, pencil urchin, collector urchin and triton shells) are low although some were observed around Kapalai. While these invertebrates might naturally occur in low numbers, the very low abundance or total absence of some of these species suggests that some harvesting has been practised in the past, with populations now so low as to hinder recovery.

The high numbers of *Diadema* urchins in Kapalai and Mataking is a cause for concern as their presence in large numbers indicates some nutrient pollution in the water. These urchins usually grow in abundance in areas where there is a high cover of algae, which is found in nutrient-rich waters. A continuous monitoring programme is needed to keep check on these urchins and the pollution in the water to avoid damage on these reefs due to bioerosion from these urchins as well as smothering of corals by algal proliferation.

Chart 9: Invertebrate Abundance – East Malaysia



	Banded coral shrimp	Diadema urchin	Pencil urchin	Collector urchin	Sea cucumber	Crown-of-thorns	Triton	Lobster	Giant Clam
Miri	0.00	0.07	0.00	0.00	0.00	0.05	0.00	0.05	0.23
Lankayan	0.00	7.45	0.00	0.00	2.32	0.05	0.00	0.00	5.76
Pulau Gaya	0.17	7.33	0.00	0.00	0.08	0.08	0.00	0.00	0.08
Kapalai	1.25	189.54	0.13	0.29	0.08	0.00	0.00	0.21	8.79
Mataking	2.13	16.29	0.00	0.00	0.04	0.25	0.00	0.00	2.67

4.4 Comparison between Peninsular Malaysia and East Malaysia

This section compares the results of surveys conducted in Peninsular Malaysia and East Malaysia and identifies some key differences between the two areas.

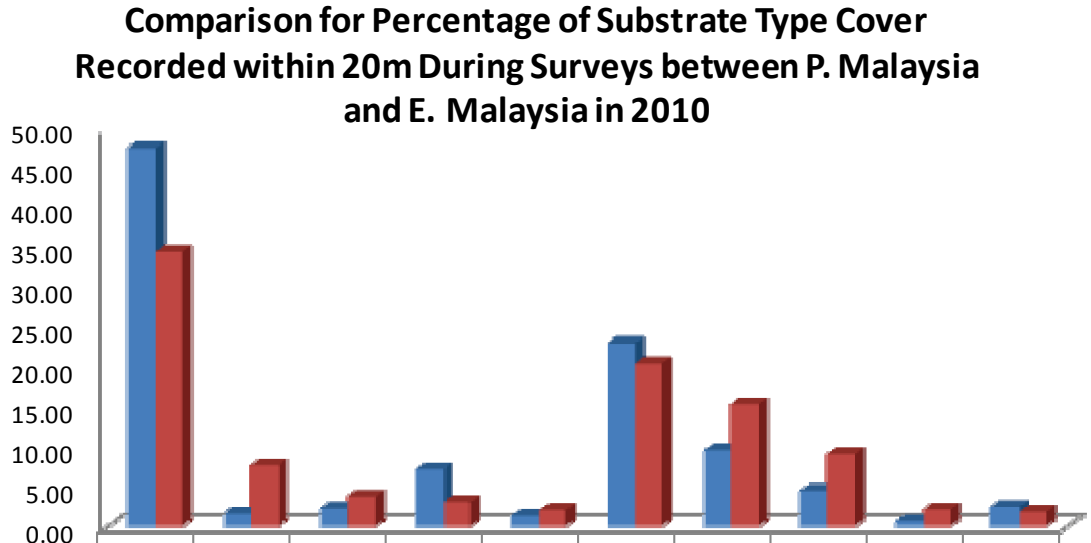
4.2.1 Substrate

According to the Coral Reef Health Criteria, the reefs around the islands off the East coast of Peninsular Malaysia and in East Malaysia are, on average, in "fair" condition, with an average Live Coral Cover (Hard Coral + Soft Coral) of 49.1% (see chart 10) and 42.2% respectively.

The high percentage of Rock cover in both areas is a healthy indication as it can facilitate new coral growth by providing a suitable surface for coral recruitment, providing levels of silt and NIA are controlled. Reefs around Peninsular Malaysia have a higher percentage of Rock at 23% (though much of this is accounted for at Kapas and Perhentian), while the reefs around East Malaysia have 20.5% Rock cover. The high percentage of Rubble on the reefs around East Malaysia is likely to be a result of fish bombing activities in the past, especially in Pulau Gaya, Kapalai and Mataking.

The average cover of Nutrient Indicator Algae (NIA) in Peninsular Malaysia is relatively high compared to East Malaysia, at 7.2% and 3.8% respectively. This is probably due to the higher density of resorts on the islands off the East coast of Peninsular Malaysia, where the tourism industry is more developed than in many parts of East Malaysia. The high number of resorts and tourists visiting the islands could have led to the influx of nutrients into the sea – through sewage and fertilisers used for landscaping.

Chart 10: Substrate Cover – Peninsular vs. East Malaysia



	Hard Coral	Soft Coral	Recently Killed Coral	Nutrient Indicator Algae	Sponge	Rock	Rubble	Sand	Silt	Other
Pen Mal	47.50	1.56	2.28	7.16	1.31	23.00	9.59	4.50	0.62	2.47
East Mal	34.50	7.66	3.76	3.07	2.06	20.45	15.43	9.08	2.14	1.85

Recently Killed Coral (RKC) results from a variety of factors, including bleaching, disease and COT predation. The percentage of Recently Killed Corals (RKC), which is higher in East Malaysia, can be a cause for concern as a continuous threat such as COT predation needs to be addressed as soon as possible to reduce the damage caused. Another cause for concern will be the relatively higher percentage of silt recorded in East Malaysia during the surveys.

4.2.2 Fish

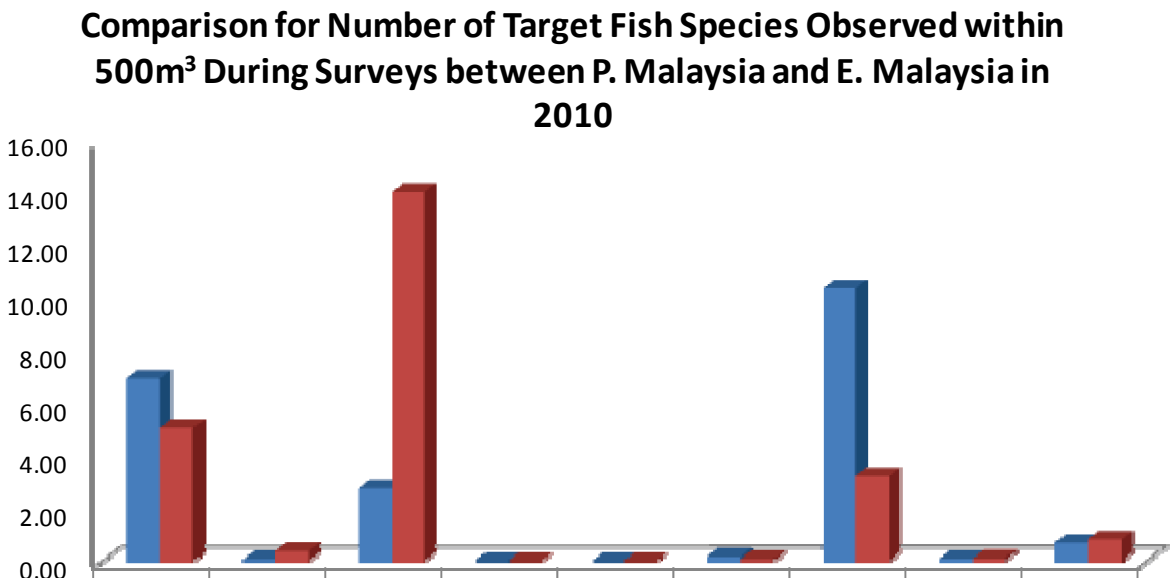
The diversity of fish observed during the surveys is similar in both Peninsular Malaysia and East Malaysia (see chart 11) and both have one indicator species not recorded at all during the surveys – Humphead wrasse in Peninsular and Barramundi cod in East Malaysia.

The rarity of prized-food fish such as Sweetlips, Barramundi cod and Humphead wrasse in both Peninsular and East Malaysia suggests that these fish have been over-harvested for the fish trade in both areas. The other food fish low in abundance is groupers, which were observed less than 4 in one survey. The higher abundance of parrotfish in Peninsular Malaysia acts as a good control to keep algal growth in check within the area.

Anecdotal observations suggest that the main cause for this is the higher number of people in East Malaysia who live in coastal areas and rely fully on fishing activities for their livelihood. Many of these fishermen are still practicing destructive fishing method such as fish bombing and poison fishing, resulting in damage to large areas of reef (up to 66% reported by managers at Mataking Island Resort) as well as removal of large amounts of fish.

The abundance of snappers on reefs in East Malaysia may be a result of the different fishing pressure applied by fishermen there. As mentioned previously, destructive fishing methods focus more on reef-dwelling fish rather than snappers, which are found above the reef structure.

Chart 11: Fish Abundance – Peninsular vs. East Malaysia



	Butterflyfish	Sweetlips	Snapper	Barramundi cod	Humphead wrasse	Bumphead parrot	Parrotfish	Moray eel	Grouper
Pen Mal	6.96	0.08	2.76	0.01	0.00	0.16	10.41	0.09	0.69
East Mal	5.08	0.37	14.07	0.00	0.02	0.07	3.25	0.10	0.81

4.2.3 Invertebrates

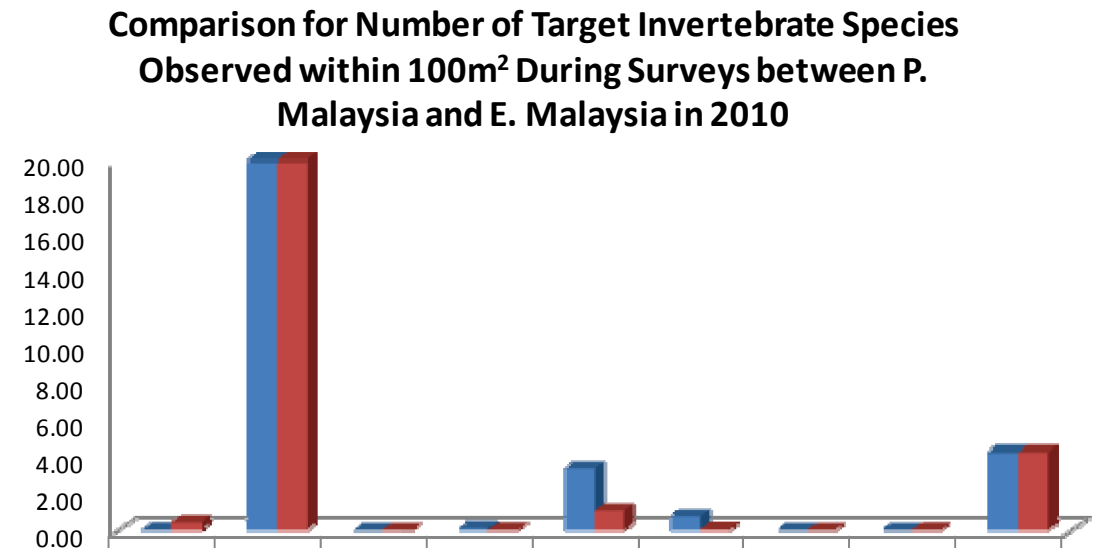
Diversity of invertebrates observed is higher in East Malaysia than Peninsular Malaysia (see chart 12). Invertebrates such as pencil urchins, triton shell and lobster, which are highly sought after for the aquarium and curio trade as well as for food, were absent from all the surveys conducted in Peninsular Malaysia. Although known to be uncommon in some of these areas, the rarity of these invertebrates suggests that small populations may have been affected by previous over-harvesting activities and are recovering very slowly.

The number of *Diadema* sea urchins in both the Peninsula and East Malaysia is relatively high compared to the other invertebrates. While their presence (together with herbivorous fish) is important to control algal growth, their number should be monitored as an increase could indicate nutrient pollution.

The number of edible sea cucumbers, an indicator of harvesting activities, was higher in Peninsular Malaysia than in East Malaysia. The number of giant clams observed was similar both in Peninsular and East Malaysia. Edible sea cucumbers are usually harvested for food and medicinal purposes while giant clams are harvested for food as well as for their shells which are sold as decorations.

The number of COTs recorded is relatively low in both areas, and credit should be given to relevant authorities and dive operators who have been organising COT removal programmes throughout the year. It is important to continue monitoring this predator as an outbreak can cause massive damage to the coral reefs.

Chart 12: Invertebrate Abundance – Peninsular vs. East Malaysia



	Banded coral shrimp	Diadema urchin	Pencil urchin	Collector urchin	Sea cucumber	Crown-of-thorns	Triton	Lobster	Giant Clam
Pen Mal	0.03	51.50	0.00	0.11	3.36	0.78	0.00	0.00	4.21
East Mal	0.44	30.25	0.02	0.04	1.10	0.07	0.00	0.04	4.22

4.5 Monitoring Changes to Reefs Over Time

On-going monitoring is an important management tool to track changes to coral reef health. With four years of data for some sites, the results from the 2010 surveys can be compared with data for previous years (for the same sites), to provide an assessment of how coral reefs have changed over the past four years.

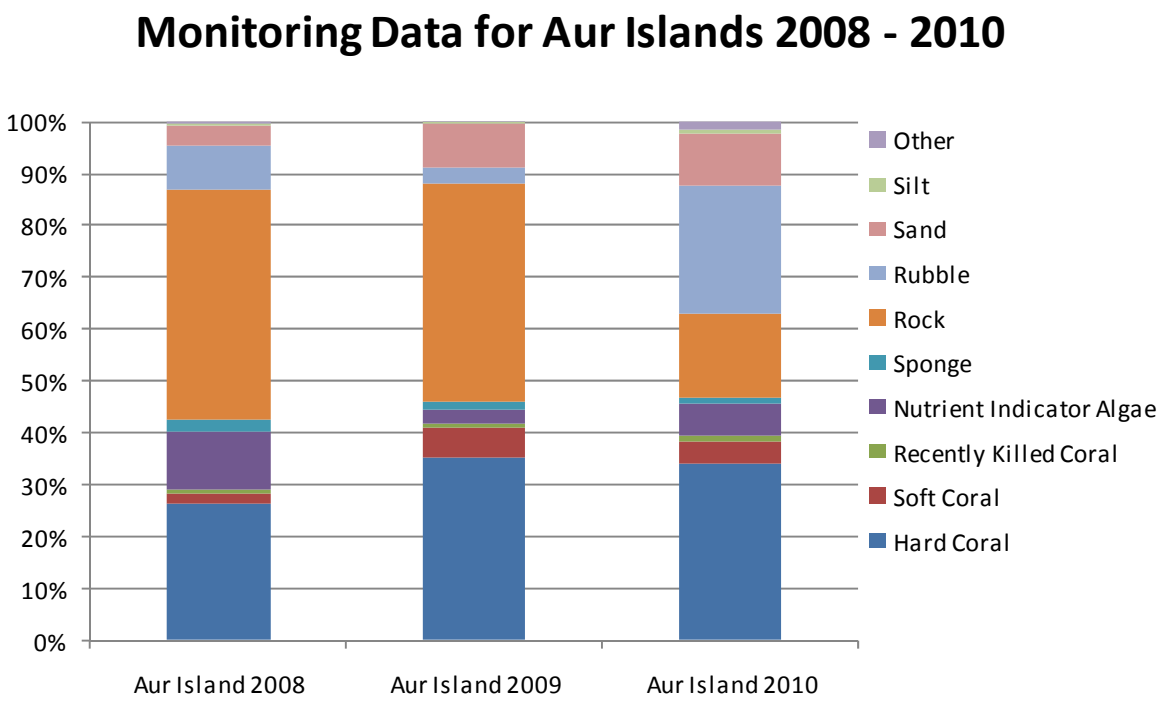
Data for some sites in Perhentian and Tioman are available from 2007-2010 while we have two or three years data for Aur and other areas in East Malaysia.

4.5.1 Aur Islands

Chart 13 below suggests that was a slight decrease of LCC at the reefs on Aur Island between from 2009 and 2010. However, this may not accurately reflect the situation around the island as only two sites at two different depths were surveyed in 2010 due to logistical difficulties.

However, the increase of NIA from 2009 to 2010 and the increase of RB should be noted as these increases can be caused by diver impact (physical damage) as well as influx of nutrient from inadequate sewage management from the resorts on the islands. These are an area of concern for managers.

Chart 13: Monitoring Data – Aur Islands



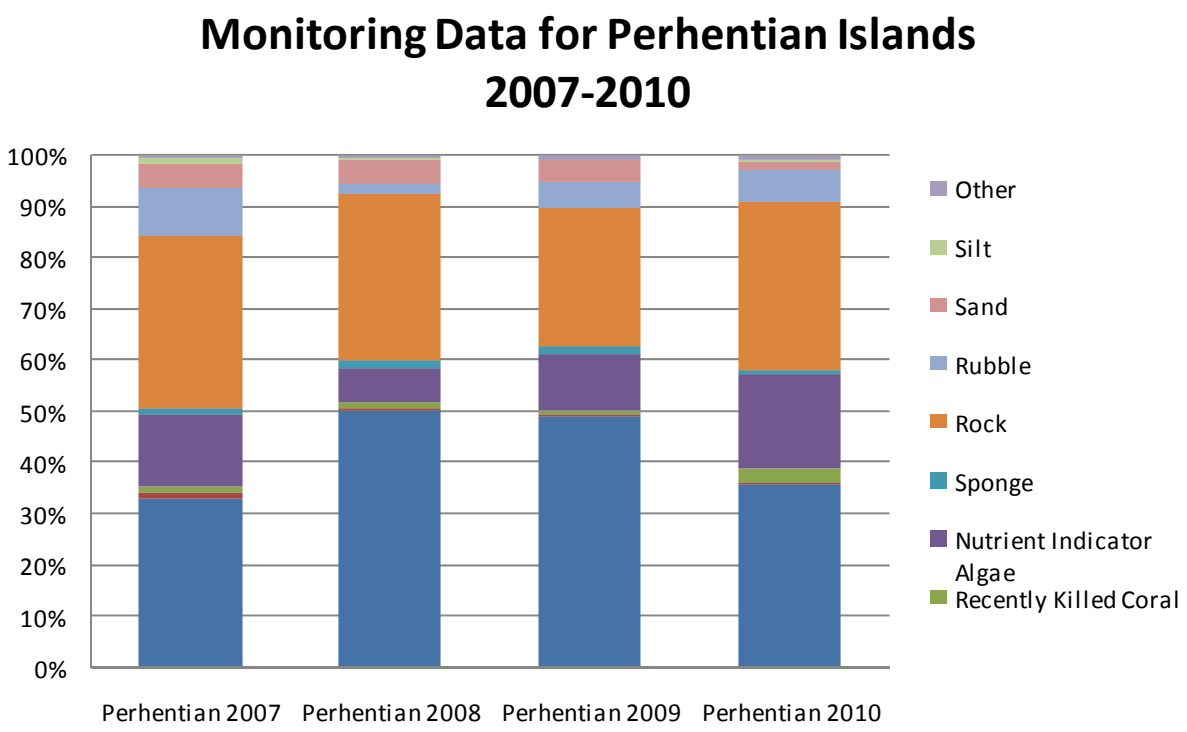
4.5.2 Perhentian Islands

Chart 14 shows a decline of LCC from 2009 of just under 50% to just over 35%% in 2010. However, some of the decline can be attributed to the limited number of surveys conducted in 2010.

It is important to note the significant increase of NIA over 3 years from 6.6% in 2008, to 10.7% in 2009 and 18.3% in 2010. The increase of NIA is likely to be partly a result of increasing amounts of nutrients in the water. This could be from sewage systems that are inadequate and unable to handle the amount of waste produced due to the high numbers of tourists visiting the islands.

Land-clearing from numerous developments over the period could also result in nutrient runoff into the water when it rains.

Chart 14: Monitoring Data – Pulau Perhentian

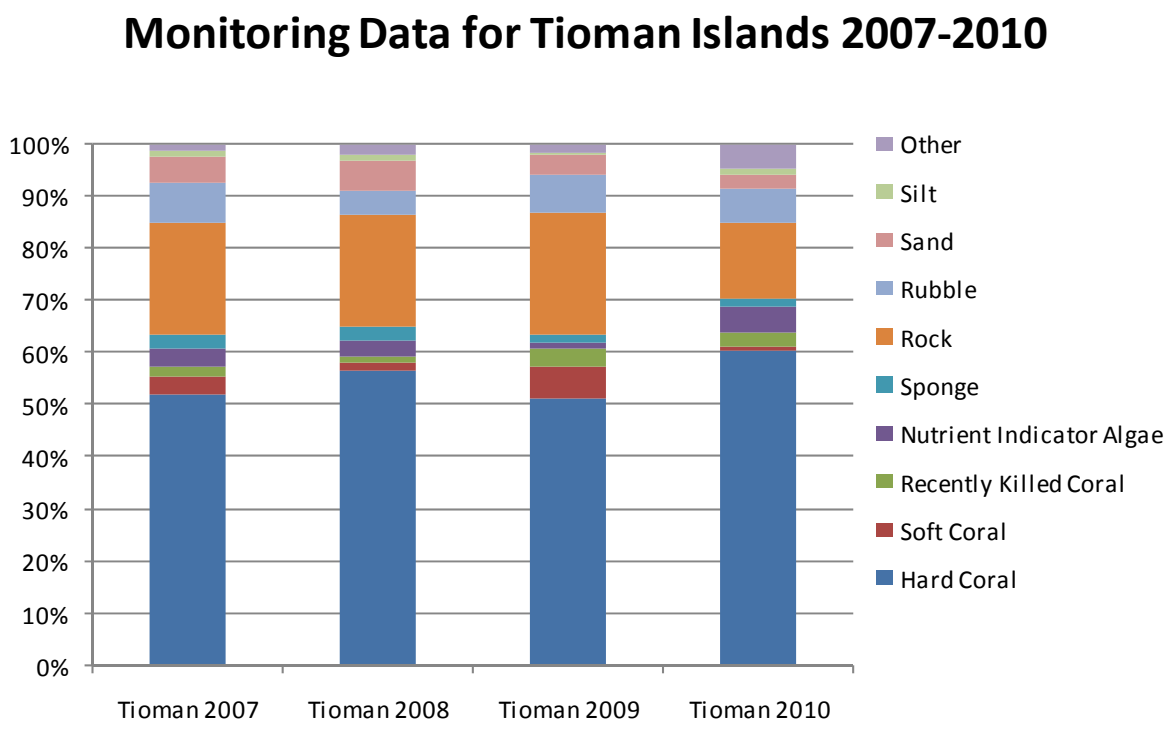


4.5.3 Tioman Islands

The data from the surveys conducted on Tioman over the last four years show that there have been no significant changes over that period of time (see chart 15). The LCC is above 50%, a rating of "good" according to the Coral Reef Health Criteria. There has been a slight increase of Hard Coral cover over the years, with the exception of a slight decline in 2009, probably resulting from the addition of new survey sites. However, the overall condition of coral reefs around Tioman Island has been consistently good over the years, with average LCC above 50%.

There is a need to look into the increase of NIA in 2010 as it was a significant increase from 1.2% in 2009 to 4.7% in 2010. The site of most concern would be in Sepoi, where over 18% NIA was recorded during the survey. This situation needs to be monitored to ensure no continuing proliferation of algae as it could have a negative impact on the corals over a long term period.

Chart 15: Monitoring Data – Pulau Tioman



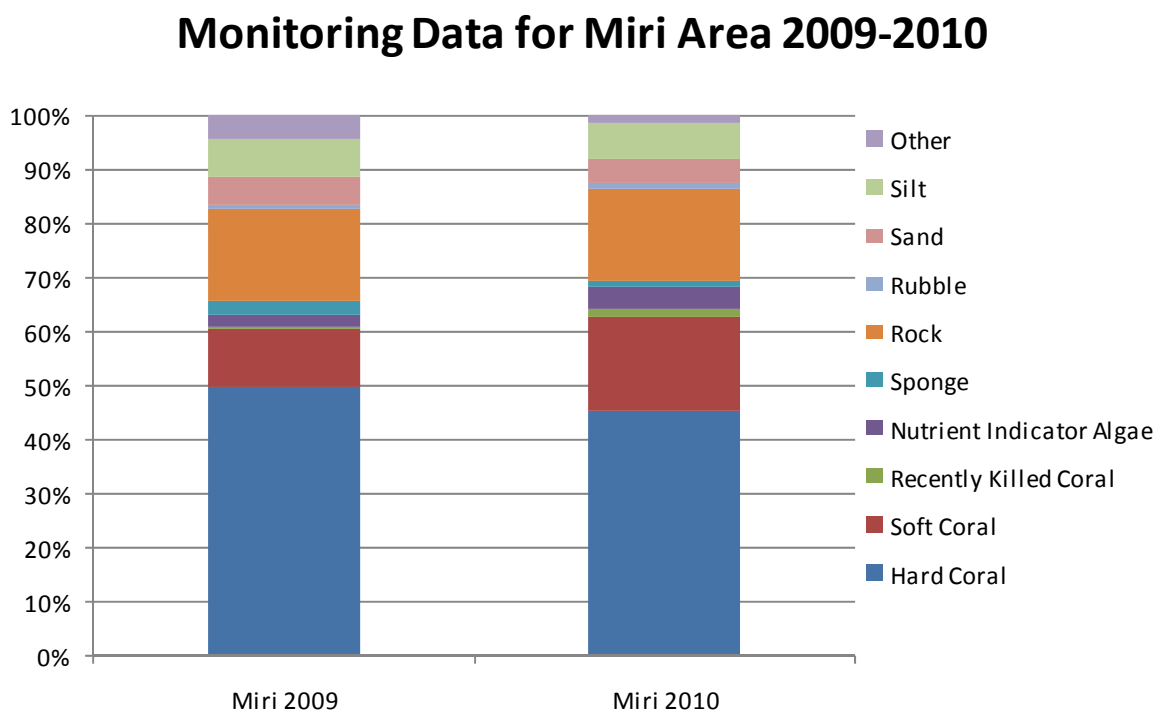
4.5.4 Miri

Surveys have been conducted at sites around Miri for the last two years. The results show no significant changes in LCC, as both years recorded over 60%, falling under the "good" category, according to the Coral Reef Health Criteria. A slight decrease of HC and increase of SC recorded in 2010 could indicate SC is out-competing HC for space and resources, which can affect the structure of the reefs and needs to be monitored.

A slight increase of NIA was also recorded during this year's survey and this also needs to be monitored continuously, to ensure the algal growth is under control.

The level of Silt (SI) appears to be elevated on reefs around Miri. However, this is probably largely due to natural factors as the coastline of Sarawak has many mangrove forests, which have naturally silty waters.

Chart 16: Monitoring Data for sites around Miri

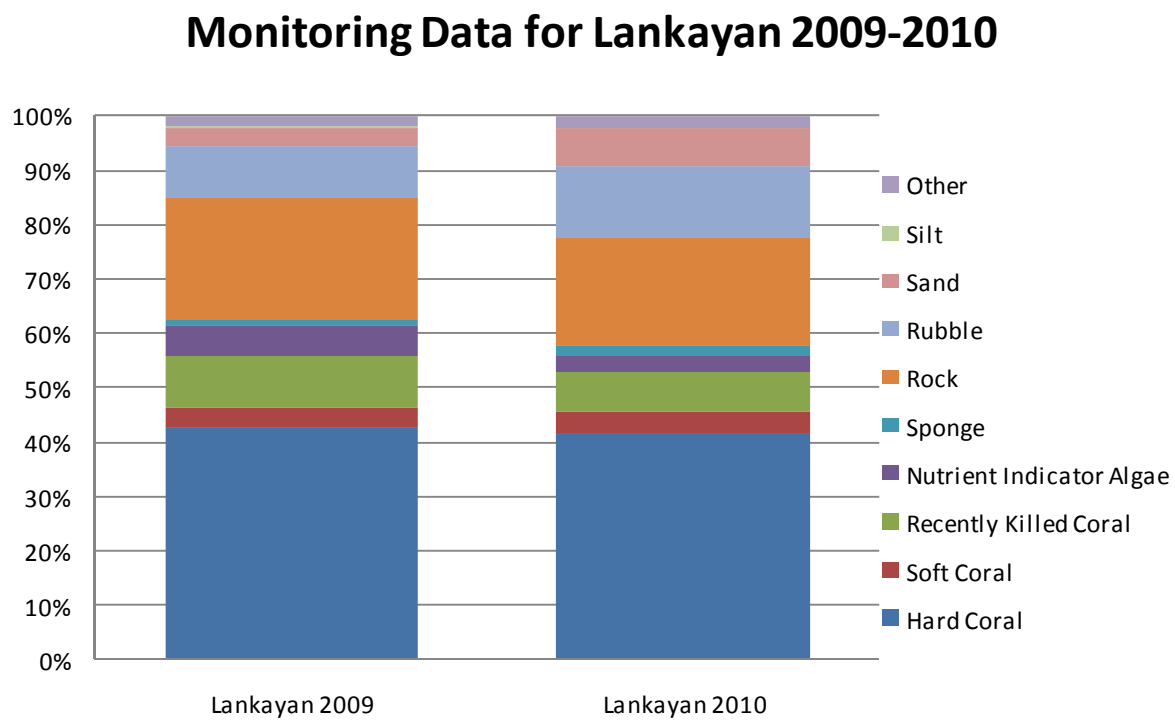


4.5.5 Lankayan

Data are also available for two years for sites around Lankayan, on the central East coast of Sabah. There is little significant change between the two years, with the condition of the reefs improving slightly with a small decrease in Recently Killed Coral (RKC) and NIA in 2010. The decrease of RKC is likely due to the efforts by the operators to remove COTs, especially after an outbreak in 2009 which resulted in high RKC cover. The decrease of NIA is also a good sign that the reefs are recovering and under less stress.

The relatively high percentage of Rock cover will also encourage further recovery of these reefs as it provides a suitable substrate for new coral recruitment in the future.

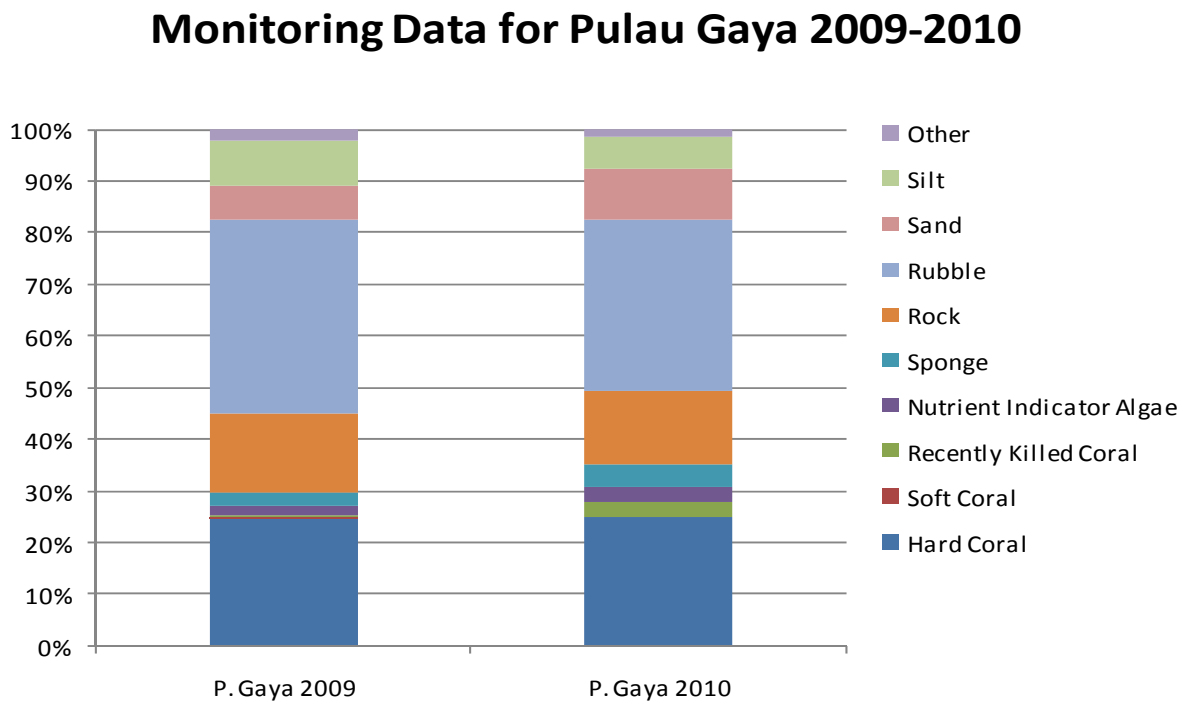
Chart 17: Monitoring Data for sites around Lankayan



4.5.6 Pulau Gaya

Only three sites have been surveyed to date at Pulau Gaya, just off Kota Kinabalu in the Tunku Abdul Rahman Marine Park, so it is difficult to draw conclusions about changes. However, the data do show that the reefs around Pulau Gaya are in "poor" condition, according to the Coral Reef Health Criteria, with LCC below 25%. The only change between the two years was a slight increase in RKC and NIA in 2010. A more comprehensive monitoring programme should be established to monitor these and other nearby reefs, to assess changes to the reefs.

Chart 18: Monitoring Data for sites around Pulau Gaya



5. Challenges & Recommendations

Most of the islands where reefs were monitored in Peninsular Malaysia are gazetted Marine Parks, where many human impacts on reefs, such as fishing, trawling, anchoring and collection of any marine life, are prohibited. However, despite the legal protection afforded (for most islands) by their Marine Park status, each island presents its own set of challenges which need to be addressed in order for the reef ecosystems to recover and thrive.

For East Malaysia, only some of the areas monitored have formal protection as gazetted Marine park areas (Gaya, Lankayan), though informal protection exists in others as a result of land/resort ownership or ongoing work by NGOs (Mataking, Kudat). These areas therefore present a different set of challenges for conservation.

This section outlines a number of recommendations for conservation activities, based on both the objective data collected through the Reef Check surveys as well as based on the subjective, but informed, observations of survey participants. These recommendations are more detailed for the islands off the East coast of Peninsular Malaysia, where more work has been carried out. Only general recommendations are possible for East Malaysia at this time.

5.1 Responding to Mass Coral Bleaching: Building Coral Reef Resilience

During 2010, global climate conditions caused mass coral bleaching throughout South East Asia. At the height of the bleaching in July-August, coral reefs in Peninsular Malaysia were badly affected, with up to 90% of reefs bleached in some areas. Although most of Malaysia's coral reefs survived this event (estimates suggest mortality rate was between 10-15% on those reefs affected), scientists agree that tropical seas will continue to warm in future years, increasing both the probability and severity of mass bleaching events.

This is a particularly challenging problem for coral reef managers, not least because the main cause of mass coral bleaching – unusually high sea temperatures – is largely beyond their control. Yet, managers can play a critical role in helping reefs survive the threat of coral bleaching.

It is strongly recommended that the Department of Marine Parks Malaysia recognise the threat posed by mass coral bleaching and take the following actions, which have been practiced in well-established MPAs to:

- Implement management plans to respond to mass coral bleaching
- Build long term resilience

Further information on this issue is contained in our Annual Report.

5.2 General Recommendations

The following general recommendations apply to all coral reef areas:

- Increase number of sites covered by survey programmes in both Peninsular and East Malaysia, and including sites outside existing Marine Parks
- Encourage more dive operators to participate in monitoring programmes and train staff as EcoDivers
- Establish Permanent Transects for surveys and disseminate details widely among dive operators and government agencies.
- Install better signage (where relevant) to ensure that visitors realize that ALL waters surrounding the islands form part of the Marine Park, rather than only the area immediately adjacent to the marine park centre; include signs of “do’s and don’ts” in coral reef areas
- Make available handouts to be given to each visitor to coral reef areas (e.g. “do’s and don’ts” and how and where to report any offense observed)
- Implement more education and awareness campaigns and talks for visitors and operators alike in coral reef areas. Encourage resorts and dive operators to apply Responsible Tourism guidelines to their operations and improve management practices
- Establish a rating system for resorts operating in coral reef areas, to provide information to customers on the degree to which operators care for the environment
- Encourage wise usage of fresh water (storing rainwater from roofs, recycling water for watering plants etc.)
- Install recycling bins and improve collection of rubbish in all areas.

5.3 Peninsular Malaysia

5.3.1 Aur Island

Aur Island is the furthest away from the mainland of all the islands. There is a very small local population on the island but the diving industry there has expanded rapidly over the past 10 years. As a result of the lack of a local Marine Park centre, combined with the distance from the mainland, enforcement of Marine Park regulations is difficult. With this lack of enforcement, fishing and trawling activities have been reported frequently, especially during the monsoon season.

Diver impact
The number of divers visiting the reefs around Aur Island has increased over the last 10 years, and it is particularly popolar as a dive training destination. Observations from divers who have been visiting the reefs around Aur mentioned that divers, particularly novice divers, have caused a lot of damage on the reefs. There is a need to monitor and improve the operations of the dive centres on the island to prevent further damage caused by divers. By requiring dive staff to become certified in the EcoDiver program, they would undergo training in the appropriate eco-friendly practices and could be encouraged to pass these along to their clients – both snorkelers and divers.

Illegal net fishing
A local dive operator also mentioned that ghost nets are found at the end of each monsoon season, indicating that illegal fishing (gill nets and/or trawling) is occurring in the Marine Park waters during the monsoon. Monitoring of fishing vessels should be carried out during the monsoon season to prevent illegal fishing.

5.3.2 The Perhentian Islands

The major environmental issue for the islands is the large number of small resorts which have sprung up during the past 12 years on both the “big” island and the “small” island, with the associated impacts.

Sewage treatment.
The smaller resorts tend to rely on septic tanks which, if not properly maintained, can leach effluent to the sea in highly porous reef rock, can easily overflow and may pollute the surrounding waters. It is recommended that a septic tank maintenance and improvement programme is implemented.

Solid waste disposal.
Solid waste disposal requires better management. Currently, solid waste from the resorts is stored on floating pontoons on the sea before removal by a barge. During rough seas the rubbish bags fall into the sea. Leacheate from the rubbish can also pollute the sea. At the least, waste should be stored in a proper storage area on land before being transferred to the barge, and an improved, more reliable and regular collection system should be implemented. Options to establish composting systems for organic waste on the islands should be studied, with the potential for biogas generation possibly creating an economic return.

Construction.
Construction of new resorts and jetties, some of which are poorly planned, lack the implementation of appropriate mitigation measures to protect the environment. Construction on the island, especially works that involve land clearing or construction in the sea, can cause sedimentation of nearby reefs if control measures, such as silt curtains, are not adequately used and maintained. The location of jetties needs to be carefully planned so that they are not built directly on reefs and have the least impact on water movement.

Illegal trawling.
The Perhentian Islands are the closest to Thailand and as such become a target for illegal trawling. Reef Check surveys are carried out at a maximum depth of 12m and it is possible that some of the damage observed during the surveys in the deeper areas may be due to trawling.

5.3.3 Redang Island

Resort development on Redang Island is almost exclusively confined to three bays; Teluk Dalam, Pasir Panjang and Teluk Kalong. The resorts tend to be large in comparison with the resorts on the other three islands.

Sewage treatment.
Several resorts have their own wastewater treatment plants. Other smaller resorts use the septic tank system with a soak away area for overflow.

NIA on reefs surveyed in Redang are indicative of increased levels of nutrient in the water consistent with sewage discharge. Regular monitoring and maintenance of the wastewater treatment systems that are available should be ensured to reduce pollution and the state government should consider the feasibility of constructing a centralized wastewater treatment plant for each bay and locating discharge points far from reefs.

Tourism impact.
The fringing reefs of the islands off the main resort area, Pasir Panjang, are popular with divers and snorkelers. However these reefs are showing signs of reduced hard coral cover. This could be due to pollution from the resorts, as mentioned above, and physical damage by snorkelers and divers. The Terengganu state government recently banned the use of fins for snorkelling in the state to prevent snorkelers from inadvertently treading on the corals and damaging them. However, further awareness training is required to reduce the amount of physical damage caused by the large numbers of visitors to the reefs around Redang Island.

The most impacted reef surveyed on Redang Island is that of the Marine Park Centre where most snorkelers are taken and allowed to feed the fish with bread. A type of calcareous algae, *Halimeda* was observed to be overgrowing the branching corals. A more detailed study should be carried out to establish the reason for the growth of the *Halimeda* so that action can be taken to prevent it from outcompeting the corals. Fish feeding with bread may encourage a few species of fish to increase, to the detriment of others.

5.3.4 Kapas Island

2010 was the first time Kapas Island was included in the survey programme. This small island south of Redang, part of the Terengganu Marine Parks, has no local population and only a small tourism market, with just three resorts and one dive operator.

Reefs around the island are in "fair" condition, which is consistent with low impacts from tourism and development. It is closer to the mainland than most other survey sites off the East coast and therefore suffers more from impacts such as river run off. Fish populations are healthy (particularly parrot fish) and Illegal fishing appears to under control.

Further monitoring is required to develop a better picture of the threats facing reefs on this island, together with a better understanding of the external impacts.

5.3.5 Tenggol Island

Tenggol is the smallest island surveyed off the East coast, and the only one with no local population. Tourism development to date is limited. Impacts are mainly from external sources.

Illegal fishing
There are regular complaints of illegal fishing around Tenggol island, particularly during monsoon season, when the resorts are closed. The only sheltered bay on the island is used as a mooring point for fishing boats throughout the year, and they discard huge amounts of trash (a cleanup in November yielded, among others, discarded oil filters, batteries, food cans, tyres and an air conditioner compressor). Closer monitoring of the activities of fishermen is required, as well as education to reduce the amount of trash they discard.

5.3.6 Tioman Island

Tioman Island is the most developed of the Marine Park islands and has better developed infrastructure than the other islands (including a limited road network and a new marina).

Development impact.
Beach erosion has been identified as a problem in Tekek village, and a project to replenish the eroding areas with sand is underway. Significant siltation was observed on the two reefs nearest the beach replenishment project. In order to prevent excessive siltation, mitigation measures (such as silt curtains) must be put in place and these measures need to be checked and maintained on a daily basis.

Sewage treatment.
Waste management is also an issue on the island. Only the large Berjaya resort has its own wastewater treatment plant, and most resorts and houses rely on a septic tank system which, if improperly maintained, can result in overflow into the sea. A programme of septic tank inspection should be implemented and the state government should consider the feasibility of constructing a centralized wastewater treatment plant for each village. The large number of *Diadema* urchins indicates an imbalance between algae, urchins and fish, and this situation should be closely observed. Regular coral reef surveys should be conducted to monitor algal growth and *Diadema* numbers. In all areas where sewage is suspected of increasing seawater nutrient levels, standard *E. coli* testing can be used to determine the extent of the problem from both the nutrient and human health perspectives.

Solid waste management.
Tioman has an incinerator for solid waste disposal but frequent breakdowns of the incinerator result in storage of solid waste nearby. It is likely that there is some leaching of pollutants into the river adjacent to the plant, and into the sea, and given the mixed nature of household waste this could include toxic components such as waste engine oil, battery acid and cleaning agents. Although this problem should be solved once a new, higher capacity incinerator is built, in the short term improved waste storage should be constructed and households educated on waste minimization to reduce pressure on the existing incinerator installation.

5.4 East Malaysia

The main threats to reefs in East Malaysia can be summarised as follows:

- East Malaysia largely escaped the mass coral bleaching that affected reefs in Peninsular Malaysia, but reefs were still recovering from significant bleaching that occurred in 2009 and are therefore vulnerable to other disturbances
- Sedimentation is a threat to the reefs. Sediments come from the river outflows around the coasts of both Sabah and Sarawak. Although silt levels on Reef Check surveys do not show up as a major substrate effect, observations during surveys detected significant amounts of silt on dead coral, as well as and in patches on live coral.
- Algal growth has accelerated on reefs formerly free of NIA in previous years. Dissolved inorganic nitrogen from fertilisers used on oil palm plantations is a threat to reef quality and with bleaching of corals already a problem, a transition to algae-dominated reefs is a concern.
- Dynamite and cyanide fishing are still commonplace in many parts of the coastline of East Malaysia, and urgent efforts are required to combat this before large areas of reef are destroyed beyond recovery
- In some areas of East Malaysia, particularly southern Sabah, high population levels are resulting in significant fishing pressure on reefs. This is exacerbated by the high mobility of local populations, which are a mix of local, bajau and Philippine citizens.
- There is concern amongst divers and local fishermen about commercial trawler fishing occasionally sweeping up fish from the reefs in some areas.
- Bumphead parrotfish, the last large fish species in Miri, have been found in the local fish market. If these fish are lost, Miri will lose an iconic fish and an important herbivore.
- In some areas, COT predation is a problem (particularly East coast of Sabah around Lankayan). Large scale COT removal programmes have shown some success, but continued efforts are required to reduce numbers of this coral predator.

Large areas of coral reefs around the coast of East Malaysia remain unprotected, though there are plans to establish new MPAs in several areas. Protecting reefs in gazetted areas can contribute to increasing their resilience to both natural (e.g. storms, disease) and man-made (e.g. dynamite fishing, over fishing) impacts, both of which are clearly significant problems in East Malaysia. There is an urgent need to increase the amount of coral reef within gazetted marine protected areas, and to put in place the necessary resources to ensure effective enforcement.

Educational programmes for local populations are also urgently required to reduce instances of destructive fishing, and to create awareness of the economic importance of reefs for future generations.

5.5 Improving Management through Monitoring

As stated in "Reefs at Risk", additional monitoring of coral reefs across Southeast Asia is essential to provide details of where and how coral reefs are threatened.

This conclusion is supported by the paucity of historical information available in Malaysia. Although coral reef surveys are being conducted by various institutions (government, academia, NGOs), lack of coordination means that:

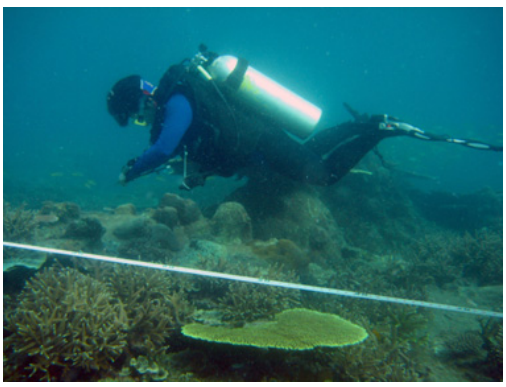
- no standardised method is applied, as a result of which data from different surveys are often not easily compared
- the data are distributed between various institutions, preventing a clear picture from emerging.

Establishing a comprehensive, coordinated monitoring programme which also includes monitoring reefs outside of the Marine Parks would have the following benefits:

- improved management of marine protected areas: better information on the current status of reefs, particularly within Marine Parks, would allow managers to design improved management interventions
- fisheries: monitoring reef health provides an indication of the health of fish stocks on the reef, allowing better management decisions on fishing policies
- economic development: tourism is an important industry in Malaysia, and the country's marine resources are a key part of the attraction to visitors. Conserving coral reefs will protect this sector and allow further growth
- stakeholder engagement: the involvement of local communities, tourism operators and tourists in the monitoring enhances the sense of ownership and responsibility while creating awareness about the reefs. It also allows for large amounts of data to be collected at a lower cost.

It is clear that there is a need for many more sites to be surveyed regularly before a detailed understanding of the status of coral reefs in the East coast islands, and Malaysia more generally, can be established. More permanent transects need to be placed at selected sites on each island to ensure regular monitoring of the same reef areas.

By supporting additional EcoDiver training in Malaysia, not only will the numbers of educated snorkelers and divers increase, but more will be available to participate in surveys of Malaysia's most valuable marine resource – coral reefs.



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- **YTL:** Contributed the proceeds from an auction of starfish art by Malaysian artists and celebrities, to Reef Check for various programmes over the next two years, including training and surveys, as well as a community outreach programme on Perhentian Islands.
- Alstom Power: through Alstom Foundation, is funding our Rainforest to Reef Programme, targeted at school children from the Marine Park Island schools. The funding will cover the cost of implementing the programme over the next three years.
- SGP: funding a two year programme of work on the Perhentian Islands to involve the local community in managing the marine resources around the islands
- KPMG: donated funds raised by staff as part of KPMG community activities; established a Corporate Reef Check team and adopted a reef in Tioman Island; funding a Rainforest to Reef programme for a school in KL.
- CIMB: funding an extension of the Rainforest to Reef Programme for schools in urban areas.
- Jendela Batik is raising funds for RCM through a donation from sales of its new collection, to be launched in early 2011.
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- Redang Kalong, Redang
- Tioman Dive Centre and Fishermen Dive Centre, Tioman
- Scuba Zone, KL
- Reef Dive Resort, Mataking
- Kapalai Resort
- Lankayan Island Resort
- Piasau Boat Club, Miri.

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REFERENCES

Burke, L., Selig, E. and Spalding, M. 2002. *Reefs at Risk in Southeast Asia*. World Resource Institute.

Carpenter KE M Abrar, G Aeby, RB. Aronson, S Banks, A Bruckner, AChiriboga, J Cortés, JCDelbeek, L DeVantier, GJ Edgar, A J Edwards, D Fenner, HM Guzmán, BW Hoeksema, G Hodgson, O Johan, WY Licuanan, SR Livingstone, ER Lovell, JA Moore, DO Obura, D Ochavillo, BA Polidoro, WF Precht, MC Quibilan, C Reboton, ZT Richards, AD Rogers, J Sanciangco, A Sheppard, C Sheppard, J Smith, S Stuart, E Turak, JEN Veron, C Wallace, E Weil, E Wood. 2008. *One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. Science* 25 July 2008: Vol. 321. no. 5888, pp. 560 – 563 DOI: 10.1126/science.1159196

Chou, L.M., C.R. Wilkinson, W.R.Y. Licuanan, P.M. Aliño, A.C. Cheshire, M.G.K. Loo, S. Tangjaitrong, A.R.Ridzwan and Soekarno, 1994. *Status of coral reefs in the ASEAN region*. p. 1-10. In : Wilkinson, C.R., S. Sudara and L.M. Chou (eds.) Proceedings Third ASEAN-Australia Symposium on Living Coastal Resources. Vol. 1: Status Review. Chulalongkorn University, Bangkok, Thailand.

Hodgson, G. 1999. *A global assessment of human effects on coral reefs.* Marine Pollution Bulletin. 38 (5) 345-355.

Hodgson, G. 2001. *Reef Check: The first step in community-based management.* Bull. Mar. Sci. 69(2): 861-868.

Hodgson, G. and J. Liebeler. 2002. *The global coral reef crisis – trends and solutions*. Reef Check, Institute of the Environment, University of California at Los Angeles.77 pp ISBN 0-9723051-0-6.

Hodgson, G. J Hill W Kiene, L Maun, J Mihaly, J Liebeler C Shuman, R Torres 2006. *Instruction Manual. A guide to coral reef monitoring*. Reef Check Foundation. Pacific Palisades, CA 86 pp.

Malaysian Coral Reef Conservation Project, 2004. *Pulau Redang Coral Reef Ecosystem Resources Assessment Studies Report*. Marine Park Section, NRE, Kuala Lumpur, Malaysia.

Malaysian Coral Reef Conservation Project, 2005. *Pulau Perhentian Coral Reef Ecosystem Resources Assessment Studies Report*. Marine Park Section, NRE, Putrajaya, Malaysia.

Maritime Institute Malaysia. 2006. *Malaysia National Coral Reef Report*. UNEP-GEF South China Sea Project and Marine Park Section, Ministry of Natural Resources and Environment, Malaysia.

Status Report on the Coral Reefs of the East Coast of Peninsular Malaysia, 2000. A consultancy report prepared for the UNDP-GEF Project Development Facility Block B document for the Conservation of Marine Biodiversity in the Marine Park Islands in Peninsular Malaysia. Department of Fisheries, Kuala Lumpur, Malaysia.

Wilkinson, C. and G. Hodgson 1999. *Coral reefs and the 1997-1998 mass bleaching and mortality*. Nature and Resources. 35(2):17-25.

Appendix 1: Survey Sites (2007-2010)

Table 1: 2007-2010 Survey Sites in Peninsular Malaysia.

Islands	2007 Survey Sites	2008 Survey Sites (*new sites surveyed in italics*)	2009 Survey Sites (*new sites surveyed in italics*)	2010 Survey Sites (*new sites surveyed in italics*)
Aur	-	-	*Atlantis Bay (shallow & deep)*	-
	-	*Pulau Lang (shallow)*	Pulau Lang (shallow & *deep*)	Pulau Lang (shallow & deep)
	-	-	*Gadung Bay*	-
	-	-	*Teluran Bay (shallow & deep)*	-
	-	-	*Diver's Lodge House Reef*	-
	-	*Pinang*	Pinang	-
	-	*Rayner's Rock*	Rayner's Rock	-
	-	*Atlantis Bay House Reef*	-	-
				Teluk Jawa (shallow & deep)
Perhentian	Batu Nisan	Batu Nisan	Batu Nisan	Batu Nisan
	Coral View Reef	-	-	-
	D'Lagoon	D' Lagoon	D' Lagoon	D'Lagoon
	Seabell (shallow & deep)	Seabell (shallow & deep)	Seabell (deep)	Seabell (shallow)
	Tanjung Besi	Tanjung Besi	Tanjung Besi	Tanjung Besi
	-	*Lighthouse*	Lighthouse	-
	-	*Batu Layar*	Batu Layar	Batu Layar
	-	*Shark Point (shallow)*	*Shark Point (medium)*	Shark Point (sallow)
	-	*Batu Tabir (deep)*	Batu Tabir (deep)	-
	-	*Tukas Laut (deep)*	*Tukas Laut (shallow)*	-
	-	-	*Tiga Ruang*	Tiga Ruang
	-	-	*Pulau Rawa*	-
Redang	Chagar Hutang	-	-	-
	-	*Chagar Hutang East*	Chagar Hutang East	Chagar Hutang East
	P. Lima Southern Tip	P. Lima Southern Tip	P. Lima Southern Tip	P. Lima Southern Tip
	P. Paku Kecil SW	P. Paku Kecil SW	P. Paku Kecil SW	P. Paku Kecil SW
	P. Pinang Marine Park	P. Pinang Marine Park	-	P. Pinang Marine Park
	-	*P. Paku Besar*	P. Paku Besar	P. Paku Besar
	-	*Kalong House Reef*	Kalong House Reef	Kalong House Reef
	-	*P. Kerengga East (shallow)*	P. Kerengga Besar NE (shallow & *deep)*	P. Kerengga Besar NE
	-	*P. Kerengga West*		-
	-	-	*P. Kerengga Kecil West*	-
	-	-	*P. Kerengga North West*	P. Kerengga Kecil West
				Pasir Akar
Tenggol	*Turtle Point*	-	Turtle Point	Turtle Point
	-	-	*Gua Rajawali (shallow & deep)*	Gua Rajawali (shallow)
	-	-	*Teluk Rajawali*	Teluk Rajawali (deep)
	-	-	*Rajawali Reef (shallow & deep)*	Rajawali Reef (deep)
	Freshwater Bay	-	Freshwater Bay	Freshwater Bay
				Pasir Tenggara
Tioman	Teluk Kador	Teluk Kador	Teluk Kador	Teluk Kador
	Batu Malang (shallow)	Batu Malang (shallow)	Batu Malang (shallow & *deep)*	Batu Malang (deep)
	Pirates Reef	Pirates Reef	Pirates Reef	Pirates Reef
	Pirates Reef East	-	-	-
	Renggis (North side)	Renggis (North side)	Renggis North	Renggis (north side)
	Renggis (South side)	-	-	-
	Renggis (West side)	Renggis (West side)	-	-
	Soyak	Soyak	Soyak	Soyak
	Soyak South (medium)	-	*Soyak South (shallow)*	Soyak South (shallow)
	Tekek House Reef	Tekek House Reef	-	-
	-	*Sepoi*	-	Sepoi
	-	*Chebeh (Deep)*	*Chebeh (Medium)*	Chebeh (deep)
	-	*Tomok*	Tomok	Tomok
	-	-	*Ali Baba Rock*	-
	-	-	*Labas (shallow & deep)*	Labas (deep)
Bidong & Yu				*Heirtage Row*
				Pulau Karah
				Pulau Tengkorak
				Pasir Tenggara Bidong
				Pulau Yu Kecil
				Pulau Yu Besar
Kapas				*Coral Garden 1*
				Coral Garden 2
				Silent Reef
				Teluk Jawa

Table 2: 2008-2010 Survey Sites in East Malaysia.

Location	2008 Survey Sites	2009 Survey Sites *(new sites surveyed in italics)*	2010 Survey Sites *(new sites surveyed in italics)*
Lankayan	-	-	*Bimbo Rock*
			Katching Star
			Mels Rock
			Pegaso
			Turtle Stop West
		Sand Bar North	Sand Bar North
		Edwin Rock	Edwin Rock
		Zorro East	Zorro East
		Sand Bar South West	Sand Bar South West
	Mid-Rock	*Jawfish*	Jawfish
	Paradise 2, Mabul	*Goby Rock*	Goby Rock
	Treasure Hunt	*Veron*	Veron
	-	*Reef 38*	Reef 38
	-	*Moray*	Moray
	-	*Ken's Rock*	Ken's Rock
	-	*Froggie Fort*	Froggie Fort
	-	*Reef 77*	Reef 77
	-	*Lycia Garden*	Lycia Garden
	-	*G. Kolam*	
	-	*SSR*	
	-	*Turtle Stop jetty*	
	-	*Turtle Stop NE*	
	-	*East Reef*	
	-	*Malu-malu*	
	-	*South Rock 1*	
	-	*BR 5*	
	-	*House Reef*	
Gaya	-	*Malohon 1 (shallow & deep)*	Malohon 1 (shallow & deep)
	-	*Malohon 2 (shallow)*	Malohon 2 (shallow)
Kapalai	Kapalai Rock		
			Mandarin Valley
			Danawan Reef Siamil
			Pygmy Rock Siamil
			Great wall
			Lobster Rock
	-		*Sting Ray City*
Mataking	Mataking House Reef	Mataking House Reef	Mataking House Reef
	-		*Cahaya Way, Bohayan Island*
	-		*Pandanan Bay*
	-		*Sting Ray City, Timba Timba*
	-		*Coral Garden Mataking*
	-		*Sweetlips Rock Mataking*
		Anemone	Anemone
		Anemone North	Anemone North
	-	*Eve's Garden*	Eve's Garden
	-	*Siwa Penyu*	Siwa Penyu
	-	*Sunday Reef*	Sunday Reef

Semporna		*Buwaning (shallow & deep)*	
		Fly Rock (shallow & deep)	
		Gusung gusung (shallow & deep)	
		Limau Jambongan (shallow & deep)	
		Lubani Reef (shallow & deep)	
	-	*Mandidarah East (shallow & deep)*	
	-	*Mandidarah South (shallow & deep)*	
	-	*Manimpan (shallow & deep)*	
	-	*Mantabuan (shallow & deep)*	
	-	*Semaggot (shallow & deep)*	
	-	*Sipindung Reef (shallow & deep)*	
	-	*Straggler's Reef*	
	-	*Tahingan (shallow & deep)*	
	-	*Malohon 1 (shallow & deep)*	
	-	*Rocky Point*	
	-	*Pulau Batik (shallow & medium)*	
	-	*Pulau Larapan (shallow & medium)*	
	-	*Pasalat Reef (shallow & medium)*	
Miri, Sarawak		*Siwa 4*	Siwa 4
		Anemone	Anemone
		Anemone North	Anemone North
	-	*Eve's Garden*	Eve's Garden
	-	*Siwa Penyu*	Siwa Penyu
	-	*Sunday Reef*	Sunday Reef

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