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# Status of Reefs in Selected Southeast Asia Countries

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In 2012 the status of Southeast Asia's coral reefs was determined using Reef Check survey methods on 295 sites from six different countries; 50 in Brunei, 22 in Philippines, 40 in Taiwan, 24 in Thailand, 18 in Indonesia and 141 in Malaysia. Data collected and assessed were the Indo Pacific Reef Check indicator fish, invertebrates and substrate. The assessment of the data shows that the reefs in Southeast Asia are in fair condition with 43.20% of live coral (hard coral + soft coral) cover. However the abundance of highly prized food fish (Barramundi Cod, Humphead Wrasse and Bumphead Parrotfish) and several other fish targeted for food were low. Invertebrates targeted for curio trade and food trade were also present in small number or completely absent at many survey sites. Overfishing seems to be the main impact to coral reefs in this region.

*Keywords:* Coral Reefs, Survey, Status, Southeast Asia and Reef Check.

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## 1. INTRODUCTION

### 1.1 Southeast Asia's Reefs

Coral reefs in Southeast Asia have the highest degree of biodiversity and most extensive coastlines of all the world's coral reefs. Total coral reef area is nearly 100,000 km$^2$, being nearly 34% of the world's total coral reef area (Tun *et al*., 2004). Southeast Asian coral reefs hold more than 75% of the world's coral species (over 600 of the world's nearly 800 reef-building coral species) and more than 33% of the world's reef fish. They also contain nearly 75% of the world's mangrove species and more than 45% of seagrass species (Burke *et al*., 2002; Tun *et al*., 2004). Most reefs in Southeast Asia are on the continental Sunda and Sahul Shelves with all reef types – fringing, platform, barrier reefs and atolls (Tun *et al*., 2008).

For thousands of years people have coexisted with coral reef ecosystems in Southeast Asia, enjoying the goods and services, protection and contribution to coastal culture and lifestyle provided by this diverse ecosystem (Burke *et al*., 2002). However, Southeast Asian coral reefs are also the most threatened and damaged reefs, facing unprecedented threats from human activities (Tun *et al*., 2004). According to Burke *et al*., (2002), the reefs of the Philippines, Vietnam, Singapore, Cambodia, and Taiwan are some of the most threatened in Southeast Asia, each with more than 95% threatened. Indonesia (over 85% of its coral reefs threatened) and the Philippines together hold 77% of Southeast Asian reefs and 79% of Southeast Asian threatened reefs. From a later paper by *Burke et al.* (2012), the percentage of threatened reefs in Indonesia has escalated to nearly 95%, while in Malaysia and Philippines almost all reefs are threatened.

### 1.2 Reef Check Survey

The protocol was designed by Dr. Gregor Hodgson, the founder of Reef Check and a coral reef ecologist, and subjected to extensive peer-review by many scientists with expertise in monitoring design. 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 and provide information about the health of a coral reef. Using a standardised methodology, data from surveys in different sites can be compared, whether on an island, regional, national or international basis (see www.reefcheck.org for more details).

The Reef Check survey also 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.

An effort was made to ensure that the Reef Check monitoring methodology was compatible with other methods used to monitor substrate cover, fish abundance and invertebrate abundance, particularly those used by Global Coral Reef Monitoring Network (GCRMN). However the Reef Check methodology represented a major step forward in the development of community-based monitoring methods and differs in major ways from any other previous methods (Hodgson, 1999).

Reef Check methods differ from others because they: 1) require minimal training time, 2) are much faster than most methods, 3) are designed for non-scientists who are experienced divers with at least a high school education so the pool of potential data collectors is huge, 4) can easily be carried out in shallow water without scuba, because they depend on counting (no measuring), 5) are holistic and include algae, fish and invertebrates; 6) include organisms selected based on market value and ecological role, 7) include an assessment of fishing and other human activities; 8) produce a relatively small amount of accurate, extremely meaningful and statistically comparable data; 9) produce data that are directly relevant to reef management; 10) produce data that are nationally, regionally and globally comparable; and 11) include separate packages for different bio-geographic regions that allow intraregional comparison (Hodgson, 1999).

Reef Check data is now widely accepted and published is scientific journals (Bruno & Selig, 2007) and the methodology commonly used by scientists and non-scientists (Hodgson, 1999 and Stepath, 2000).

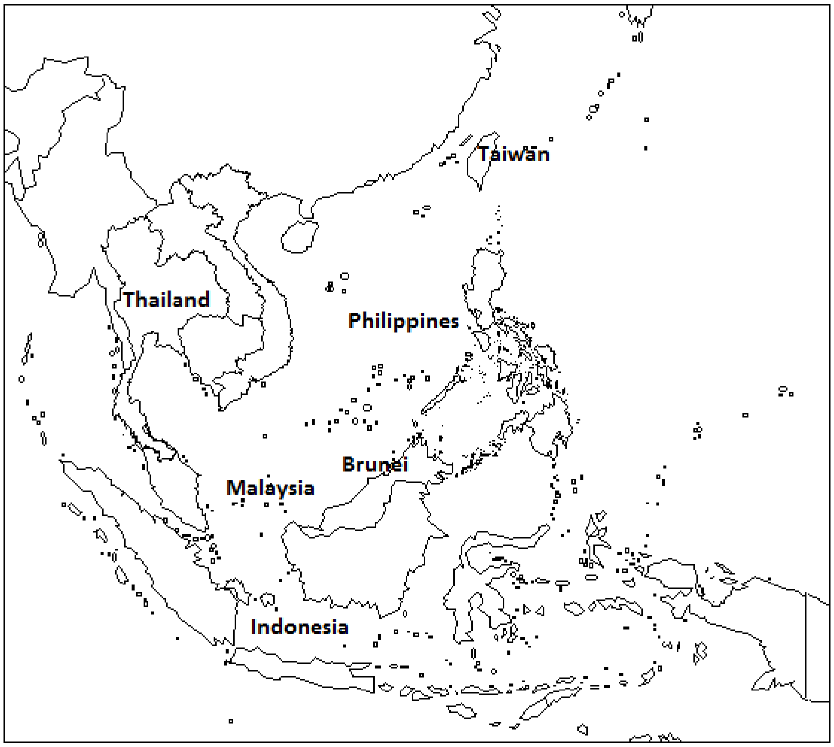
### 1.3 Objective

This study was carried out to determine the status of coral reefs in Southeast Asia.

## 2. MATERIALS AND METHODOLOGY

### 2.1 Survey sites

Surveys were carried out at 295 sites and spanned over 6 countries within the Southeast Asia region as shown in Map 1. A total of 50 sites were surveyed in Brunei, 22 in Philippines, 40 in Taiwan, 24 in Thailand, 18 in Indonesia and 141 in Malaysia. Surveys were done by different teams of EcoDivers based in each country. The survey sites were not selected specifically for this study but instead were determined by team leaders and country coordinators. Due to the large number of sites and their distribution in some countries, a very large map is needed to distinguish individual sites clustered in areas in each country, hence only a general map detailing the locations of each country is given here. Please contact Reef Check Headquarter at rcinfo@reefcheck.org for sites coordinates.




**Map 1** – Selected countries in Southeast Asia

### 2.2 Survey techniques – Data Collection

Reef Check surveys were conducted along a fixed depth of two depth contours (3 to 6m and 6 to 10 m depth). A 100m transect line was deployed and four 20m sections were surveyed, each section separated by 5m, which provided four replicates per transect for statistical analysis.

Generally, three types of data were collected, 1) abundance of fish commonly targeted by fishermen and aquarium collectors, 2) abundance of invertebrates commonly targeted as food species or collected as curios, and 3) percentage cover of substrate category.

#### 2.2.1 Fish Belt Transect

The fish belt transect was the first survey completed during each dive because fish can easily be disturbed by divers. A lag period of 15 minutes before starting the fish visual survey was allocated after deploying the transect line. The waiting period was necessary to allow fishes to resume normal behaviour after being disturbed by the diver deploying the transect line (Hodgson et al., 2006).

Divers assigned to count fish swim slowly along the transect counting the indicator fish seen within 2.5 m on either side of the tape and up to 5 m above the tape. At every 5 m along the tape, divers stop and wait for one minute before proceeding to the next 5 m stop point. The stop is necessary for indicator fish to come out of hiding (Hodgson *et al.,* 2006).The indicator fish are butterflyfish (Chaetodontidae), sweetlips (Haemulidae), snappers (Lutjanidae), barramundi cod (*Cromileptes altivelis*), humphead wrasse (*Cheilinus undulates*), bumphead parrotfish (*Bolbometopon muricatum*), parrotfish (Scaridae) over 20cm, moray eel (Muraenidae) and grouper (Serranidae) over 30cm (Hodgson *et al*., 2006).

Fish were counted while divers were swimming and while stopped along the entire length of each 20 m transect. This was a combined timed and area restricted survey: four segments of 20 m long x 5 m wide x 5m high = 500 $m^3$ with three 5 m gaps where no data were collected. At each depth contour, there are sixteen "stop-and-count" points, and the goal is to complete the four segments of 500 $m^3$ belt transect in one hour (Hodgson *et al.,* 2006).

### 2.2.2 Invertebrate Belt Transect

Once the fish belt transect was completed, divers assigned to count invertebrate carried out the belt transect survey for invertebrates using the same belt transect that was used for the fish survey. The total survey area was 20 m long x 5 m wide= 100 $m^2$ for each segment. Although the invertebrate survey was similar to the fish survey, the diver did not need to stop every 5 m, instead each diver swam slowly along the transect counting the indicator invertebrates (Hodgson *et al.,* 2006). The indicator species were: banded coral shrimp (*Stenopus hispidus*), *Diadema* urchins (*Diadema* spp.), pencil urchin (*Eucidaris* spp.), collector urchin (*Tripneustes* spp.), sea cucumbers (*Thelenota ananas*, *Stichopus chloronotus*, *Holothuria edulis*), crown of thorns (*Acanthaster planci)*, triton shell (*Charonia tritonis*), lobster (Decapoda), and giant clam (*Tridacna* spp.).

### 2.2.3 Line Transect

When the invertebrate belt transect was almost completed, divers assigned to record substrate began the line transect. Data on substrate was collected using the Point Intercept method, which involved recording the code of the substrate type that lay directly below the transect line at 0.5 m intervals i.e. at: 0.0 m, 0.5 m, 1.0 m, 1.5 m etc. up to 19.5 m (40 data points per 20 m transect segment) (Hodgson *et al.,* 2006). The substrate categories were hard coral (HC), soft coral (SC), recently killed coral (RKC) or coral that is dead but skeletal structure and corallites are still obvious, nutrient indicator algae (NIA), sponge (SP), rock (RC), rubble (RB), sand (SD), silt (SI) and other (OT) which include sessile organisms such as giant clams, gorgonians and anemone. The combined percentage of HC and SC is then reported as percentage live coral cover.

All raw data were entered into Reef Check Excel spreadsheets (data forms) which had built-in macros to calculate the mean, standard deviation, standard error and totals for parameters of interest.

## 3. RESULTS AND DISCUSSION

This paper provides an overview of the status of coral reefs for Southeast Asia based on the results from standardised Reef Check surveys conducted in 6 countries in 2012.

Some limitations apply to the results presented in this study, firstly, the number of survey sites for each country presented in this paper varied based on the availability of Reef Check survey data.

Secondly, Taiwan is a state in East Asia. However it is included in this study as the Reef Check “Indicator Species” used for surveys in Taiwan are the same as those used in other countries in Southeast Asia, which is the Indo-Pacific Indicator Species.

## 3.1 Southeast Asia

### Substrate

The table below shows the Coral Reef Health Criteria used in this study.

**Table 1:** Coral Reef Health Criteria (Chou et al, 1994)

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

According to the criteria (Table 1), the general condition of Southeast Asia's coral reefs was categorised as "fair", based on the average live coral cover (Figure 1) from all the surveys of 43.20%.

Recently killed coral is coral that has died within the past one year (Hodgson *et al.,* 2006) and the level (3.58%) was relatively low, indicating few recent impacts to reefs.

Rock comprises both natural rock and dead coral (coral dead for more than 1 year). Rock is critical for reef recovery, regeneration and extension as it forms the base for new corals to recruit onto (Davies *et al*., 2013). Therefore, some amount of rock is important, and the level of 26.84% was considered normal. It should be noted that new coral recruits cannot settle onto rock that has significant algae coverage; and under these conditions settlement of new recruits will be reduced (Hoey *et al*., 2011). This demonstrates the importance of healthy herbivore populations, which graze on algae and keep it under control, providing clean surfaces for coral recruits.

Rubble comprises small pieces of rock, coral fragments, dead shells and other small pieces of substrate. These are created by a number of factors, some natural such as storms (Harborne *et al*., 2000) and others from human activities, including fish bombing (Koh *et al*., 2002) and physical impacts from boats, anchors and reef users (Tratalosa *et al*., 2001). Changing levels of rubble can be an indicator of recent disturbance, and on damaged reefs with high levels of rubble, coral regeneration is slow due to the difficulty of coral recruiting onto a mobile substrate: new coral recruits are easily damaged or displaced on a mobile substrate moving around in local currents and this state of current-induced abrasion of coral recruits is thus detrimental to the post settlement survivorship of corals (Fox, 2004). The average level of rubble (9.91%) was considered within acceptable limits, though as described below in the sections on specific reef areas, the level of rubble varies widely and in some areas it is a cause for concern.

Nutrient Indicator Algae is an indicator of nutrient enrichment associated with sewage pollution (Hodgson, 1999). At 3.42%, NIA did not appear to be a threat, though as described below in the sections on specific countries the level varied widely and in some areas it was a cause for concern. At 2.33%, the level of Sponge was not high and does not appear to be a threat. In response to disturbances, sponge blooms and can cover large areas of reef (Hodgson, 1999).

Sand is a natural component of reefs, and can be expected to be found on any surveys. Increasing amounts of sand in a given coral reef can be an indication of disturbance as dead coral breaks off, disintegrates into rubble coral and is further eroded into fine particles (sand) by wave action (Sheppard *et al*. 2005). The current level of sand (8.04%) was considered acceptable. Silt (SI) arises from a variety of natural sources (e.g. mangroves and mud flats) as well as from land use changes, including agriculture, forestry and development. Silt can smother corals, depriving them of sunlight and causing coral death. The average level of SI for Southeast Asia is low at 0.72%.

The category Others (OT) includes all other sessile organisms that do not indicate any impacts, but are natural components of coral reefs. The average level of OT in Southeast Asia was 1.95%.

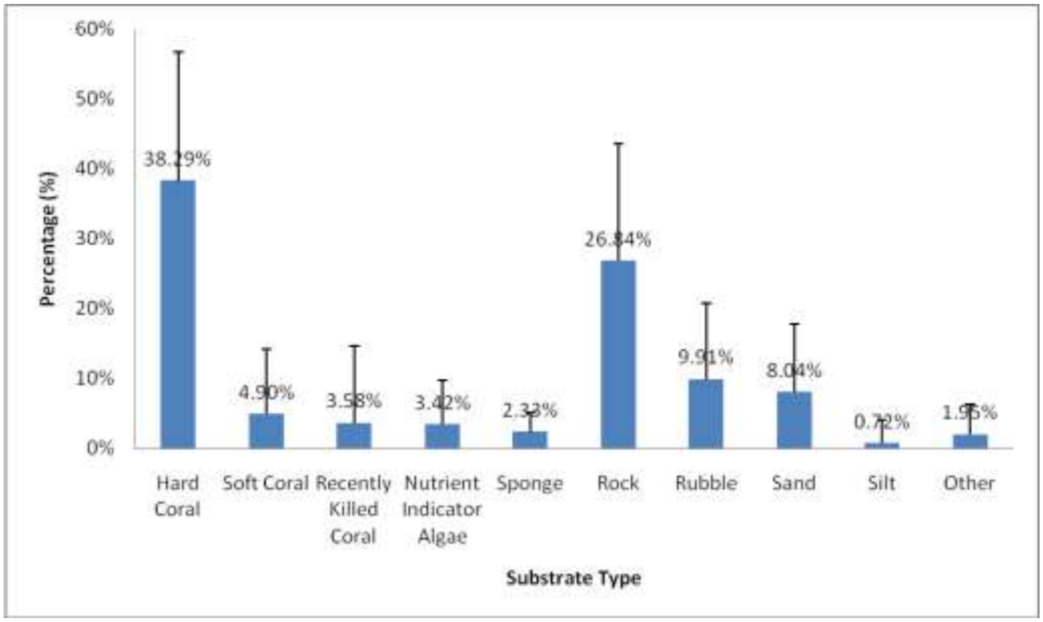



**Figure 1** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Southeast Asia, 2012 Substrate Cover

**Fish**

Reef Check indicator fish species were chosen because of their desirability for various types of exploitation, for example:

- Butterfly fish: targeted for the aquarium trade
- Sweetlips, snapper, barramundi cod, parrotfish, moray eel, grouper: targeted as food fish
- Humphead wrasse, bumphead parrotfish: targeted for the live-food fish trade.

The abundance of indicator fish counted during the 2012 surveys is shown in Figure 2 below.

Abundance of several fish varieties that are targeted for food was low, with abundance of many being less than 1 individual per 500m$^3$ survey transect (including sweetlips, barramundi cod and moray eel). The most abundant food fish was snapper (7.90 individuals per 500m$^3$).

The high value of large, single humphead wrasse and bumphead parrotfish results in targeted fishing effort for these particular species. A single large humphead wrasse could demand prices from US$11,700 up to US$33,250 and these prices are expected to increase as the fish become rarer (Donaldson and Sadovy, 2001). The abundance of these important species was very low, less than 1 individual per 500m$^3$ survey transect. Greater protection is necessary to aid recovery of populations of these iconic species, and on-going monitoring will help track their population recovery.

On a more positive note, the presence of butterfly fish in most survey sites was a good indication that there was low collection pressure for these fish, a popular item in the aquarium trade and usually missing on reefs fished for aquarium trade (Hodgson *et al.*, 2006). Furthermore, the high numbers of butterfly fish at some survey sites reflects the fairly healthy status of reefs around Southeast Asia, as they thrive on healthy reefs with many species, if not all, feeding mainly on live tissue of hard corals as food (Hourigan *et al*., 1988).

Equally important are healthy parrotfish populations (average abundance 2.44 individuals per 500m$^3$ survey transect). Parrotfish are herbivores and are an important control on the amount of algae growing on coral reefs, helping to protect corals from proliferation of algae. This is achieved by grazing behaviour of parrotfish that limit corals' algal competitors (Mumby, 2009). Consequently, it promotes settlement of new coral recruits (Davies *et al*., 2013).

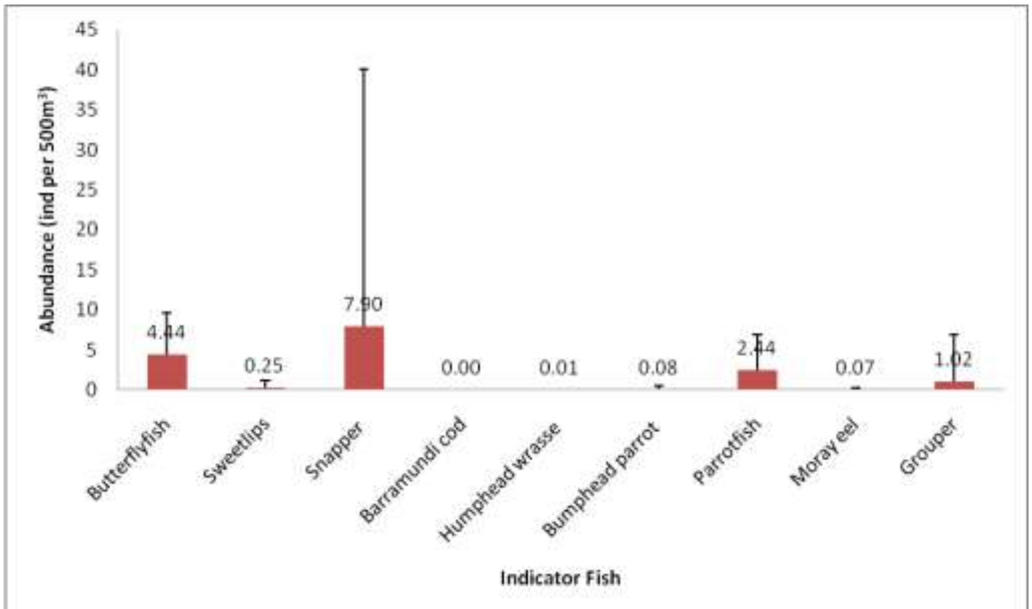



**Figure 2** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Southeast Asia, 2012

**Table 2: Number of sites where indicator fish were observed**

| **Indicator Fish** | **Number of sites where indicator fish were observed** | | | | | |
|---|---|---|---|---|---|---|
| | **Brunei** | **Philippines** | **Taiwan** | **Thailand** | **Indonesia** | **Malaysia** |
| Butterflyfish | 49 | 22 | 35 | 22 | 18 | 137 |
| Sweetlips | 38 | 3 | 31 | 3 | 16 | 41 |
| Snapper | 39 | 12 | 9 | 13 | 17 | 93 |
| Barramundi cod | 0 | 0 | 1 | 0 | 2 | 2 |
| Humphead wrasse | 1 | 0 | 0 | 0 | 0 | 5 |
| Bumphead parrotfish | 9 | 0 | 0 | 0 | 0 | 16 |
| Parrotfish | 45 | 18 | 15 | 15 | 18 | 122 |
| Moray eel | 5 | 10 | 10 | 4 | 7 | 29 |
| Grouper | 27 | 5 | 3 | 17 | 14 | 91 |
| **Total of sites** | **50** | **22** | **40** | **24** | **18** | **141** |

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**Invertebrates**

The invertebrate indicators are targeted for:

- Curio trade: banded coral shrimp, pencil urchin, triton
- Food: collector urchin, sea cucumber, lobster, giant clam
- Imbalance/predator: *Diadema* urchin, crown-of-thorns.

The abundance of indicator invertebrates documented during the 2012 surveys is shown in Figure 3 below.

Abundance of those invertebrates targeted for the curio trade was at or near zero (banded coral shrimp 0.10 individuals per 100m$^2$ survey transect; pencil urchin 0.01; and triton 0.03). Out of 295 sites surveyed, only 36 sites recorded banded coral shrimp, 7 sites recorded pencil urchin and 5 sites recorded triton. While this may be partly explained by low natural abundance, the low abundance may also indicate significant fishing pressure for these species. However, without baseline data from each area, it is difficult to determine whether this low abundance was due to high levels of fishing for aquarium trade or due to naturally low numbers. Nevertheless, significant conservation measures will be required to assist populations to increase and/or recover.

Similarly, two species targeted for food trade were at or near zero. No collector urchin was reported at 96.61% of the survey sites and no lobster was reported at 85.76% of the surveys sites, with very small numbers at most for both species (collector urchin 0.02 individuals per 100m$^2$ survey transect and lobster 0.05). Even though lobsters usually hide during the day and hunt nocturnally, they are easily observed during the day due to their long antennae which usually extend outside their hiding space. Thus it is very unlikely that many lobsters were missed during surveys as the survey protocol requires searching the crevices (Hodgson, 1999). Some populations of the species targeted for food trade were larger, including sea cucumbers (1.03) and giant clams (2.32).

The abundance of long-spined sea urchins *(Diadema sp.)* varies widely between areas, and in some sites they were present in sufficient numbers to cause a concern. In a balanced reef ecosystem, the numbers of *Diadema* urchins, in combination with herbivorous fish, keep algal growth in check and increase the amount of substrate available for settlement by colonial invertebrates (Bradley & Kenneth, 2009). However, these urchins can reproduce rapidly in conditions in which their main food source (micro- and macro- algae, which proliferate in nutrient rich water) is abundant. Thus, high or increasing numbers of *Diadema* could indicate above normal levels of nutrients.

In high numbers, *Diadema* can have two negative impacts. First, if algae are scarce, their feeding preference can change to coral tissue, and large numbers actively grazing can cause a weakening of the hard coral structure (Carreiro-Silva and McClanahan, 2001). Controlling nutrient pollution can reduce this problem, as can healthy populations of herbivores. Secondly, urchins scour the reef as they move over the surface during feeding, removing a large proportion of calcium carbonate in addition to the algae growing on the reef and potentially damaging the reef structure and ecology due to the considerable rates of bio-erosion (Carreiro-Silva and McClanahan, 2001; Griffin *et al*., 2003). The scouring caused by urchin feeding might also contribute to coral death, particularly for juvenile corals (Sammarco, 1980)

Crown-of-thorns starfish 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 crown-of-thorns per hectare (10,000m$^2$), or 0.2-0.3 per 100m$^2$ (Harriott *et al*., 2003) The abundance of crown-of-thorns found during surveys (0.17 per 100m$^2$) was below this range, suggesting that crown-of-thorns numbers are within acceptable limits.

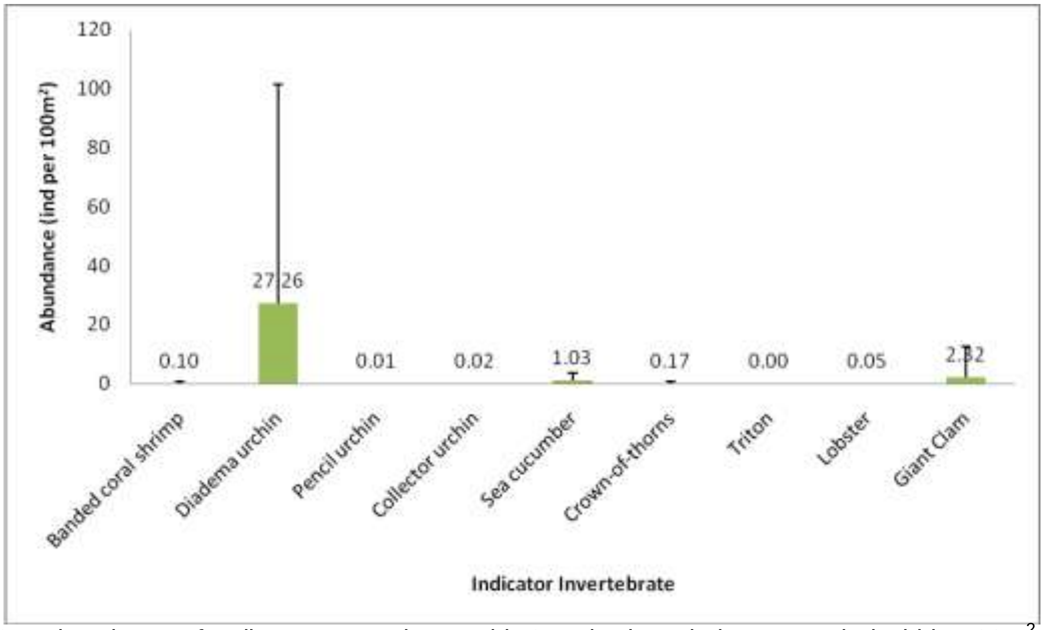


**Figure 3** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys Southeast Asia, 2012

**Table 3: Number of sites where indicator invertebrate were observed**

| **Indicator Invertebrate** | **Number of sites where indicator invertebrate were observed** | | | | | |
|---|---|---|---|---|---|---|
| | **Brunei** | **Philippines** | **Taiwan** | **Thailand** | **Indonesia** | **Malaysia** |
| Banded coral shrimp | 1 | 7 | 5 | 3 | 8 | 12 |
| Diadema urchin | 6 | 21 | 28 | 17 | 14 | 92 |
| Pencil urchin | 0 | 1 | 0 | 0 | 3 | 3 |
| Collector urchin | 0 | 3 | 5 | 1 | 0 | 1 |
| Sea cucumber | 21 | 1 | 0 | 14 | 10 | 72 |
| Crown-of-thorns | 4 | 6 | 2 | 4 | 6 | 34 |
| Triton | 2 | 0 | 0 | 0 | 3 | 0 |
| Lobster | 13 | 2 | 5 | 4 | 9 | 9 |
| Giant Clam | 28 | 12 | 23 | 14 | 18 | 104 |
| **Total of sites** | **50** | **22** | **40** | **24** | **18** | **141** |

### 3.2 Brunei

A total of 50 coral reef sites were surveyed in Brunei and 48% of the sites were in fair condition using the Coral Reef Criteria in Table 1. Only 2% were in excellent condition, while 22% and 28% were in good and poor condition respectively (Figure 4). Overall, the coral reefs in Brunei were considered to be in fair condition, with an average of 38.67% live coral cover (Figure 5). The proportion of rock was high (35.56%), much of which was dead coral. At 0.36% and 0.25%, the level of recently killed coral and silt did not appear to be a threat. The level of rubble (10.21%) was considered within acceptable limits, though it varied widely and in some areas it was a cause for concern. At 3.91%, nutrient indicator algae level was rather high, rising to as high as 25.63% at one site and over 10% at three sites.

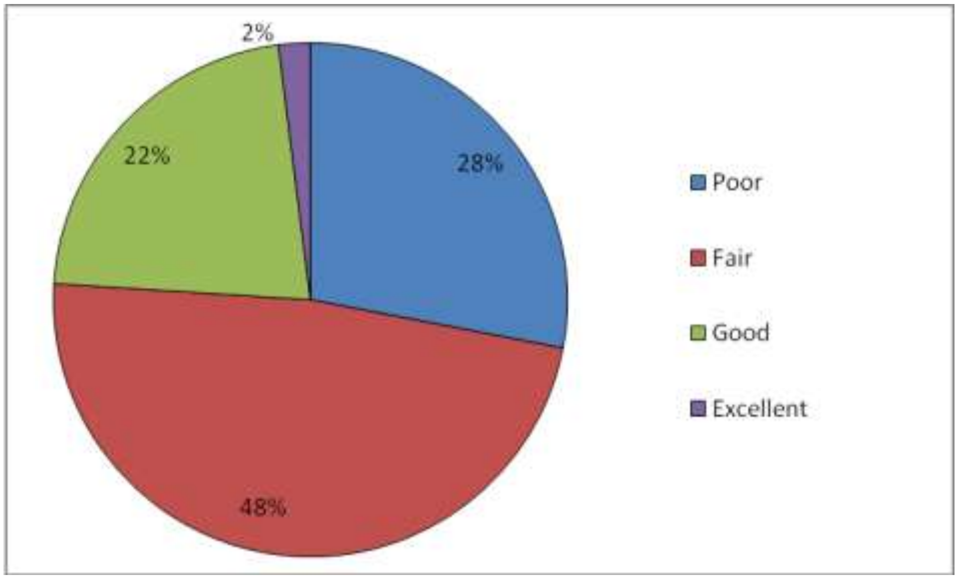


**Figure 4** – Percentage of sites in different conditions for Brunei

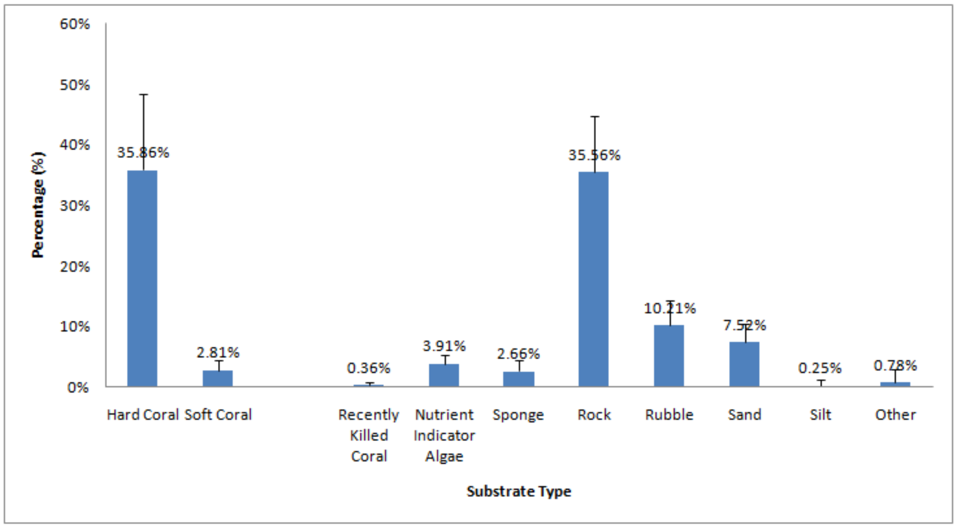


**Figure 5** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Brunei, 2012

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Eight out of nine indicator fish were observed, however their abundance was very low (Figure 6). Butterfly fish (1.73 individuals/500m$^3$) recorded the highest abundance, followed by parrotfish (1.63); and snapper (1.45). The abundance of other indicators was less than one (sweetlips 0.26, humphead wrasse 0.01, bumphead parrotfish 0.12, moray eel 0.01 and grouper 0.19 individuals/500m$^3$).

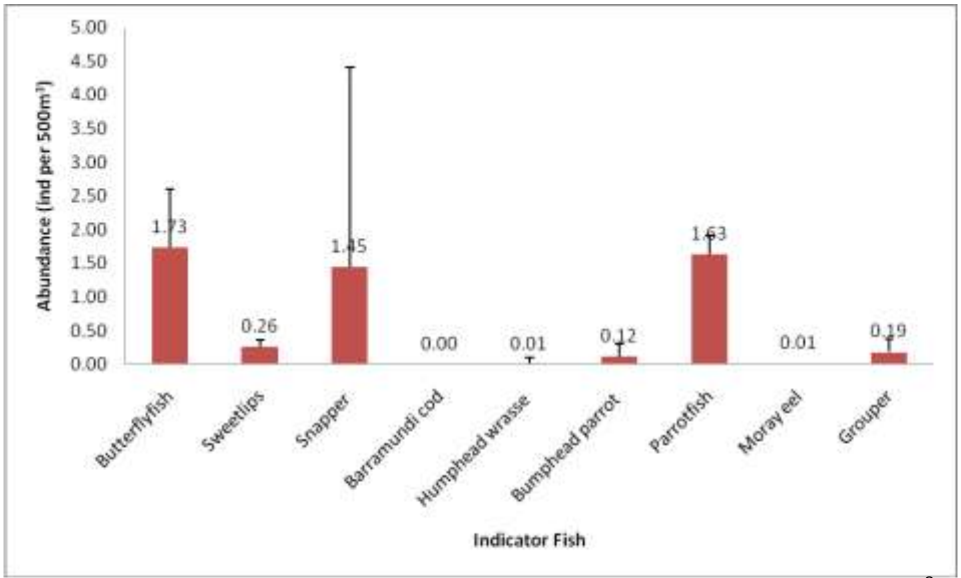


**Figure 6** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Brunei, 2012

Seven out of nine indicator invertebrate were observed, including banded coral shrimp, *Diadema* urchin, sea cucumber, crown-of-thorns, triton, lobster and giant clam (Figure 7). However, their abundance was very low, less than 1 individual/100m$^2$.

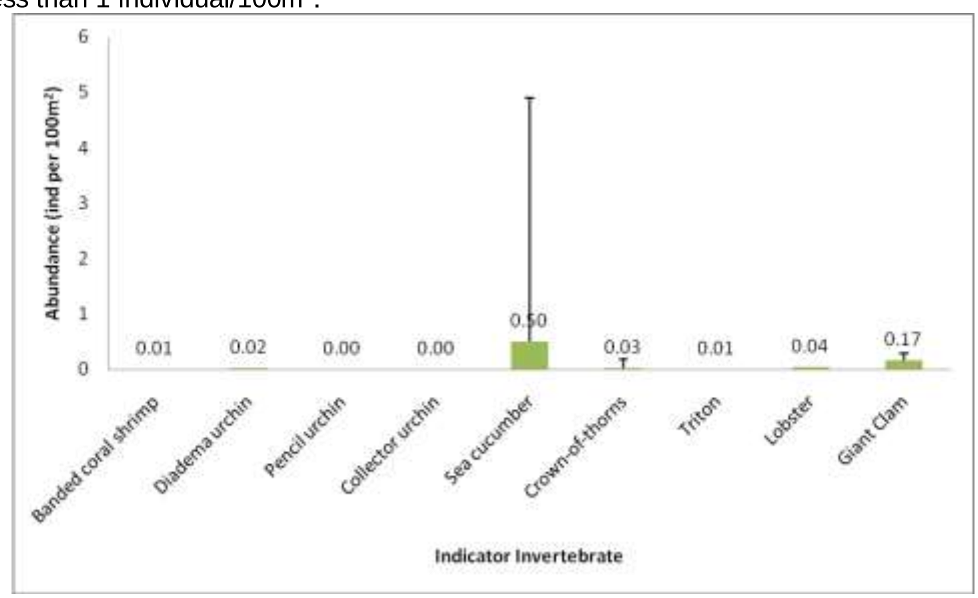


**Figure 7** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys in Brunei, 2012

### 3.3 Philippines

A total of 22 coral reef sites were surveyed in Philippines and 54% of the sites were in good condition. No sites were in excellent condition, while 32% were in fair condition. Only 14% were in poor condition (Figure 8). Generally, the coral reefs in Philippines were in fair condition, with 47.39%% live coral cover (Figure 9). Although the average level of silt was 2.13%, it was a cause for concern in some areas where one site recorded 27.50% and two sites recorded over 6%.The same goes to nutrient indicator algae. Although the average level was at 3.30%, three sites recorded over 10%. The level of rubble (7.44%) was considered within acceptable limits, though it varied widely and in some areas it was a cause for concern.

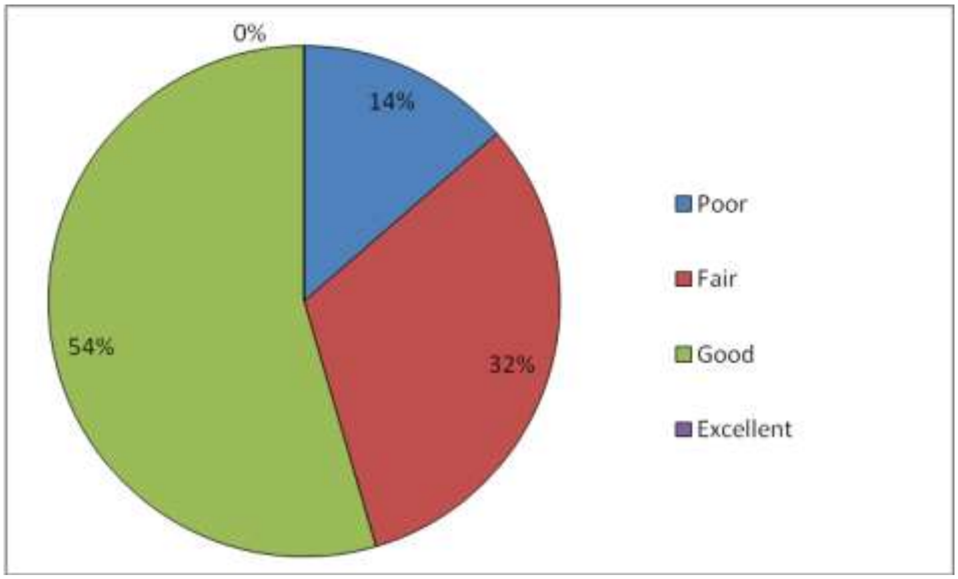


**Figure 8** – Percentage of sites in different conditions for Philippines

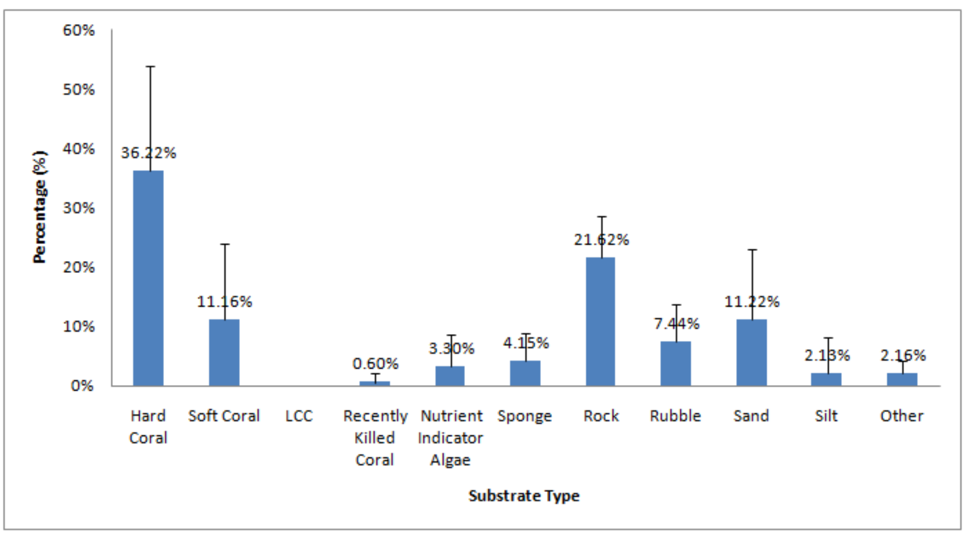


**Figure 9** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Philippines, 2012

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Three indicator species were completely absent from surveys: Barramundi Cod, Humphead Wrasse and bumphead parrotfish (Figure 10). Abundance of butterfly fish (12.57 individuals/500m$^3$) was the highest. Other indicators present in low number, including sweetlips (0.06), snapper (2.14), parrotfish (2.19), moray eel (0.23), and grouper (0.18).

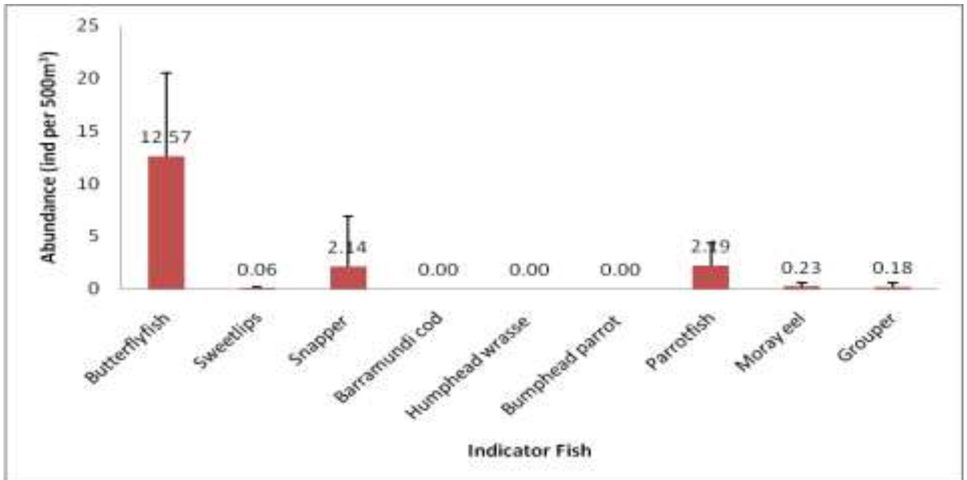



**Figure 10** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Philippines, 2012

Eight out of nine indicator invertebrate were observed (Figure 11). *Diadema* Urchin (19.45 individuals/100m$^2$) recorded the highest number, followed by giant clam (2.50). The abundance of other indicator species was very low, less than one, banded coral shrimp (0.12), pencil urchin (0.01), collector urchin (0.03), sea cucumber (0.02), crown-of-thorns (0.39), and lobster 0.03 individuals/100m$^2$.

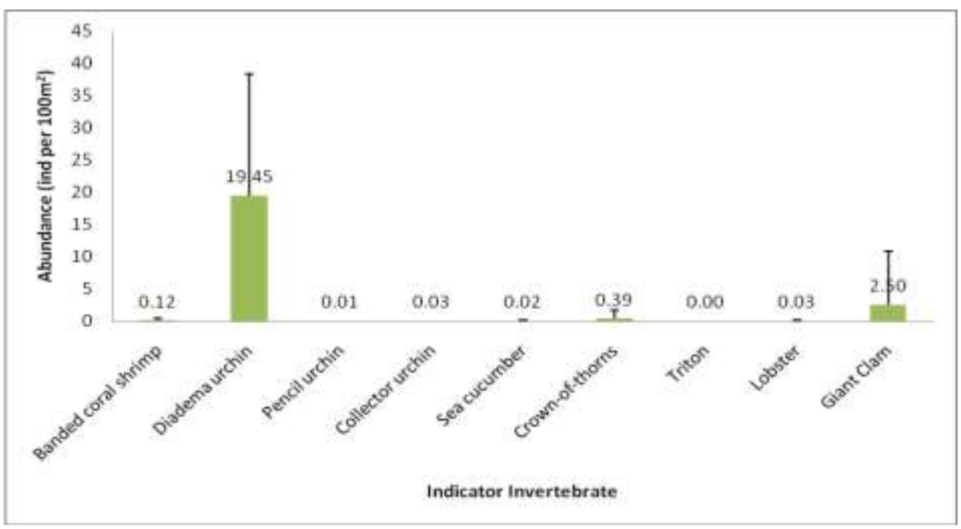



**Figure 11** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys in Philippines, 2012

### 3.4 Taiwan

A total of 40 sites were surveyed in Taiwan and 50% of the sites were in fair condition. No sites were in excellent condition, while 28% and 22% were in good and poor condition respectively (Figure 12). Overall, coral reefs in Taiwan were in fair condition, with 37.28%% live coral cover (Figure 13). The proportion of rock is high (42.16%), rising to above 70% at three sites. At 0.42%, the level of silt did not appear to be a threat. Nutrient indicator algae was high at 8.14% and a cause for concern. One site recorded as high as 57.50% and another site 40.63%; eleven other sites recorded over 10%. The level of rubble (4.05%) was considered within acceptable limits, though it varied widely and in some areas it is a cause for concern.

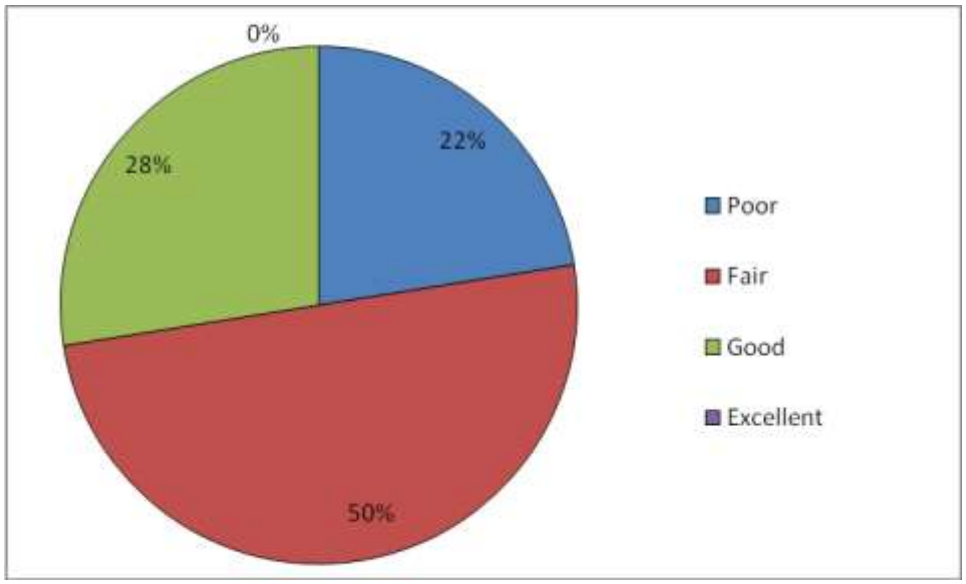
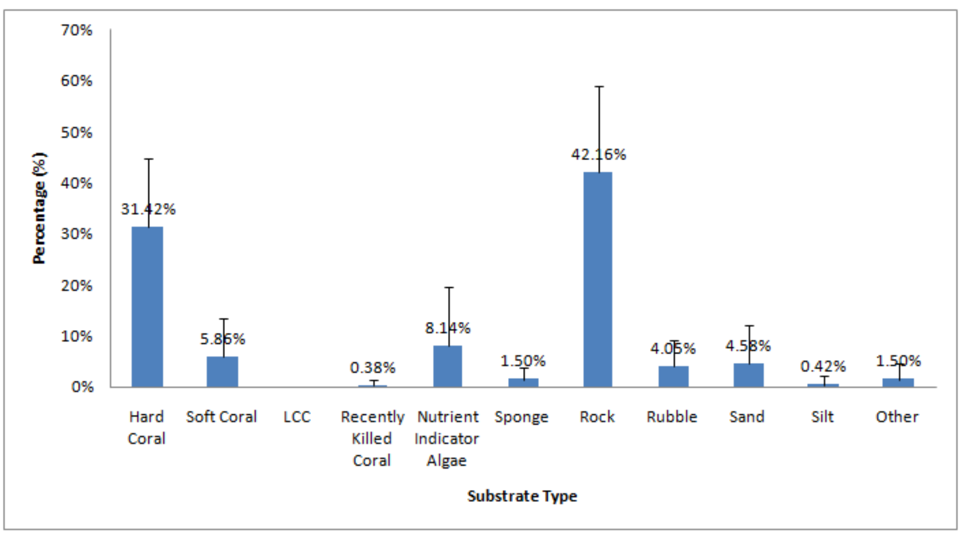



**Figure 12** – Percentage of sites in different conditions for Taiwan




. **Figure 13** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Taiwan, 2012

Two indicator species were completely absent from surveys, including humphead wrasse and bumphead parrotfish (Figure 14). Abundance of other indicator species was very low, less than 1 individual/500m$^3$ except for butterfly fish (1.93).

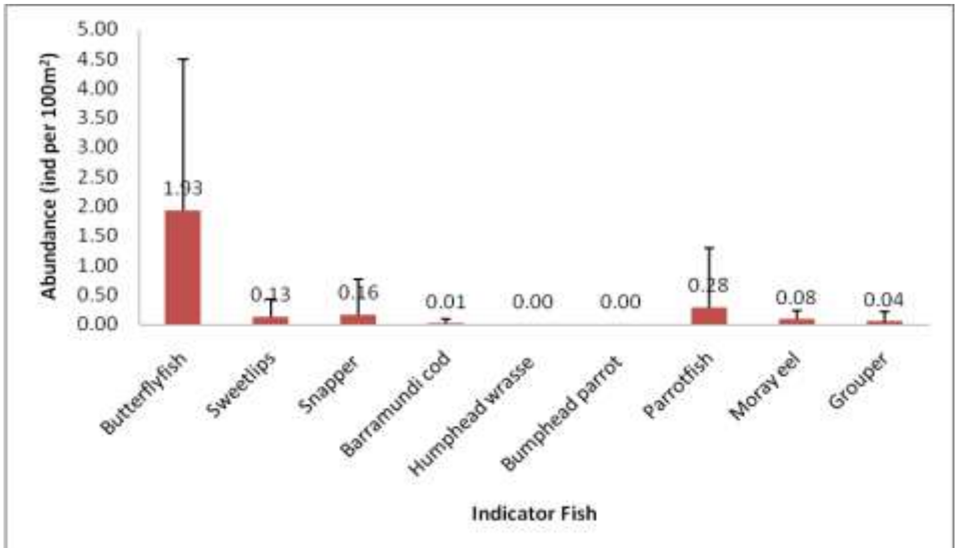



**Figure 14** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Taiwan, 2012

Six out of nine indicator invertebrates were observed, including banded coral shrimp, *Diadema* urchin, collector urchin, crown-of-thorns, lobster and giant clam (Figure 15). However, their abundance was very low, less than 1 individual/100m$^2$ except for *Diadema* (3.11).

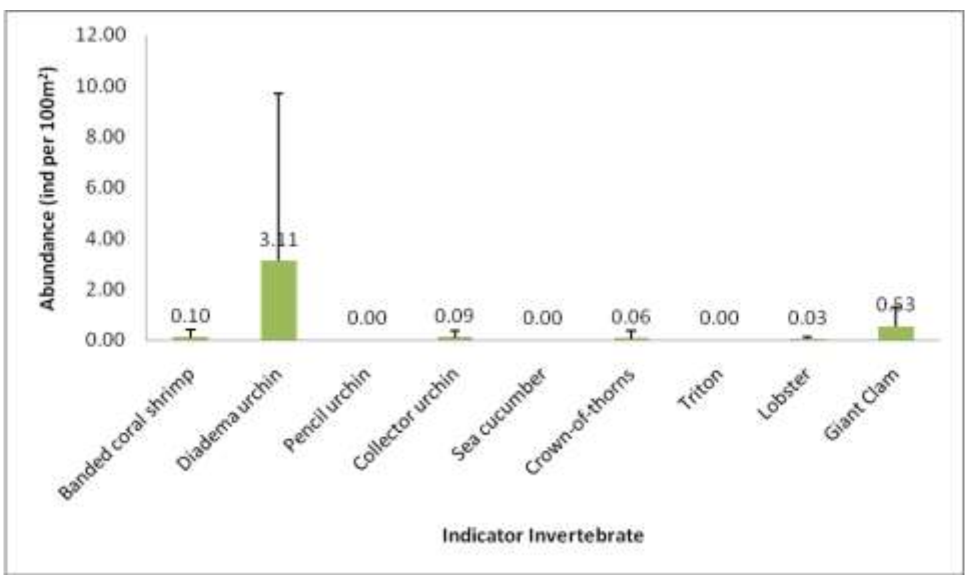



**Figure 15** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys in Taiwan, 2012

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### 3.5 Thailand

A total of 24 sites were surveyed in Thailand and 54% of the sites were in poor condition. No sites were in excellent condition and 42% were in fair condition. Only 4% were in good condition (Figure 16). Generally, coral reefs in Thailand barely passed the criteria to be categorised in fair condition, with 25.14%% live coral cover on average (Figure 17). The proportion of recently killed coral is very high (32.56%), indicating huge recent damages to the reefs. Two sites recorded over 70% and eight sites over 40%. At 0.15% and 0.03%, the level of nutrient indicator algae and silt did not appear to be a threat.

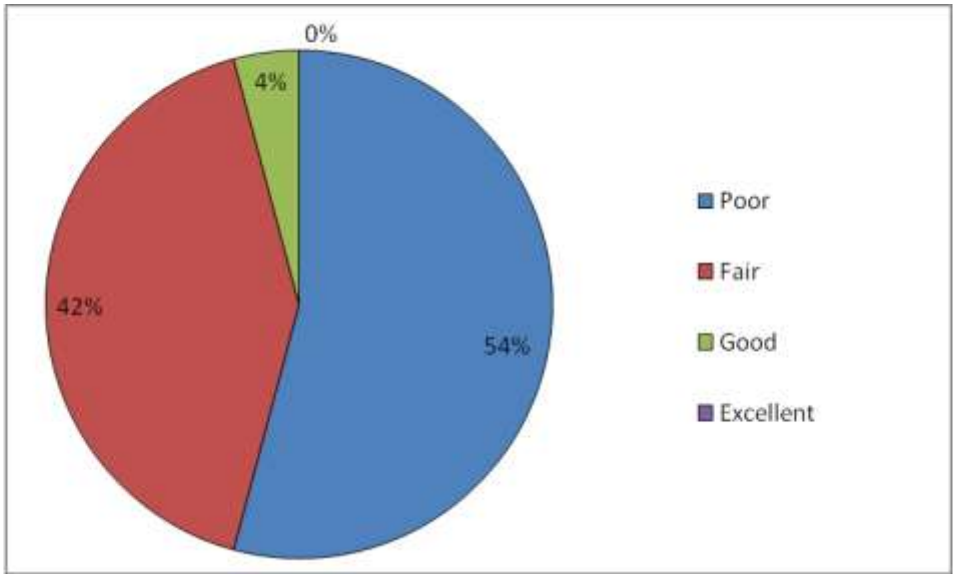
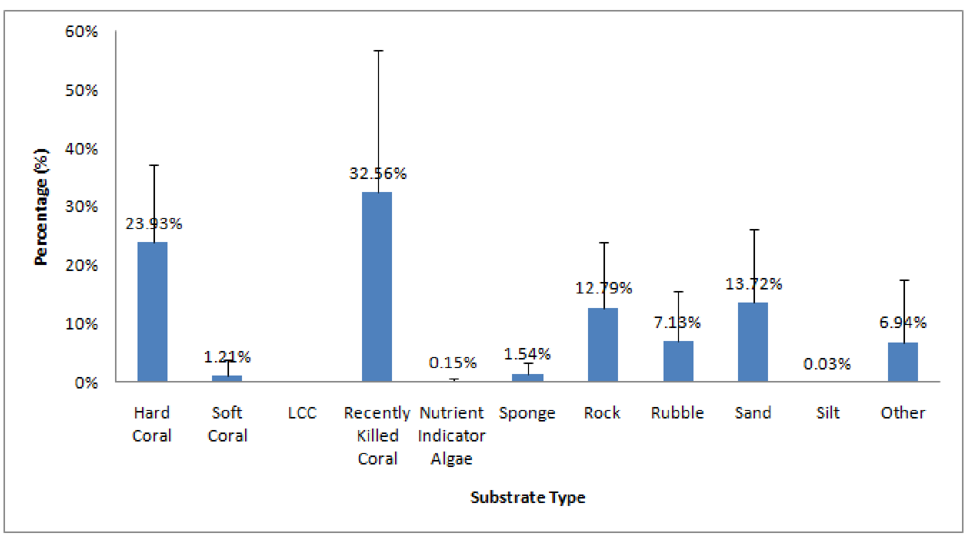



**Figure 16** – Percentage of sites in different conditions for Thailand




. **Figure 17** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Thailand, 2012

Three indicator fish species were completely absent from surveys: barramundi cod, humphead wrasse and bumphead parrotfish (Figure 18). Abundance of snapper (20.63 individuals/500m$^3$) was the highest, followed by grouper (7.68), parrotfish (6.34) and butterfly fish (6.20). Others were present in low numbers, less than one (sweetlips 0.02 and moray eel 0.05).

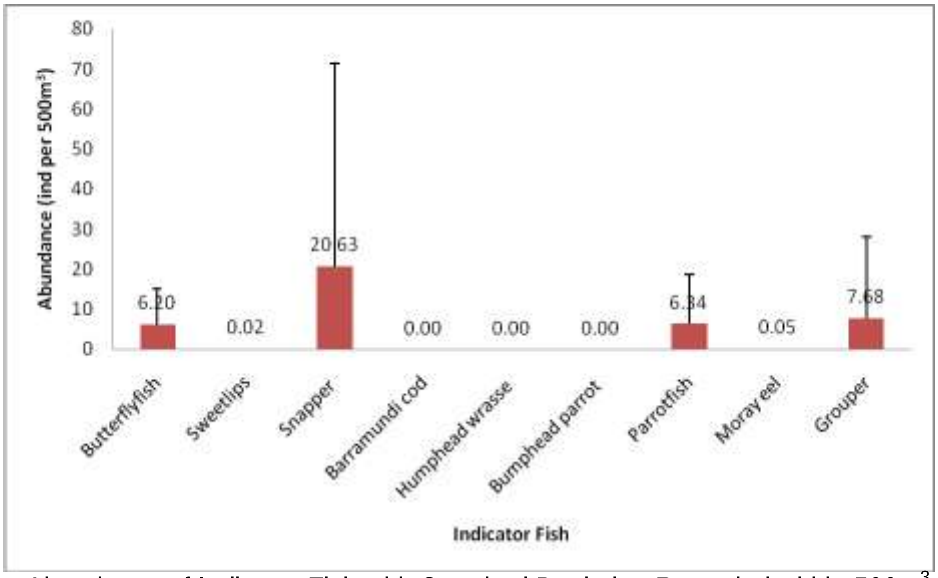



**Figure 18** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Thailand, 2012

Eight out of nine indicator invertebrates were observed (Figure 19). *Diadema* urchin (94.74 individuals/100m$^2$) recorded the highest number, followed by giant clam (14.96). Abundance of other indicator species was very low, less than one except for sea cucumber (1.61).

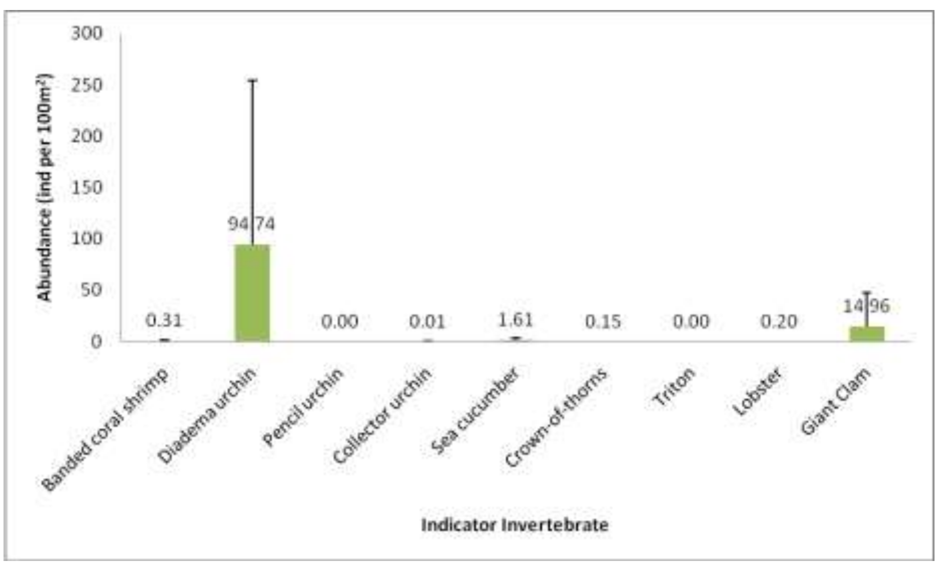



**Figure 19** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys in Thailand, 2012

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### 3.6 Indonesia

A total of 18 sites were surveyed in Indonesia and 72% of the sites were in good condition. 6% were in excellent condition and 22% were in fair condition. No sites were in poor condition (Figure 20). Overall, coral reefs in Indonesia were considered to be in good condition, with 58.75%% live coral cover (Figure 21). The level of rubble (11.08%) was considered within acceptable limits, though it varies widely and in some areas it was a cause for concern. One site recorded as high as 38.13% and another site 26.63%. At 2.60%, average Nutrient indicator algae level was low, but did rise to as high as 15% at one site. The level of silt was low at 0.66% and did not appear to be a threat.

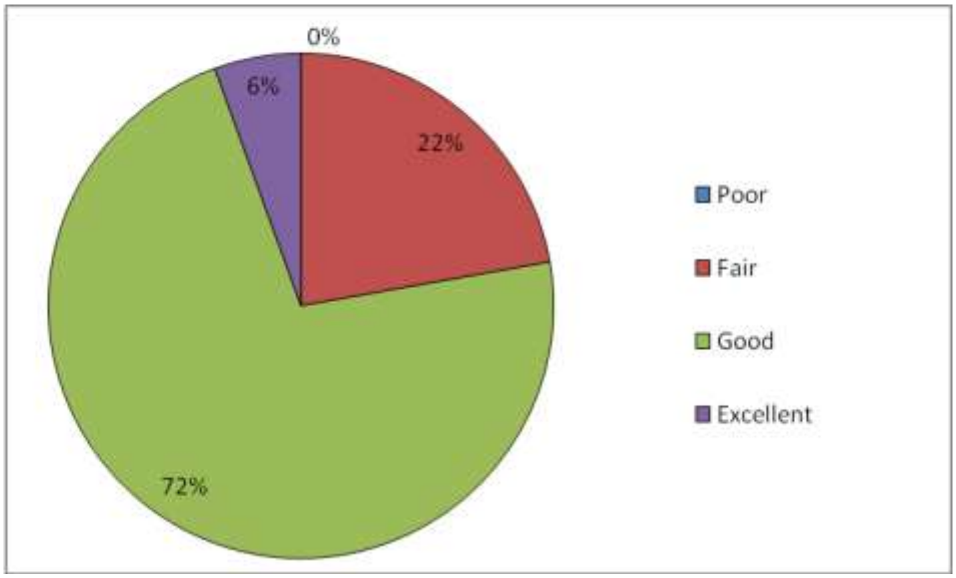
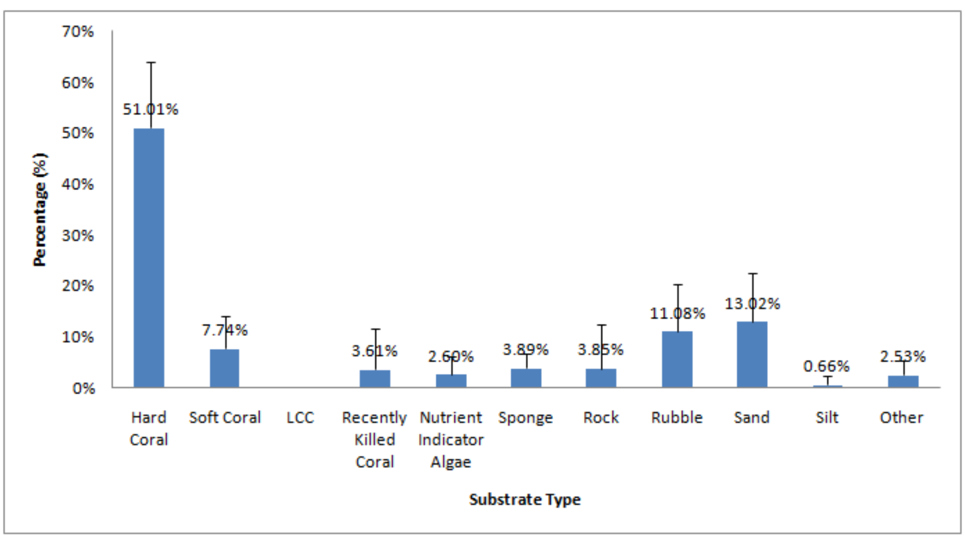



**Figure 20** – Percentage of sites in different conditions for Indonesia




. **Figure 21** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Indonesia, 2012

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Two indicator species were completely absent from surveys: humphead wrasse and bumphead parrotfish (Figure 22). Butterfly fish (4.91 individuals/500m$^3$) recorded the highest abundance, followed by parrotfish (3.71) and snapper (3.46). Abundance of other indicator species was low, including sweetlips (1.00), barramundi cod (0.03), moray eel (0.14) and grouper (0.60).

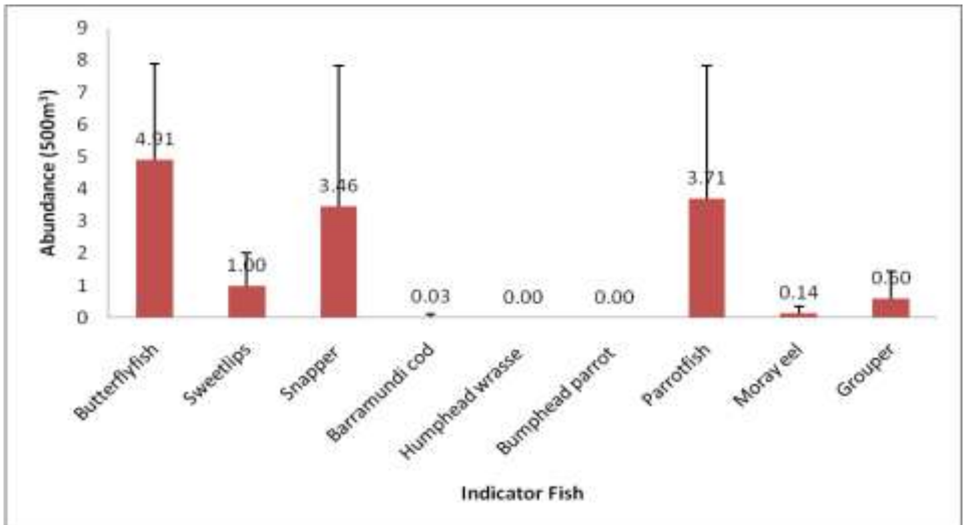


**Figure 22** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Indonesia, 2012

Eight out of nine indicator invertebrates were observed, including banded coral shrimp, *Diadema* urchin, pencil urchin, sea cucumber, crown-of-thorns, triton, lobster and giant clam. However, their abundance was very low, less than 1 individual/100m$^2$ except for *Diadema* urchin (1.88).

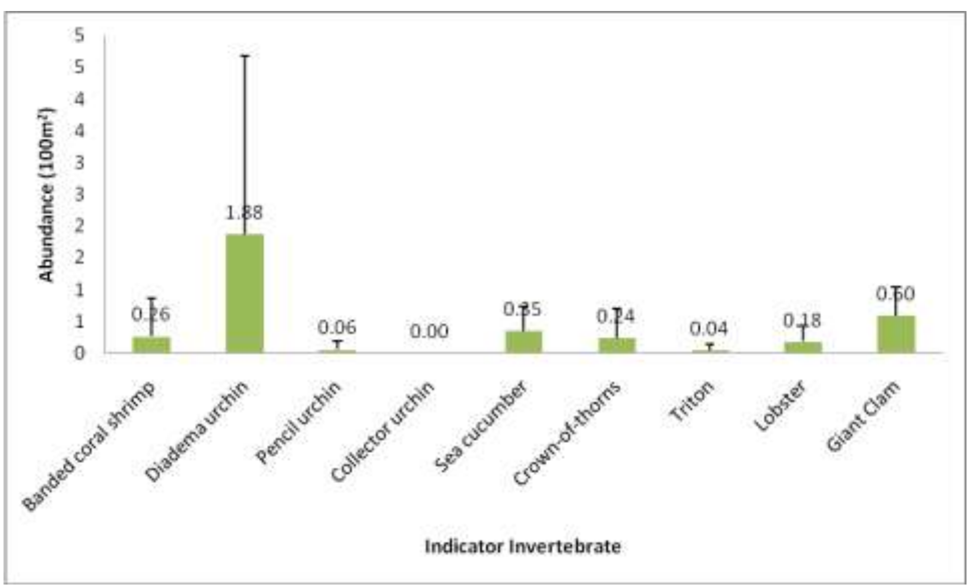


**Figure 23** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys in Indonesia, 2012

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### 3.7 Malaysia

A total of 141 sites were surveyed in Malaysia and 41% of the sites were in fair condition. 8% were in excellent, 33% were in good and 18% were in poor condition (Figure 24). In general, coral reefs in Malaysia were considered to be in fair condition, with 46.37%% live coral cover (Figure 25). The low level of recently killed coral (1.52%) and silt (0.85%) indicate little recent damages to reefs. At 2.60%, nutrient indicator algae was low on average, rising to as high as 31.25% at one site and over 20% at three sites. The level of rubble (11.85%) was considered within acceptable limits, though it varied widely and in some areas it was a cause for concern. One site recorded as high as 63.13% and seventeen sites over 30%.

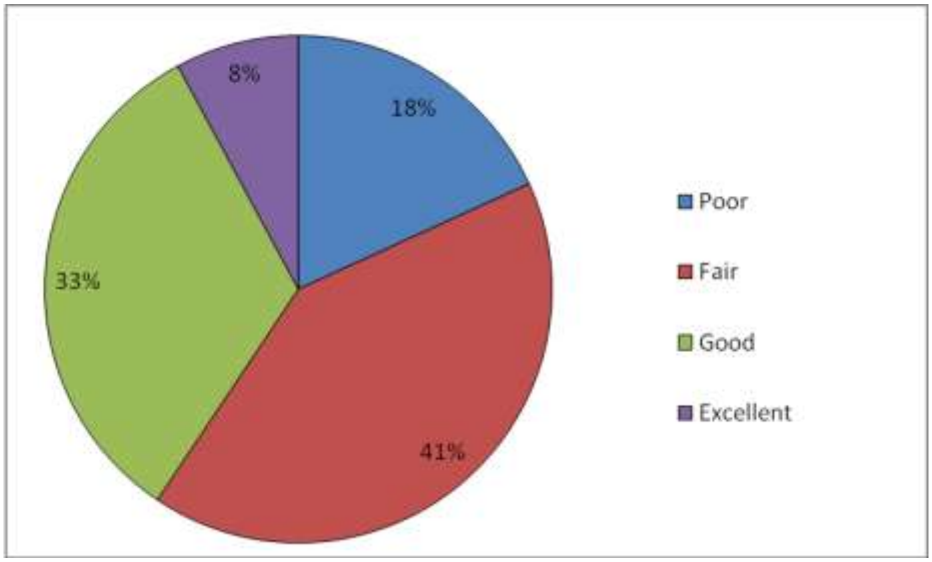
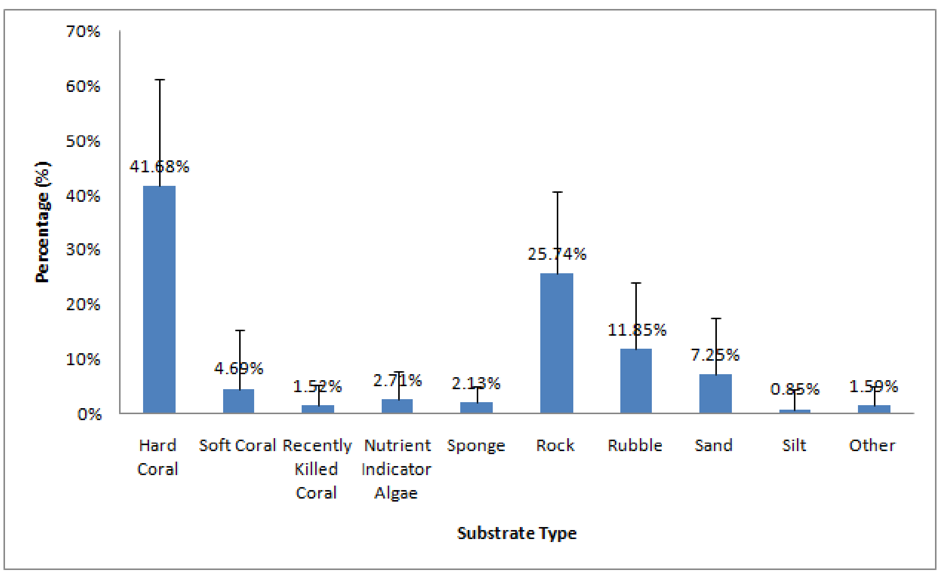



**Figure 24** – Percentage of sites in different conditions for Malaysia




. **Figure 25** – Average Percentage of Substrate Cover with Standard Deviation Recorded within 20m Surveys in Malaysia, 2012

Eight out of nine indicator fish were observed, however their abundances were low (Figure 26). Snappers recorded the highest abundance (11.13 individuals/500m$^3$), followed by butterfly fish (4.47) and parrotfish (2.53). Other indicators were present but in very low number, less than one, including sweetlips (0.25), humphead wrasse (0.01), bumphead parrotfish (0.12), moray eel (0.05) and grouper (0.71).

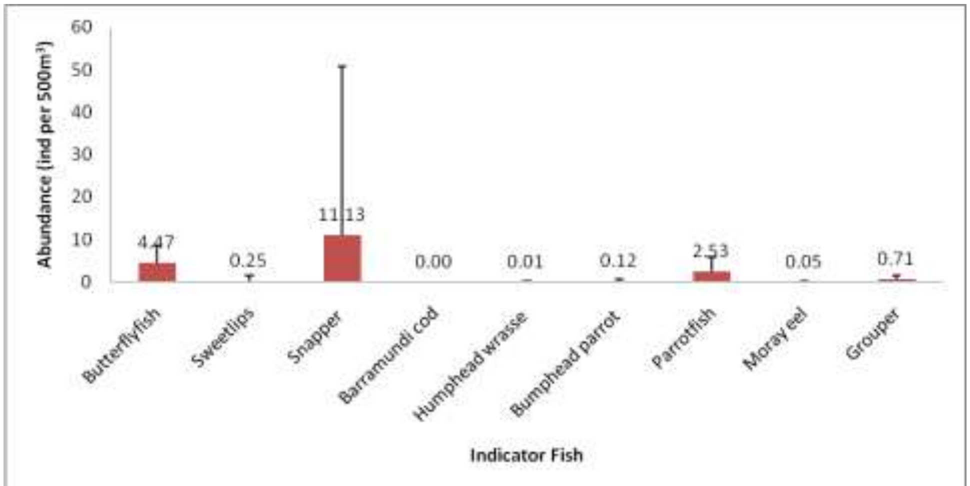



**Figure 26** – Abundance of Indicator Fish with Standard Deviation Recorded within 500m$^3$ Surveys in Malaysia, 2012

Six out of nine indicator invertebrates were observed, including banded coral shrimp, *Diadema* urchin, sea cucumber, crown-of-thorns, lobster and giant clam (Figure 27). *Diadema* urchin (35.36 individuals/100m$^2$) recorded the highest number, followed by giant clam (1.72) and sea cucumber (1.56). Abundance of other indicator species was very low, less than one.

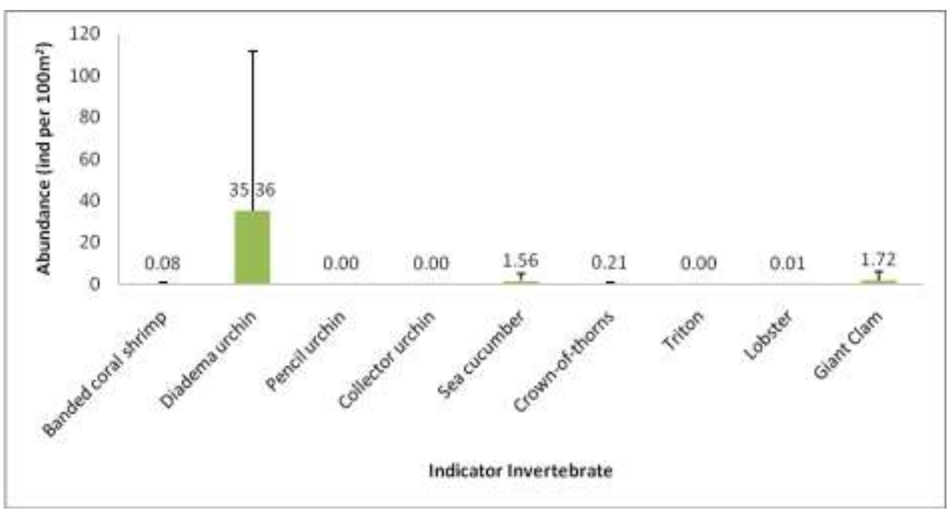



**Figure 27** – Abundance of Indicator Invertebrate with Standard Deviation Recorded within 100m$^2$ Surveys in Malaysia, 2012

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## 4. CONCLUSION AND RECOMMENDATIONS

In 2012, six Southeast Asian countries conducted reef check surveys on their respective coral reefs. The numbers of surveys conducted in some of the six countries were not sufficient to fully represent the condition of reefs for that particular country. This can be seen for countries like Philippines and Indonesia where surveys were conducted in less than 25 sites, which is small in comparison to the amount of coral reef in those countries. More sites would make both local and regional interpretations of coral reef health more reliable. As a result, the 2012 survey data does not represent and cannot be taken as the real situation of the country. By increasing the number of sites surveyed and ensuring all the sites are surveyed annually, the Reef Check survey data could provide crucial insight in detecting changes on the reefs on a local and regional scale, as well as providing information for evaluating the success or failure of reef conservation efforts.

However, some broad conclusions can be drawn. There is clearly a wide variation in the condition of coral reefs around the region and in individual countries. This is perhaps indicative of varying levels of local threats and managers would be advised to focus on reducing local threats as far as possible (e.g. from tourism and destructive fishing methods).

The low abundances or absence of most indicator fish and invertebrate indicators suggest that reefs have been overfished. Overfishing of key fish species has been shown to cause a physical breakdown of the coral reef system (McClanahan *et al*., 1995) Therefore, increasing the amount of coral reef in protected areas and strict enforcement of regulations is critical to allow the populations of these indicator species to recover. Introducing aquaculture of these individuals to meet the growing demand for seafood and to build up the natural populations to the size where they can begin to reproduce naturally may also be an option.

Experience in several countries suggests that community involvement in managing reefs may effectively help reef recovery, in addition to instilling sense of ownership and willingness to be the guardian of the reefs among the communities. Involving local communities in monitoring their own reefs can be an important step in building this commitment.

## 5. ACKNOWLEDGEMENTS

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