THE STATUS OF CORAL REEFS AND RATE OF SEDIMENTATION AT PULAU SEPANGGAR AND BATU POINT, PULAU GAYA, KOTA KINABALU

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ABSTRACT

Sedimentation has been regarded as one of the major factors that cause degradation of coral reef health at global level. This study examined the effect of sedimentation on coral reefs by comparing a Marine Protected Area and a non-Marine Protected Area in Kota Kinabalu which were Batu Point, Pulau Gaya and Pulau Sepanggar respectively. Control site was also located at Pulau Sepanggar. At each location, two stations were surveyed. Status of coral reefs was surveyed by using line intercept transect, coral reef fish visual census and invertebrate survey. Two 20 m line transects were laid at each depth. Sedimentation rates were measured using sediment traps which were placed at two different depths. The samples were collected once a month and further analyses were carried out in laboratory to determine total sediment trapped, calcium carbonate content, organic matter content and sediment composition. Water samples were also collected once a month for total suspended solids (TSS) analysis. Low fish abundance and diversity were sighted at reefs of Pulau Sepanggar. There was no indicator fish sighted at 5 m depth reefs surveyed at Pulau Sepanggar. Pulau Sepanggar was also low at invertebrates diversity compared to Batu Point. Majority of invertebrates sighted at Pulau Sepanggar were long-spined black sea urchins. Presence of crown-of-thorns starfish at control site is a matter of concern as its outbreak has a major damaging effect on reef corals. All reefs at 10 m depth had relatively good coral cover (61.48 ± 3.03 %). Reefs at both depths of Batu Point were categorized as good in terms of coral cover. Reefs of 5 m depth at Pulau Sepanggar fell into 'fair' category though reefs of 10 m depth were also considered in good condition. Higher coral diversity index was determined at Batu Point compared to Pulau Sepanggar. Yet, statistical test showed no significant difference in coral diversity with location and depth as factors. Higher sedimentation rate was recorded at Batu Point. Recreational activities at Batu Point were suspected to be the factor. Total suspended solids value was higher at Pulau Sepanggar than at Batu Point due to runoff of coastal development from Kota Kinabalu. Significant relationship between sedimentation rate and coral cover was not determined. Results suggested that more detailed study and continuous monitoring are required to investigate the effects of sedimentation on status of coral reefs.

STATUS TERUMBU KARANG DAN KADAR SEDIMENTASI DI PULAU SEPANGGAR DAN BATU POINT, PULAU GAYA, KOTA KINABALU

ABSTRAK

Sedimentasi merupakan salah satu factor degradasi terumbu karang di peringkat global. Kajian ini mengkaji kesan sedimentasi ke atas terumbu karang melalui perbandingan antara kawasan perlindungan marin (Batu Point, Pulau Gaya) dengan kawasan bukan perlindungan marin (Pulau Sepanggar) di Kota Kinabalu. Kawalan ditempatkan di Pulau Sepanggar. Dua stesen dikaji di setiap lokasi. Status terumbu karang dikaji dengan menggunakan transek garis, sensus visual ikan terumbu karang dan invertebrata. Dua transek garis berukuran 20 m dipasangkan di setiap kedalaman. Kadar sedimentasi diukur dengan menggunakan perangkap sedimen yang dipasang pada dua kedalaman yang berbeza. Persampelan dilakukan sebulan sekali dan sampel dianalisis dalam makmal untuk menentukan jumlah sedimen, kandungan kalsium karbonat, kandungan bahan organik dan komposisi sedimen. Persampelan air laut juga dilakukan sebulan sekali untuk analisis jumlah sedimen terapung. Bilangan dan diversity ikan adalah rendah di Pulau Sepanggar. Tiada ikan penunjuk direkodkan pada kedalaman 5 m. Diversiti invertebrata di Pulau Sepanggar lebih rendah daripada Batu Point. Majority invertebrata di Pulau Sepanggar ialah landak laut. Kehadiran tapak 'crown-of-thorns' di lokasi kawalan perlu diberi perhatian kerana percetusan species ini akan memusnahkan populasi batu karang. Semua terumbu karang pada kedalaman 10 m mempunyai litupan batu karang yang baik (61.48 ± 3.03 %). Litupan batu karang pada kedua-dua kedalaman yang dikaji di Batu Point adalah baik. Litupan terumbu karang pada 5 m di Pulau Sepanggar adalah sederhana walaupun litupan terumbu karang pada 10 m adalah baik. Index diversiti batu karang adalah lebih tinggi di Batu Point berbanding dengan Pulau Sepanggar. Namun, ujian statistik tidak menunjukkan perbezaan yang penting dalam diversiti batu karang antara lokasi yang berbeza dan kedalaman yang berbeza. Kadar sedimentasi di Batu Point adalah lebih tinggi. Faktor penyebab yang dijangkakan ialah aktiviti rekreasi di Batu Point. Jumlah sedimen terapung adalah lebih tinggi di Pulau Sepanggar berbanding dengan Batu Point disebabkan pengaliran masuk sedimen dari kawasan pembangunan persisiran pantai di Kota Kinabalu.Hubungan yang penting antara kadar sedimentasi dengan

litupan batu karang tidak dapat dibuktikan. Kajian yang lebih terperinci dan pemonitoran yang berterusan diperlukan untuk mengkaji kesan sedimentasi ke atas status terumbu karang.

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%	percent
°C	degree Celsius
cm^2	centimetre square
H'	Shannon-Wiener diversity index
HCl	hydrochloric acid
H_2O_2	hydrogen peroxide
µm	micrometer
m	meter
m^2	meter square
mg	milligram
ml	millilitre
L	litre
TSS	total suspended solids

CHAPTER 1

INTRODUCTION

1.1 Coral Reefs

Coral reefs are made of vast amounts of calcium carbonate ($CaCO_3$), limestone that is deposited by living things (Castro and Huber, 2003). These living things that help to build coral reefs are corals, algae and invertebrates such as sponges, clams, and bryozoans. Coral reefs have been estimated to occupy about 600,000 square miles of the surface of the earth, which represents about 0.71 percent of the total area of the planet (Nybakken, 1997). Coral reefs occur in many different sizes and shapes. In general, coral reefs are grouped into three categories which are atolls, barrier reefs, and fringing reefs.

Corals are a group of marine coelenterates which are mostly colonial but some are solitary and occur only in polyp stages. Most (true corals) of them belong to the order Madreporaria but some others belong to subclass Octocorallia. Besides a group of Hydrozoa, the *Millipora* and its allies are also called corals due to their skeletal structure but they have no real similarity with true corals. Madreporarian corals which are true corals are the builders of coral reefs and island (Bhamrah and Juneja, 2001).

The reefs are essentially massive deposits of calcium carbonate produced primarily by true corals with minor additions from calcareous algae and other organisms that secrete calcium carbonate. Hermatypic corals are those that produce reefs and are found only in the tropical regions; ahermatypic corals which are distributed worldwide do not form reefs. Hermatypic corals have in their tissues small symbiotic plant cells called zooxanthellae. These cells are not found in ahermatypic corals. Corals obtained food materials from the zooxanthellae. The zooxanthellae also enhance the ability of corals to lay down calcium carbonate. In return, the zooxanthellae in corals receive nutrients in the form of nitrates and phosphates produced in the metabolic processes of the coral that are rare in external waters (Nybakken, 1997).

1.2 Importance of Coral Reefs

Coral reefs protect coasts, making them safe for navigation, fishing and tourism. Reef structure acts as a breakwater, a natural barrier that reduces wave action, protecting the shorelines from erosion by waves and current. It also protects the coastlines from storm damage and flooding. Although coral reefs usually occur in low-nutrients waters, they are one of the most productive ecosystems on earth. Coral reefs are natural habitats and shelter for marine plants and animal. They are the reservoirs of biological diversity. Coral reefs are nursery ground for fishes, lobsters and prawns. Moreover, they harbor species yet to be identified (Kunzmann, 2004).

Coral reefs provide goods with a high value. Worldwide, reefs yield a value of about US$ 375 billion per year, of which US$ 100 billion is food from reefs or reef

environments. Coral reefs are sources of protein, food and foreign exchange. Reef dependent fisheries have been playing a significant role in the economy, particularly in tropical countries and some developing countries (Kunzmann, 2004). Furthermore, many plant and animals such as sponges, mollusks, fishes and echinoderms that grow on reefs are important in curio trade. On top of that, the coral reefs are of much importance to oil industry as they form highly valuable sites for the accumulation of petroleum deposits. Reef materials are also used as building materials. Coral skeletons are used in the formation of lime, mortar and cement (Bhamrah and Juneja, 2001). Besides that, coral reefs are world-famous tourist site. They have attracted tourists and divers from around the world. Hence, they are a vital source of income for many tropical countries (Chadwick, 1999).

Coral reefs have high pharmaceutical value too. Coral skeletons provide raw material for implant surgery. Many coral reef species contain bioactive substances that yield compounds active against inflammations, asthma, heart disease, leukemia, tumors, bacterial, fungal infections, and viruses, including HIV (Chadwick, 1999). They produce chemicals like histamines and antibiotics that can be used in pharmacology, medicine and science.

1.3 Reef Disturbance and Degradation

People in Southeast Asia have coexisted with coral reef ecosystems for thousands of years. Despite their worth, coral reefs in Southeast Asia face unprecedented threat levels from human activities. A report by World Resources Institute shows that almost 60 percent of all reefs worldwide are endangered though human disturbance or

activities, such as coastal development, overexploitation, destructive fishing methods, increasing sedimentation and eutrophication, and pollution from domestic and industrial sewage (Kunzmann, 2004). The report also shows that 80 percent of all reefs are negatively impacted in Southeast Asia.

Coral bleaching is a phenomenon which could cause catastrophic coral mortality. Coral bleach when they expel the zooxanthellae that normally inhabit their tissues. Following the expelling of the zooxanthellae, corals become white. If the zooxanthellae are absent for a significant time, the coral will die. Usually the bleaching affects most of the coral species and is most severe in shallow water areas (Nybakken, 1997).

1.4 Sedimentation

Sedimentation, resulting from land clearing, construction, mining, dredging and drilling activities, poses major threats to corals. While some coral species are able to tolerate varying periods of exposure to high levels of suspended sediment, high sedimentation adversely affects many aspects of coral survival, including coral growth and recruitment (English *et al.*, 1994). This can result in fewer coral species, less live coral, lower coral growth rates, greater abundance of branching forms and decreased net productivity.

An increase of sedimentation in reef waters can affect the coral cover and diversity by reducing light availability, increasing energy demand for self cleaning activities and smothering tissues if high accumulation occurs (Hoi, 2005).

Zooxanthellae need light for photosynthesis; hence corals can only grow in shallow water where light can penetrate (Castro and Huber, 2003). Sedimentation will reduce the primary energy source of the corals. Corals deal with excess silt, pollutants, and similar irritants by secreting more of the mucous protein that coats their outer tissue. This costs the coral energy. Another disadvantage is that viruses, bacteria, and fungi consider the slimy layer a fine place to breed. As corals continue to deplete their metabolic reserves and microbes prosper, infection occurs easily (Chadwick, 1999). Moreover, increasing energy demand for self cleaning will hamper other vital functions such as feeding, growth and reproduction (Hoi, 2005).

1.5 Reefs in Sabah

Destructive fishing and sedimentation are key pressures currently threatening reefs in Sabah (Burke *et al.*, 2002). Continuous sedimentation caused by coastal development in Sabah has led to degradation and death of coral reefs (Hoi, 2005).

The shallow reefs of Tunku Abdul Rahman Park used to boast fairly good diversity of marine life and interesting underwater scenery. However ongoing land reclaimation and development activities along the Kota Kinabalu waterfront have affected the general water quality of the coastal area and in the park (Ridzwan and Alex, 1996). High level of suspended particle or silt in the water column has led to sedimentation or siltation on the nearby coral reefs. On top of that, in May 1998, 30 to 40 percent of the live coral cover at Pulau Gaya, adjacent to the Park, was reported as bleached when the temperature reached 32 °C (Pilcher and Cabanban, 2000).

The construction of container port of the Sabah Ports Authority at Sepanggar Bay has resulted in sediments entering the water column during dredging and reclamation activities. Furthermore, reduced flow through the mouth of Sungai Menggatal led to deposition of suspended sediments carried through the river system. Besides that, Sungai Inanam has drained sediment directly into Sepanggar Bay. Heavy sediment loading has been related to the long term decline of reef in Kota Kinabalu area (Hoi, 2005).

1.6 Aims of Study

The purpose of this study is to determine the effect of sedimentation on coral reefs at Pulau Sepanggar and Batu Point, Pulau Gaya. The specific objectives of this study are:

i. To determine the abundance and diversity of fishes and invertebrates at Pulau Sepanggar and Batu Point, Pulau Gaya.

ii. To determine the coral cover and coral diversity at Pulau Sepanggar and Batu Point, Pulau Gaya.

iii. To measure the rate of sedimentation at Pulau Sepanggar and Batu Point, Pulau Gaya.

iv. To compare the status of coral reefs and rate of sedimentation at Pulau Sepanggar and Batu Point, Pulau Gaya with the control site at Pulau Sepanggar.

The scope of this study is to identify the effect of sedimentation on coral reefs by comparing a Marine Protected Area (Batu Point, Pulau Gaya) and a non-Marine Protected Area (Pulau Sepanggar).

1.7 Hypothesis

The hypothesis of this research is that sedimentation will affect the status of coral reefs, i.e. increasing the rate of sedimentation will result in decreasing the diversity of coral reefs. In this research, Batu Point, Pulau Gaya is expected to have a lower rate of sedimentation than Pulau Sepanggar as Pulau Gaya is within the Marine Protected Area. Meanwhile, Pulau Sepanggar will have a higher rate of sedimentation due to runoff of coastal development from Kota Kinabalu and its location which is near to two estuaries. Hence, Batu Point, Pulau Gaya is expected to have better coral reefs compared to Pulau Sepanggar. However, the control site, which is also at Pulau Sepanggar, is expected to be in pristine condition, with the assumption that it is not much affected by sedimentation from coastal development as it is at the opposite side of the island that is not facing Kota Kinabalu.

CHAPTER 2

LITERATURE REVIEW

2.1 Reef Building Corals

The reef building corals, also known as hermatypic corals, require warm, shallow waters, and are limited to continental island shores in tropical and subtropical zones (Bhamrah and Juneja, 2001). These corals are sensitive to the changing climate. A 1998 survey indicated that 16 percent of the world's reefs were destroyed during that year's El Nino event (Ahmed *et al.*, 2001).

Coral communities are also extremely sensitive to pollution and can only survive within small ranges of salinity, temperature and sunlight. Well-developed reefs require average salinities of around 35 parts per thousand. They occur where the average minimum water temperature is not less than 20 °C, usually in tropical waters between 25° north and south of the equator. As hermatypic corals contain symbiotic algae in their gastrodermal tissue, the distribution of reefs is therefore limited to those depths, which receive sufficient light for photosynthesis to occur. This can be up to 75 to 100 m. However, most active reef building occurs in the top 20 to 25 m of water (Johnston, 1986).

Colonies of corals grow slowly, seldom more than a half inch a year (Chadwick, 1999). Reef growth is inhibited where there is high turbidity and high sedimentation rates (Johnston, 1986).

2.2 Invertebrates

Invertebrate groups such as Giant Clams, edible sea cucumbers, Crown-of-Thorn starfish and Triton shell are important as they are indicators of the status of coral reefs. When populations of Giant Clams, edible sea cucumbers, lobsters, Tritons and cowries are rare, this may indicate that they are being exploited. Like other coral reef communities, invertebrates are targeted for collection and fisheries too. Edible sea cucumbers and Giant Clams are harvested for food. Meanwhile, Tritons and Cowries were collected for the curio trade. Besides that, attractive organisms such as Banded coral shrimps are not spared from the aquarium trade (Koh et al., 2002). Crown-of-Thorn starfish also poses threat to coral populations. This predator feeds on corals by extruding its stomach out onto the coral to digest the living tissue layer, causing the corals to bleach.

2.3 Coral Reef Fishes

Coral reefs harbor more species and diverse fish communities than any environment on earth. The most striking feature of coral reef fish is their biodiversity, in terms of both species number and the range of morphologies. There are more than 3000 coral fish species known in Southeast Asia (Kunzmann, 2004). This number increases as new exploratory surveys are done. The high diversity is partly due to the fact that

coral reefs provide a wide variety of habitats (Nybakken, 1997). Coral reefs encompass not only coral, but also areas of sand, various caves and crevices, areas of algae, shallow and deep water, and different zones progressing across the reef.

Coral reef fish communities play an important role in coral reef ecosystem, for example, they act as grazers which control algal growth (English *et al.*, 1994). Coral reef fishes are of considerable economic value to the adjacent coastal cities. They are commercially important for both fisheries and tourism. There are professional and recreational fisheries in developing and developed countries around the world, which target for selected high value species. Apart from this, there is a growing aquarium fish industry for many small reef species in many parts of the world.

The reef fishes of Southeast Asia are an intimate part of the huge Indo-Pacific fish community. Nearly all the families, genera and many individual species are distributed throughout the tropical Indian and Pacific Oceans (Allen, 1996). According to Allen, 1996, the eleven most common families on a typical reef are gobies (Gobiidae), wrasses (Labridae), damselfishes (Pomacentridae), cardinalfishes (Apogonidae), groupers and anthias (Serranidae), surgeonfishes (Acanthuridae), blennies (Blennidae), butterflyfishes (Chaetodontidae), snappers (Lutjanidae), pipefishes (Syngnathidae), and parrotfishes (Scaridae).

2.4 Threats to Coral Reefs

Major threat factors to coral reefs can be classified as natural or human-induced. Natural threat factors include climate change, tropical storms and coral diseases.

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