The present status of coral reef condition in Bunaken National Park and Manado Bay, North Sulawesi, Indonesia

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Abstract Manado Bay fronts Manado City, North Sulawesi with its total population of ca. 500,000 people. In 1992, the government established a National Park in the bay to protect coral reef ecosystems on five particular islands facing Manado Bay. Life Form Category by Linear Intercept Transect in 2 sites has good conditions (ca. 55%), 2 sites have moderate (ca. 30%), and the other 2 (two) sites are in a poor condition (<20%). In comparison to studies from the early 1990s the present coral condition seems to have decreased. Anthropogenic activities from the city and the increasing number of foreign and domestic visitors who dive in the park are probably the cause of the park’s coral deterioration in Manado Bay. Since 1996, new construction and coastal reclamation in the city have also used the hard substrates for new coral recruitment. However, the excellent grade of water quality in the bay is an important factor in which the new coral colonies have successfully settled on the new hard substrate.

Keywords coral, life form, reclamation, water quality

Introduction

Bunaken National Park (BNP) and Manado Bay are adjacent to the waters of the Sulawesi Sea. Both areas have ecologically important roles for fisheries and the tourism of Manado City as well as North Sulawesi; especially with the presence of the coral reef ecosystem. Manado City is populated with ca. 500,000 people and is transversed by 6 rivers that have an outlet to the bay. Since BNP was established in 1992, the tourists who visit the park for diving or other ecotourism reasons have strongly increased. Therefore, this has no doubt influenced the tolerance level according to the carrying capacity of the park. As such, the coral reefs, as one of the ecological values to both areas, might be threatened as well. The aim of the present study is to clarify the current coral reef conditions in those areas and to compare them with previous studies to determine whether the coral reefs have changed or deteriorated.

Material and methods

The field studies were conducted at 5 diving points
(Mike’s Point, Cha-cha House Reef Point, Fukui’s Point, Tawara’s Point, and Raymon’s Point) on Bunaken Island of BNP and 3 points at Manado Beach using SCUBA for underwater measurements, recordings, and observations. The living hard coral percentage was calculated using LIT (Line Intercept Transect) method, and was then analyzed using Life Form Category (English et al. 1997) in order to know if, at a particular, area there were some living hard corals. This can be described by determining the Mortality Index (Gomez et al. 1994) and the interaction between corals and their associated organisms. Therefore, butterfly fishes (Family Chaetodontidae) were observed and counted by visual census by following the length of LIT transect (100 m) and observed all butterfly fish within 2–5 m on the left and right sites of the transect. The observation thus covered about at least 400 m² for each transect. Physical environmental parameters such as temperature, salinity, and visibility have also been measured as well as water chemical quality around the study areas. The water samples from each diving point were collected underwater (5 m depth) and put to the black bottle sample that already in the cooler box. Afterwards, all water samples were brought to the recommended laboratory to measure some environment important parameters such as Fluoride, Nitrate, Nitrite, Cyanide and Sulphate.

Results

According to the scale used by Yap and Gomez (1984), these results show that 2 diving points in the Bunaken National Park site are still in good condition (50–60%), and those are: Mikes’ Point and Fukui’ Point, 2 other diving points are in moderate condition (30–40%), and one diving point is in poor condition (<20%). Figure 1 shows the percent coral coverage at each point. 46 hard coral genera from 96 species were found in the BNP sites, while 43 hard coral genera from 180 species were found in Manado Bay. All sites were dominated by genus Acropora Oken, 1815. The mortality Index of 5 points at Tawara’s Point showed a higher (78.84%) than the other points. Mike’s Point and Fukui’ Point had lower percentages in this index: 39.99% and 45.49% respectively. While Cha-cha House Reef and Raymonds at moderate levels of 63.81% and 66.13%. Figure 2 shows the result of the Mortality Index at these points.

The seawater physical parameters (temperature, salinity, and visibility) of all diving points in Bunaken Island were at a normal condition that is suitable for coral growth. Water chemical quality that was measured at each diving points were also at normal levels according to the government rules of seawater limited thresholds. According to the coral organism growth requirements, the physical parameters were at a normal level for efficient coral growth. The salinity in both areas was approximately 33–35‰ and the water temperature was between 27–29°C. The visibility of the water column, especially at the BNP sites, was sufficient for light penetration to a depth of 24–28 m. These results clearly show a significant correlation with the percentage coverage of living hard coral. According to the threshold level of some important water chemical qualities for the National Park and for marine organisms as decided by the Environmental Ministry of Indonesia.

![Fig. 1](image1.png)

Fig. 1  Living Hard Coral Percent Coverage of 5 diving points at Bunaken Island, Bunaken National Park, North Sulawesi (75–100% Excellent; 50–74% Good; 25–49.9 Moderate; 0–24.9% poor (Yap and Gomez 1984)
the Republic of Indonesia (Anonymous 2004) such as Fluoride Standard Level (SL) 15.0 mg/l found arr. 0.00–0.03, Nitrate (SL 10.0, found arr. 0.08–0.12), Nitrite (SL 0.6, found arr. 0.004–0.011), Cyanide (SL 0.2, found arr. 0.001–0.003) and Sulphate (SL 4.0 found arr. 0.39–0.42) no concentration was above the standard level.

In the Manado Coastal Site, the three study sites are located in the front of reclamation area. Figure 3 shows that all 3 sites are in a moderate condition. No site is in a good or excellent condition or even in a poor condition, since the coral reefs on this area have just been established recently about 10 years ago. A mortality determination study on this young coral reef ecosystem was not conducted.

As evidenced, in the BNP sites, about 31 species of butterfly fish were found from among 619 individuals, and in the Manado sites, 10 species out of 198 individuals. Both areas are mostly dominated by species _Chaetodon kleinii_ Bloch, 1790.

### Discussion

The increasing number of visitors in Bunaken National Park, especially for diving or underwater ecotourism, in Bunaken Island, is beneficial to the economic development of North Sulawesi. However, some are concerned about the status of Bunaken National Park as a conservation area. Therefore, the economic factor of ecotourism’s activities on this park should be reconsidered. Turak and de Vantier (2004) concluded that the carrying capacity of the whole park in regards to diving activities, remains below the threshold level, however, monitoring and evaluation research in the park since 1993 (Kusen et al. 1993) has demonstrated that the status of the coral reef is not good or excellent. In regards to the Life Form Category, it is but only moderate. This condition has not significantly changed according to previous research conducted between 2000–2004 (Gumolili 2004), especially in the Bunaken Island waters. The present study generally shows a more improved condition since, in the Life Form Category, two of the five diving points are shown in a good condition (50–60%). However, one study site (Site I) was found in the poor category. However, Kusen and Rondo (1992) observed that the percent coverage of hermatypic coral at Bunaken Island, before it was established as a national park, was in an excellent condition (75.52%).

The coral reef on the outside walls of the reclaimed area of Manado City (a commercial construction area) that was constructed from enormous sized stones was also found to be in moderate condition. These stones in the wall beneath the surface also function as a hard substrate for coral planula. As such, the coral organisms in this area have just settled and grown since 1996 and are no more than 15 years old in comparison to the Bunaken Island coral reef ecosystem. The living hard coral percent coverage was high at Mike’s Point and Fukui’ Point but showed a low Mortality Index. From these data, we could assume that these areas were in a good or even excellent condition in the Life Form Category. The environmental physical parameters showed no change since 1993 (Kusen et al. 1993), and these conditions are optimal for coral animal growth. The water chemical quality parameters are also below threshold levels and no chemicals have been introduced to the environment. The possible threats from anthropogenic activities from the city through its six rivers
as inlets into Manado Bay might not significantly influence the water quality so far, although some of the Manado City people use the rivers to dispose of domestic sewage. The water’s physical and chemical qualities strongly influence coral growth and survival for Manado Bay waters and the surrounding area of the BNP. These areas are supported by good water conditions because of the current patterns, semi diurnal tide patterns, as well as current velocity; all of which simultaneously provide regular water mass changes in those areas. The status of the coral reef, indicated by the presence of one of the coral reef ecological indicators: the associated organism, fishes from the Family Chaetodontidae (butterfly fishes) found in BNP and in the Manado coastal area (especially at the reclamation area). It is well-known that butterfly fishes only exist where corals grow well, especially branching corals such as Acropora sp. Oken, 1815. Most branching coral are found in all sites dominated by coral species from the genus Acropora.

In conclusion, the present status of the coral reef condition in BNP and Manado Bay are generally in a moderate Life Form Category. Therefore, ecological protection should be considered and then enforced by the city and provincial management as well as the central government. The important role of coral reefs as germ cell banks for fisheries and related organisms should be a high priority. The aesthetic configuration of coral reefs for underwater tourism, which also has beneficial impacts of coral reef conservation, should be well managed and should not go beyond the area’s carrying capacity. The monitoring and evaluative research in both areas should regularly be established at the appropriate time series to update data and information.

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