Coral disease at Mansuar Island, Raja Ampat, Indonesia

B Subhan¹, D Arafat¹, F Rahmawati¹, YH Dasmasela², Q M Royhan¹, H Madduppa¹, P Santoso¹ and B Prabowo¹

¹Department of Marine Science and Technology Faculty of Fisheries and Marine Science, IPB University, Indonesia
²Faculty of Fisheries and Marine Science, University of Papua, Indonesia
*e-mail: beginersubhan@apps.ipb.ac.id

Abstract. Coral reef has been facing rapid destruction nowadays. Raja Ampat Islands in Papua has one of the highest coral reef diversities and is located within the Coral Triangle area. The coral condition in Raja Ampat is still categorized as healthy. However, it started to show some of the habitat degrading signs. Coral disease is one of the main causes in coral reef ecosystem decline. This study aims to measure the level of coral disease based on coral disease category prevalence observation at Mansuar Island in Raja Ampat, Papua. The method used in data sampling is by using 5 x 50 m Belt Transect. The results show that as many as 28 coral genera were found from all of the observation sites with Fungia being the most abundant. There are 7 coral health categories, dominated by Tissue Discoloration Non-White. There are 5 coral diseases found namely Yellow Band Disease, White Syndrome, Brown Band Disease, Atramentous Necrosis, and Ulcerative White Spots.

1. Introduction
Coral reef is a component of marine ecosystem which boasts high diversity and productivity. But nowadays this coral reef has been undergoing a major decline. According to previous research around 19% of the coral reef ecosystem on earth has been destroyed with no chance of recovering, 15% with high risk of human activity pressure within 10 to 20 years, and 20% is threatened by destruction in the long run [1].

Raja Ampat Islands in Papua has high natural resources, especially marine ecosystem. Raja Ampat consists of several large islands such as Waigeo, Batanta, Salawati, Misool and hundreds of small islands in the adjacent areas. Those are a part of Coral Triangle area which boasts the highest marine diversity on earth [2]. According to [3] the coral reef condition in Raja Ampat Islands can be categorized as healthy. But signs of habitat destruction have emerged due to fish bombing and fish poisoning [2].

The survival of the coral reef largely depends on impacts from human activities such as climate change, terrestrial and marine pollution, habitat degradation, overfishing, coastal development, fish bombing, waste dumping, beach reclamation, ship grounding around the coral reef, tourism, etc [4][5]. It is inevitable that tourism also plays a part on coral disease outbreaks in coral reef area.

Coral disease is one of the main causes of coral reef habitat degradation on earth [6]. The main reason is still unknown, but it was assumed that human activities have altered the environmental condition in coral reef area and therefore decreasing the resilience of the coral towards microbial infection and also increase the pathogen virulence[7]. According to [8] the level of threat on coral reef in Indonesia that was caused by human activity reached 95%. Coral could be categorized as healthy, bleached, or infected.
The most common coral diseases according to [9] are Black Band Disease, Skeletal Eroding Band, White Syndrome, Brown Band, Tumor, Black Necrosing Syndrome, and Pigmented spots. [10] has his own category to identify the coral health namely Tissue Loss-Predation, Tissue Loss-non-Predation, Tissue Discoloration-White, Tissue Discoloration-non-White, Growth anomalies, and Compromised Health.

Mansuar Island is a part of Dampier Strait marine conservation area and as diving site. At present there is a few information or research on coral disease in Mansuar Island Raja Ampat. This research aimed to measure the level of coral disease based on coral disease category prevalence observation at Mansuar Island, Raja Ampat, Papua.

2. Materials and methods

2.1 Time and location

This study was conducted on August 8th – 9th 2010 at Mansuar Island in Raja Ampat, divided into 3 different sites.

Table 1. Location of sampling station.

| Diving Location | Latitude(N/S) | Longitude(E) |
|-----------------|---------------|--------------|
| Site 1          | 00°34’17.8"   | 130°39’36.8" |
| Site 2          | 00°35’25.9"   | 130°36’11.8" |
| Site 3          | 00°36’12.4"   | 130°33’26.5" |

SCUBA and underwater camera are used as main tools for field data sampling. The sampling method is by using 5 x 50 m belt transect. All corals would be observed within the transect area. The observation includes coral identification up to the genus level and coral health classification (healthy or infected) using Underwater Cards for Assessing Coral Health on Indo-Pacific Reefs. [10] is also used for determining the coral health.

The prevalence of coral disease is determined by recording the number of infected coral cases and the total number of healthy corals per unit area (in this case 250 m²). The prevalence value is used to determine the coral disease which infect the coral [10]. The abundance of coral disease is calculated by dividing the total number of one particular infected coral with the total number of infected corals [10].

Figure 1. Study site Mansuar Island, Raja Ampat, West Papua.
3. Results and discussion

Based on the observation conducted in Raja Ampat, as many as 28 genera were found, namely Acropora, Ctenactis, Diploastrea, Echinopora, Favia, Favites, Fungia, Galaxea, Goniastrea, Goniopora, Herpolitha, Hydnopora, Millepora, Montastrea, Montipora, Mycedium, Oulophyllia, Pachyseris, Paraclavarina, Pectinia, Physogyra, Platygyra, Plerogyra, Pocillopora, Porites, Sandalolitha, Serriatopora, Stylophora.

![Coral Genus Abundance](image)

**Figure 2.** Genus abundance in Mansuar Island.
Fungia is the most dominant genus with total number of 61.7 ± 28 (individual), while Galaxea, Goniopora, Hydnophora, Montastrea, Mycedium, Oulophyllia, Palaclavaria, Pectinia, Physogyra, dan Plerogyra are the least dominant genus, recording just 1 individual each.

The coral health condition in Raja Ampat is divided into 7 different categories, namely Tissue Loss-Predation, Tissue Loss-Coloured Band Disease, Tissue Loss-No Overlying Band of Coloured Material, Tissue Discoloration-White, Tissue Discoloration-Non-White, Growth Anomalies, and Compromised Health. On Tissue Loss- Predation category a Brown band disease was found, while on Tissue Loss-No Overlying Band of Coloured Material category Ulcerative White Spots (UWS), White Syndromes (WS), and Atramentous Necrosis (AtN) were found.

A Focal bleaching (FBL) and Non focal bleaching (NFBL) were found in Tissue Discoloration-White category. Pigmentation Response (PR) and Yellow Band Disease (YBD) were found in Tissue Discoloration-Non-white. Explained Growth Anomalies (EGA) and Unexplained Growth Anomalies (UGA) were found in Growth anomalies. Competition and Sedimentation Damage were found in Compromised health category. The Tissue Discoloration-Nonwhite category percentage has the highest value, 27.65 ± 5.31 % and growth anomalies has the least value, 1.14 ± 0.66 %.

Table 2. Coral health and diseases in Mansuar Island.

| Site | Coral Health and Diseases Category | Genus |
|------|----------------------------------|-------|
| 1.   | Brown Band Disease               | Porites Fungia |
| 2.   | Competition-Agressive Overgrowth | Acropora Fungia |
|      |                                  | Goniatrea Pocillopora |
|      |                                  | Montastrea Seriatopora |
|      |                                  | Goniopora Montipora |
|      |                                  | Porites Ctenactis |
| 3.   | Focal Bleaching                  | Acropora Fungia |
| 4.   | Non Focal Bleaching              | Ctenactis Fungia |
| 5.   | Pigmentation Response            | Acropora Porites |
| 6.   | Predation                        | Goniastrea Montipora |
| 7.   | Sedimentation Damage             | Acropora Diploastrea |
The type of coral diseases found in Raja Ampat based on the observation ranges from 10 – 12 types of diseases (Table 2). Coral diseases was found in Site 3 has namely Atramentous necrosis, Brown Band Disease, Unexplained Growth Anomalies, White Syndrome, and Yellow Band Disease (Figure 7).
On site 2, as many as 10 types of Coral health category were found (Figure 6) which includes all the diseases from site 3 (excluding Expanded Growth Anomalies dan Unexplained Growth Anomalies). Spatially, almost all types of diseases are evenly distributed. At least each types of disease could be found in every site, with the exception of Expanded Growth Anomalies, Unexplained Growth Anomalies and Ulcerative White Spots. Competition – Aggressive Overgrowth is the most common diseases found in all of the genus. On site 1 there are 10 genus that were infected (Figure 4), 9 genera for site 2 and 7 genus for site 3.

Prevalence of Yellow Band Disease has the highest value (23.58 ± 4.62 %). This disease commonly attacks corals from Fungiidae family, especially *Fungia* and *Ctenactis*, but can also be found in other genus such as *Sandalolitha, Porites, Favia, dan Herpolitha*. Yellow Band Disease is initially found only
in Caribbean water [11]. But [12] found a similar lesion on disease outbreaks on Diploastrea sp., Herpolitha sp., and Fungia sp. in Indo-Pacific water. Yellow Band Disease in Indonesia was originally found on Fungiidae family in Bali in 2005 and in Gili Trawangan in 2007 [13]. Then [14] found that this disease attacked a family of Fungiidae in Pramuka Island, Kepulauan Seribu with a staggering 68% percentage.

Yellow Band Disease infects symbiotic algae that lives inside the coral and causes cell damage [15]. The pathogen that is responsible for this disease is *Vibrio* bacteria, especially *V. alginolyticus* and *V. harveyi* [12][13][15]. The resulting impacts are that of slow growth rate, biomass decline and inability of corals to reproduce [12]. The prevalence value from White syndrome disease is 3.2 ± 1.7 %. This disease is found infecting *Fungia, Stylophora, Montipora, Sandalolitha, Ctenactis, Acropora,* and *Porites.* White Syndrome is a disease which punctuated with a white area as a result of rapid coral tissue decay where it leaves a distinctive mark between the healthy tissue and the infected tissue [16]. White Syndrome disease has been found all over the globe such as in Caribbean, Great Barrier Reef, Red Sea and Kepulauan Seribu (Hobbs and Frisch 2010; Subhan et al. 2011). It is a result of Programmed Cell Death (PCD) or intrinsic factor, pathogen driven, stress caused by physiologic factor, or a combination of both [16].

The prevalence of Brown Band Disease has a value of 2.25 ± 0.03 %. This disease is found on all of the sites. Corals infected by this disease are among others *Porites, Fungia, Echinopora, Pachyseris, Seriatopora,* dan *Acropora.* It is first found in Great Barrier Reef [9]. This disease is marked with a wide area of brown zone that divides the healthy tissue and the infected tissue. The brown color is a result from groups of ciliophora that infect the zooxanthellae tissue. According to Sweet and [17], cilia that comes from *Scuticociliatia* subclass is proved to be swallowing symbiotic algae in whole and generates symptoms of that of Brown Band Disease.

The prevalence of Atramentous Necrosis disease has a value of 0.75 ± 0.44 %. This disease infects *Montipora, Favites, Pectinia,* and *Echinopora* and was only found in site 2 and 3. This disease is marked with gray lesion which is actually black but is covered by white layer [18]. Originally it started with one tiny bleaching spot, then followed by a loss of tissue and combination of adjacent lesions [4]. According
to[18] this disease is closely related to the sea water temperature, because [19] found out the symptoms of Atramentous Necrosis in Magnetic Island, Great Barrier Reef is apparent where the temperature is at its peak and dissapeared as soon as the temperature goes down, but appears again when the temperature goes up again. The most commonly infected corals are Montipora, Acropora, Echinopora, Turbinaria, and Merylina [4].

The prevalence of Ulcerative White Spots has the least value of 0.38 ± 0.38 %. This disease is only found infecting Ctenactis. This disease is usually found on Porites, but the observation explained otherwise. This disease is marked with a white round shaped small lesion (3-5 mm) and spread throughout coral colonies. The originally white spot could eventually lead to tissue damage and coral death[20]. Prevalence from Pigmentation Response has a value of 4.07 ± 1.98 %. This disease is found infecting Ctenactis, Fungia, Montipora, Sandalolitha, and Porites. According to [10] Pigmentation Response is not a coral disease. The symptoms of this disease si marked with bright colored lesion such as pink or purple on Porites and bright blue on Acropora. The lesion could be a line, a bulge, an aggregation, or randomly shaped. Pigmentation Response is a response from corals towards any kind of disturbance such as algae, other invasive organisms, competitor [4].

Coral bleaching can be found with two patterns, one is focal bleaching and the other one is non focal bleaching. Prevalence of focal bleaching is 4.70 ± 1.72 %. Focal bleaching usually attacks Porites, Ctenactis, Acropora, Sandalolitha, and Fungia. Prevalence of non-focal bleaching is higher at 9.01 ± 2.26 %. Non focal bleaching usually attacks Acropora, Fungia, Ctenactis, Seriatopora, Favites, Goniastrea,Favia, and Montipora.

Coral bleaching is a symptom of degrading coral health caused by various environmental stresses [21]. The main cause is among other the drastic changes of sea water temperature, sun radiation intensity, a combination of both, declining salinity, bacterial infection, high turbidity, sedimentation and pollution[3][22][4] categorized coral bleaching as a health disturbance and not a disease. The reason behind this is because in coral bleaching the tissue is still intact and alive despite losing its symbiotic algae (zooxanthellae). The loss of this symbiotic algae eventually caused loss of pigmentation and hence the white coloration is present.

Figure 7. a) Pigmentation Response; b) Competition – Sponge; c) Predation-Drupella; d) Filamentous Algae; e) Atramentous Necrosis.
Sedimentation damage is visible on *Goniastrea, Acropora, Porites, Diploastrea, Montipora, Pachyseris,* and *Echinopora* with prevalence value of 3.38 ± 1.74 %. Sedimentation damage is a symptom of coral health disturbance where the coral surface is covered by fine sediment, resulting in tissue loss. The main causes are turbid water, dredging activity, runoff from terrestrial area through rivers or directly to the ocean [4,23].

Prevalence from competition – Agressive Overgrowth has the highest value (20.48 ± 0.57 %) and is a coral health coral disturbance where other organisms grow above the living coral tissue, causing the coral to be stressed. Common organisms found to be competing with coral are cyanobacteria (algae), sponges and red filamentous algae. Competition by cyanobacteria is marked with a chunk of fine gray, orange and yellow-colored algae attached to the coral surface, covering the tissue[10]. Competition from sponge is characterized by the presence of sponge above the coral surface with a white distinctive line as a border. Rapid sponge growth could lead to coral death[10]. While competition from red filamentous algae is characterized by the attachment of filament on mucus surface which accumulate sediment[10].

Explained Growth Anomalies has a prevalence value of 0.63 ± 0.63 % and an invertebrate galls is present in the coral. Invertebrate galls is a symptom where the coral changes its skeletal form due to the presence of invertebrate such as crab or barnacle[10]. In this study, invertebrate galls infects *Stylophora, Porites,* and *Echinopora.* Unexplained Growth Anomalies has a small prevalence value of 0.51 ± 0.33 %. On Unexplained Growth Anomalies irregular white plaques are commonly found. The symptom is characterized by circle to randomly-formed lesion with normal to bright colored, sometimes even bleaching and the skeleton (coralite, ridges, valley) is chaotically formed [10]. Irregular White Plaques only hit *Acropora.*

Prevalence value by predation is 6.27 ± 1.29 %. In the study location, a predation by *Drupella* and *Coralliophila* was present. Drupella predation is characterized by the randomly-shaped loss of tissue caused by biting. The lesion pattern is usually shaped from bottom to the upper side [10]. Drupella predation could be identified by the looking around the lesion or around the colony. Coralliophila predation is characterized by the presence of Coralliophila snail which lives on coral and the scar from the biting could be clearly seen. The result is the loss of tissue therefore the coral would be more vulnerable to diseases [10].

### 5. References

[1] Wilkinson C 2002 Status of Coral Reefs of the World: *Coral Reefs*

[2] McKenna S A, Allen G R and Suryadi S 2002 *A Marine Rapid Assessment of the Raja Ampat Islands, Papua Province, Indonesia*

[3] Turak E and Souhoka J 2003 Coral Diversity and the Status of Coral Reefs in the Raja Ampat Islands *Report on a rapid ecological assessment of the Raja Ampat Islands, Papua, Eastern Indonesia held October 30 – November 22, 2002. Final Draft November 2003*

[4] Raymundo L J, Couch C S, Bruckner A W and Harvell C D 2008 *Coral Disease Handbook: Guidelines for Assessment, Monitoring & Management*Westmacott S, Teleki K, Wells S and West J 1948 *Management of Bleached and Severely Damaged Coral Reefs*

[5] Harvell C, Jordan-Dahlgren E, Merkel S, Rosenberg L, Raymundo G, Smith E and Willis B 2007 Coral disease, environmental drivers, and the balance between coral and microbial associates *Oceanography* 20 173–95

[6] Lamb J B and Willis B L 2011 Using Coral Disease Prevalence to Assess the Effects of
Concentrating Tourism Activities on Offshore Reefs in a Tropical Marine Park

Conservation Biology

[7] Burke L, Reyntar K, Spalding M And Perry A 2012 Reefs at Risk Revisited in the Coral Triangle
[8] Willis B L, Page C A and Dinsdale E A 2004 Coral Disease on the Great Barrier Reef Coral Health and Disease
[9] Beeden R, Willis B, Raymundo L, Page C and Weil E 2008 Underwater Cards for Assessing Coral Health on Indo-Pacific Reefs (The University of Queensland: Australia.)
[10] Cervino J, Goreau T J, Nagelkerken I, Smith G W and Hayes R 2001 Yellow band and dark spot syndromes in Caribbean corals: Distribution, rate of spread, cytology, and effects on abundance and division rate of zooxanthellae Hydrobiologia
[11] Dona R, Cervino J, Goreau T, Bartels E, Hughen K, Smith G and A Dona 2008 Coral Yellow Band Disease; Current Status in the Carribean, and Links to New Indo-Pacific Outbreaks Proceedings of the 11th International Coral Reef Symposium (Florida)
[12] Cervino J M, Thompson F L, Gomez-Gil B, Lorence E A, Goreau T J, Hayes R L, Winiarski-Cervino K B, Smith G W, Hughen K and Bartels E 2008 The Vibrio core group induces yellow band disease in Caribbean and Indo-Pacific reef-building corals Journal of Applied Microbiology
[13] Subhan B, Rahmawati F, Arafat D and Bayu N A 2011 Kondisi kesehatan karang fungiidae di perairan Pulau Pramuka, Kepulauan Seribu Jurnal Teknologi Perikanan dan Kelautan
[14] Cervino J M, Hayes R L, Polson S W, Polson S C, Goreau T J, Martinez R J and Smith G W 2004 Relationship of Vibrio species infection and elevated temperatures to yellow blotch/band disease in caribbean corals Applied and Environmental Microbiology
[15] Ainsworth T D, Kvennefors E C, Blackall L L, Fine M and Hoegh-Guldberg O 2007 Disease and cell death in white syndrome of Acroporid corals on the Great Barrier Reef Marine Biology
[16] Sweet M and Bythell J 2012 Ciliate and bacterial communities associated with White Syndrome and Brown Band Disease in reef-building corals Environmental Microbiology
[17] Anthony S L, Page C A, Bourne D G and Willis B L 2008 Newly characterized distinct phases of the coral disease “atramentous necrosis” on the Great Barrier Reef Diseases of Aquatic Organisms
[18] Jones G P, McCormick M I, Srinivasan M and Eagle J V. 2004 Coral decline threatens fish biodiversity in marine reserves Proceedings of the National Academy of Sciences of the United States of America 101 8251–3
[19] Raymundo L J H, Harvell C D and Reynolds T L 2003 Porites ulcerative white spot disease: Description, prevalence, and host range of a new coral disease affecting Indo-Pacific reefs Diseases of Aquatic Organisms
[20] Santoso DA 2006 Pemutihan Terumbu Karang Jurnal Hidrosfer 2 61–6
[21] Brown BE 1997 Coral bleaching: causes and consequences Coral Reef 16 S129-S138
[22] Rogers C 1990 Responses of coral reefs and reef organisms to sedimentation Marine Ecology Progress Series