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Status of coral reefs conservation using coral morphological classification in Wakatobi National Park

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Abstract. Coral reef ecosystems are one of the most productive natural resources of biodiversity in coastal areas. Estimates of the value of coral reef conservation can be used to select which areas are most suitable for protection within zones or zones of marine protection. This study aims to look at the protection status of coral reefs based on the coral morphology classification approach in Wakatobi National Park (WNP). Implementation of research in September 2016 to November 2017 in WNP, Southeast Sulawesi. This research method is built with a conservation classification based on three angles diagrams namely r (ruderals), K (Competitors), and S (Stress-Tolerators). The results of diagram analysis for 29 observation stations showed that the location was categorized into 11 locations for ruderal, 6 locations for competitors and 12 locations for mixed categories. The strategy for managing coral reefs in conservation areas can be done by looking at locations that are prioritized for protection, therefore morphology-based classification approaches can be applied in assessing the health conditions of coral reefs. For policy makers it is very helpful in determining the direction of area management, especially in the protection of coral reefs.

1. Introduction
Coral reefs can support livelihood activities in coastal areas [1, 2]. More than 275 million people live close to coral reefs, having ecological, social and economic benefits [3]. Coral reefs can be said to be tropical forests of marine ecosystems, play an important role in protecting coastal areas from the threat of damage and besides having very high biodiversity [4].

Wakatobi National Park (WNP) is the second large-scale conservation area in Indonesia covering 1.3 million hectares located in the world triangle of coral reefs, its waters are affected by the Bali Flores Sea ecoregion. WNP area has a high diversity of marine resources, one of which is a supplier of fish larvae [5, 6, 7]. Coral reef areas are used as fishing grounds, marine tourism, and inter-island access points. The beauty of enchanting coral reefs makes Wakatobi as one of the best diving locations by world divers. 396 scleractanian coral species and 31 fungi coral species in the region were recorded [8, 6, 9].

The existence of coral reefs is threatened by damage, according to Wilson et al. [10]; Roth et al. [11]; WWF [9], a serious threat related to the sustainability of coral reef conservation is, such as overfishing by destructive means, the occurrence of sea water temperature rise which results in bleaching of coral colonies, sea sand mining and development in coastal areas. Excessive fishing eliminates potential predators that compose, control populations and species dominance [12, 13]. At present the role of stakeholders in the conservation area of TNW has quite a lot of functions and objectives, starting from the central and regional governments, local communities, *adat* (local) stakeholders, private sector, NGO and academics [14].

So far, the definition of the health status of coral reefs is only based on the percentage of live coral cover, not equipped with other indices such as conservation classes which are more accurate to predict the value of biodiversity and fishery potential [15]. The value of coral reef conservation can predict the condition of coral biodiversity, invertebrates, fish, the potential for fish abundance and habitat for endangered animals in a watershed [15]. For decision makers by knowing the conservation value of an area, it can be easier for managers to formulate policies for the determination of protection zones.

Estimates of the value of coral reef conservation are carried out to select which areas are most suitable for protection within the marine protection zoning area [16]. Based on this, the purpose of this study was to analyze the status of coral reef conservation and classify coral reef communities based on morphology (life form) to predict the value of coral reef conservation as a consideration in the conservation management process.

2. Material and Methods

The research is conducted from September to November 2016 and September to November 2017. The study is located at the four main islands in WNP namely Wangi-wangi, Kaledupa, Tomia and Binongko, Wakatobi Regency, Southeast Sulawesi Province (Fig. 1). Data collection uses survey and observation methods. Data collected consists of primary and secondary data.
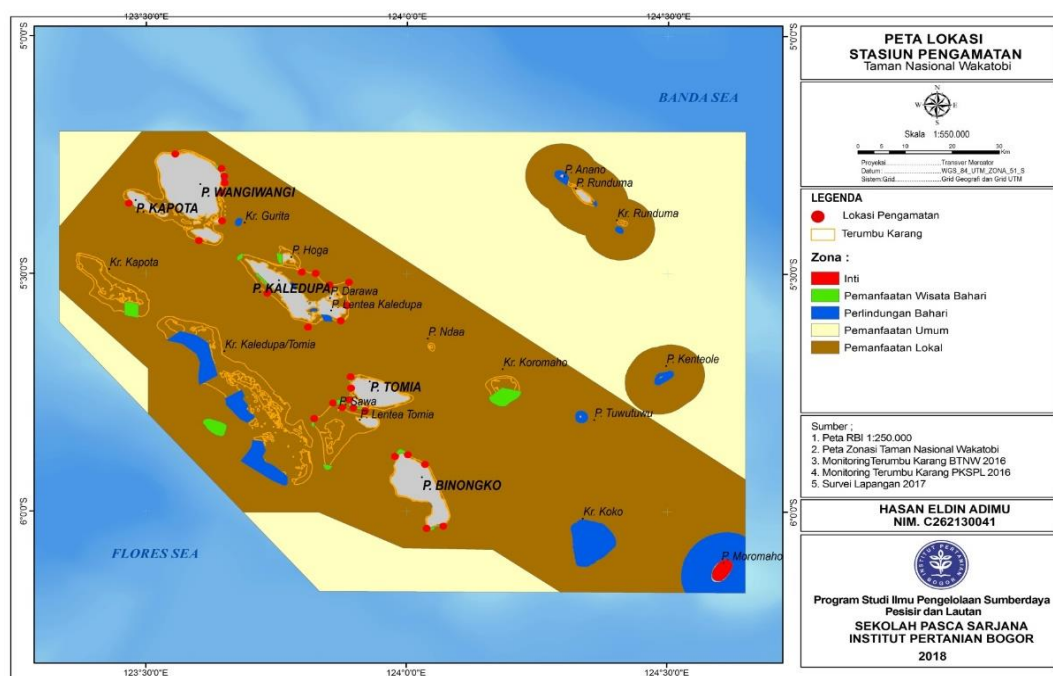

Figure 1. Map of coral reef observation stations in WNP.

Observation of coral cover was carried out at 29 stations using the Point-Intercept Transect (PIT) method on coral form and other basic substrate on certain forms [17, 18]. The registrar is tasked with recording the life form data of the coral/base substrate at each interval at depths of 3-10 meters, which is noted, is that the coral/base substrate life form is right below those points. Recording starts on the first

roll meter at the point 0.5 m then 1 m, 1.5 m, 2 m... and so on, up to the point 50 m. Data collection was also carried out through coral video transect (CVT) [19] video transect (carried out when the transect was installed with the recording position directly above the transect until the end of the transect. The depth of transect was at 3-10 meters intervals.

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The data for filling out the analysis of the r-K-S triangle in (Fig. 2) are derived from the percentage of live coral cover data, which can be seen from the morphology and life form of coral found at the observation station. After that, the percentage of life cover (percent life cover) is calculated. The results of the sum cover sum of the live coral forms are then categorized in 3 groups of coral adaptation strategies, namely: ruderals (r), competitors (K) and stress-tolerator (S). The sum of the three categories is always 100% [15].
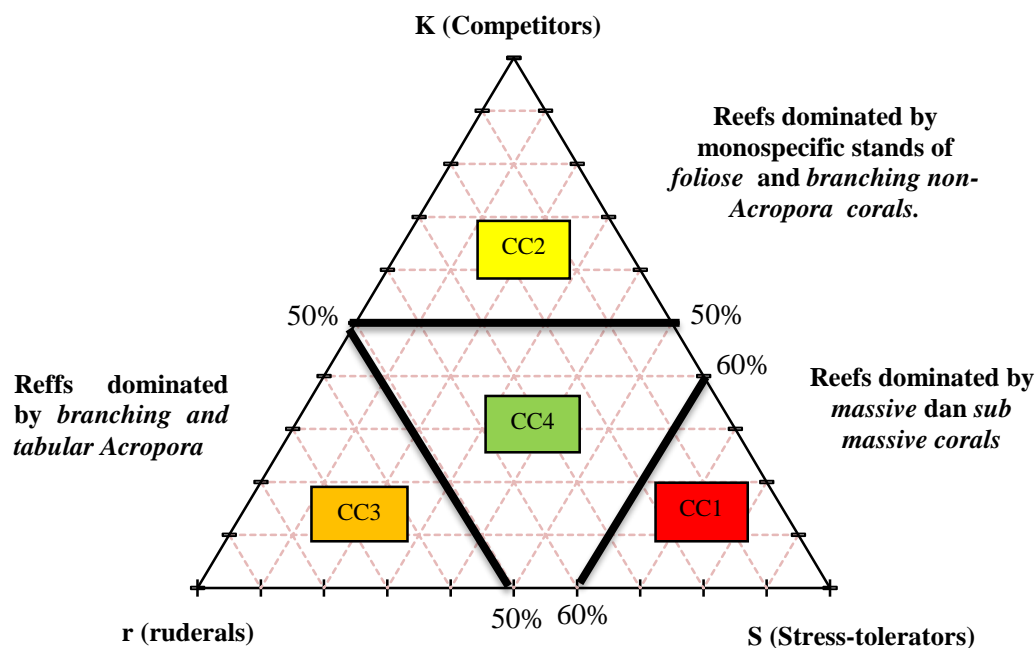

Figure 2. Triangle r-K-S classification of coral reefs, modification Edinger dan Risk [15].

Assessment for conservation classes (conservation class), namely KK1 (Conservation Class 1) if the place has a value (> 60%) Stress tolerators or locations that have high pressure levels, corals that are able to adapt are massive and sub massive coral types that tend to be more dominate. KK2 if it has a value (> 50%) Coral competitors in this region are coral species that are able to adapt to high space competition, corals that are able to survive are dominated by non-acropora, foliose, and branching corals. KK3 if it has (> 50%) r (ruderals) the coral that grows is dominated by the type of acropora tabulate and branching. While KK4 consists of a mixture of morphology (life form) coral from the other three classes. In this analysis, the One-way ANOVA statistical test was conducted to see differences in coral cover on each island.

Habitat complexity of each site was estimated as coral morphological diversity, calculated as the Shannon-Weaver diversity of coral morphologies, mH′, [15]:

$$mH^I = \sum -(pi)(\log_2 pi)$$

where:

m = morphology

H^I = diversity index

pi = proportion of coral colonies including morphology /*life form* ke-*i*

Analysis of the percentage of coral cover is calculated by the equation [20]:

$$(\%)\text{coral cover} = \frac{\text{category } life\ form}{\text{total category } life\ form}$$

Classification of coral reef conditions based on Gomez and Yap [21] criteria, 0-25% categorized as damaged; 26-50% categorized as medium; 51-75% categorized as good; and 76-100% categorized very well. Mortality index refers to Gomez et al. [22]:

$$\text{Coral mortality index} = \frac{\text{dead coral}}{\text{live corals+dead corals}}$$

The analysis also used a one-way ANOVA test and tukey (HSD) follow-up test. Analysis using the XLstat 2018 program.

3. Results and Discussion

3.1. Coral health

The distribution of observation locations consisted of Binongko Island with location codes B1, B2 ... B5 (n = 5), Kaledupa Island K1, K2 ... K8 (n = 8), Tomia Island T1, T2 ... T8 (n = 8) and Wangi Island - fragrant W1, W2 ... W8 (n = 8), more clearly can be seen in (Fig. 3).

The results of the study are based on the classification of Gomez and Yap (1998) coral cover, the condition of corals damaged (0-25%) found in 7 stations, namely (B3, K4, K5, K6, K8, T5, and T8). Medium coral conditions (25-50%) are found on 12 stations (B4, B5, K2, K3, K7, T2, T4, T7, W1, W5, W6, and W8. Good conditions (51-75%) are at 9 stations (B1, K1, T1, T6 W2, W3 and W6, B2, and T3). Average (± SE) coral cover was obtained by Binongko Island 39.84% ± 10.2, Kaledupa Island 31.63 (%) (± 6.2), Island Tomia 38.52 (%) (± 7.3) and Wangi-wangi Island 46.03 (%) (± 3.8) can be seen in (Fig. 4). Based on statistical tests (one-way ANOVA, F = 11.25, p = 0.48) of the four islands The average is the same as seen from the significance value of 0.48 or greater than> 0.05, so that differences in coral cover between islands have no significant or significant effect, generally based on calcifications Gomez and Yap [21] the condition of coral reefs is in moderate condition This result was reinforced by several previous studies which stated that the health of coral reefs in TNW was (moderate) conditions including Ban et al. [23]; Giyanto et al. [24]; Sutono [25].
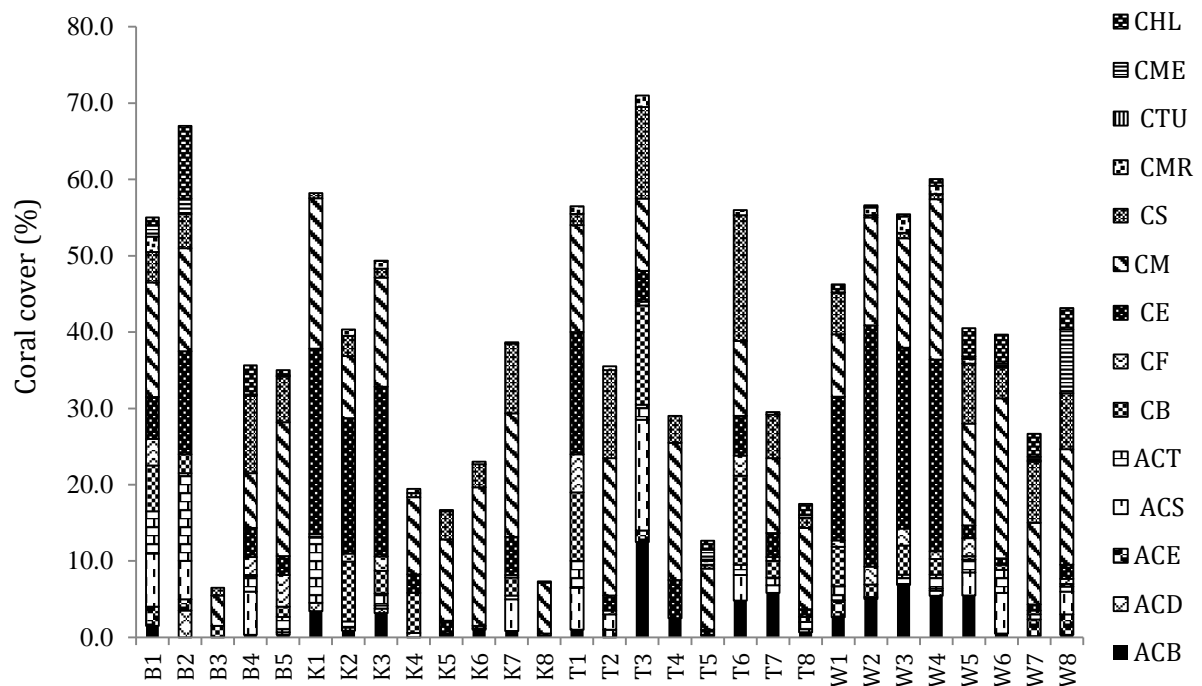
Figure 3. Results of analysis of coral reef cover based on morphological forms.

Wilson et al. [10] management priorities that need to be considered to improve Wakatobi coral reef resilience. First, eliminate the threat of destructive fishing and other activities that damage coral substrates such as coral / sand mining and destruction by anchors. Second, management of fisheries management through regulation and supervision of zoning systems to ensure healthy populations of herbiforous fish in WNP.
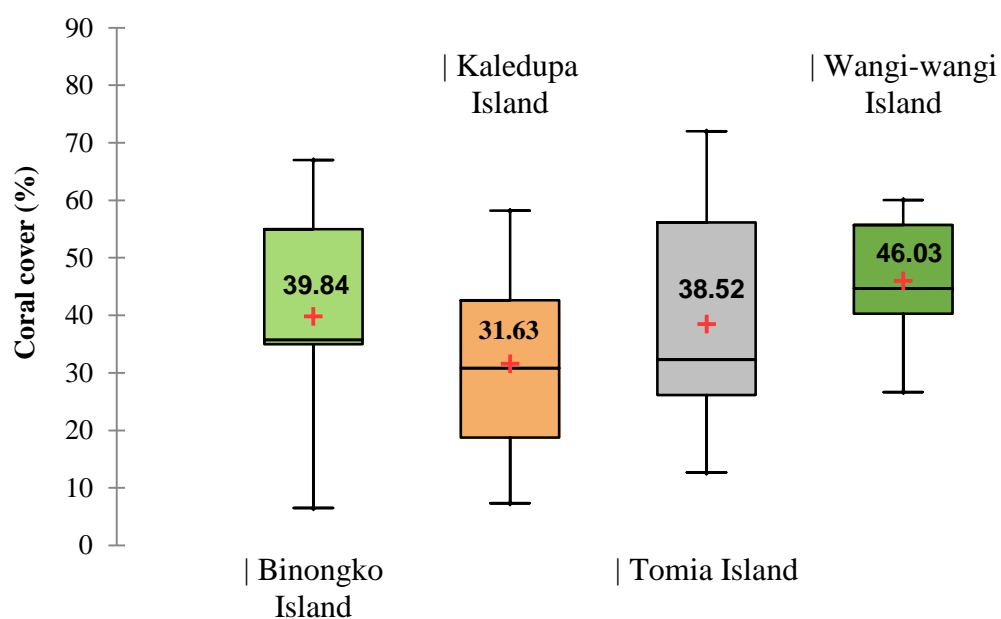

Figure 4. Boxplots the analysis of average coral cover on the four main islands of WNP.

3.2. Coral reef classification

The results of classification of coral reefs based on coral morphology are used to determine conservation classes. After the conservation class was obtained, it was then analyzed based on coral mortality index, habitat complexity/morphological diversity, and coral cover. More can be seen in (Table 2) and (Fig. 5).

Table 1. Average values of coral mortality, coral diversity and coral cover indices, based on conservation classes.

Class Conservation	Indeks Mortality (IM)	Habitat complexity morfologi (mH')	Coral cover (%)	Total (n) Station
CC 1	0.51[a]	1.19[a]	23.9[a]	12
CC 2	0.25[b]	1.58[a]	50.7[b]	6
CC 3	-	-	-	-
CC 4	0.29[b]	1.84[b]	48.7[b]	11

The numbers on the line followed by the same letter are not significantly different at the 0.5% test level (Tukey HSD Test)
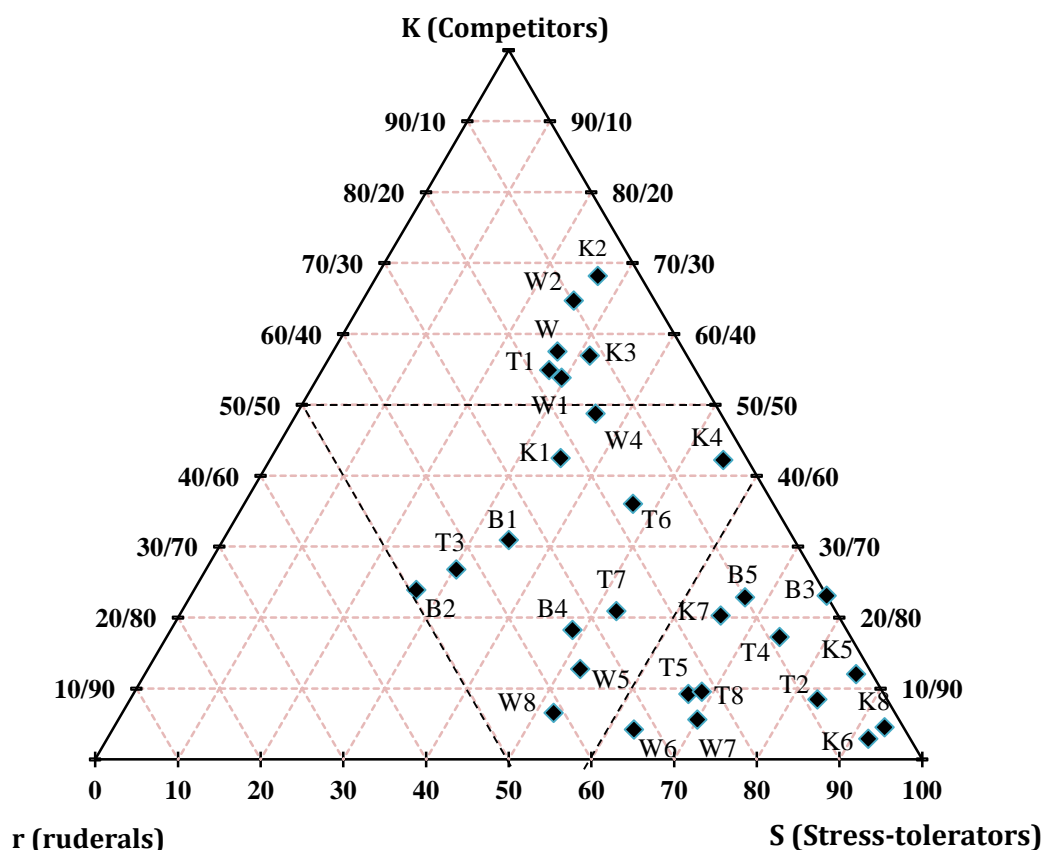

Figure 5. Plotting results in the triangle r-K-S where each station shows the characteristics of its constituent habitat (n = 29).

Based on (Table 2), (CC1) had a low morphological diversity of 1.19 (mH) ± 0.09 (SE), bad coral cover 23.9 ± 3.7 and a high coral mortality index 0.51 (mH ') ± 0.05 (SE). On the other hand (CC2) and (CC4), have moderate to good diversity and conditions of coral and a low mortality index. Based on the results of this classification can show which locations that have high pressure or stress this can be seen with low diversity, low coral cover and high coral mortality index.

The diversity index (CC4) (no dominance) higher than (CC1) and (CC2). High diversity is caused by the absence of pressure so that the morphological diversity of the coral in this location persists well. The purpose of establishing conservation areas in terms of ecological considerations is to focus on protecting areas that have high biodiversity so that it becomes the most optimal and efficient choice for the success of coral reef management. Even though there are only limited uses that can be used with strict requirements based on recommendations from managers in conservation areas.

Conservation classification as shown by ternary diagrams, coral reef conditions, live coral cover and coral mortality index, according to [15], unhealthy coral reefs are indicated by the dominance of massive and submassive corals (CC1), low habitat complexity (mH') live coral cover (poor condition), and high live coral mortality ratio (mortality index, MI,> 0.33). In this study (CC1) consists of 12 locations, close to the coastal area and is a fishing activity, there is sedimentation (Tomia), seaweed cultivation (Kaledupa) and tourist sites. Spatially the results of classification of coral reefs can also be seen in (Fig. 6).
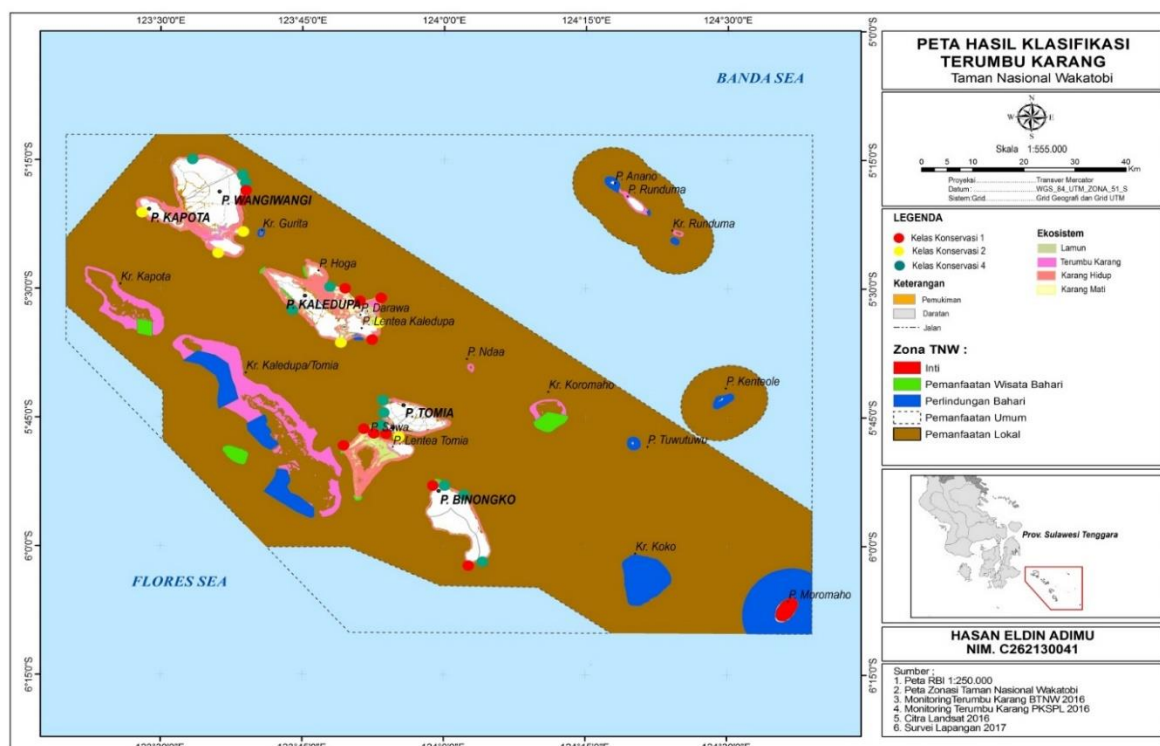

Figure 6. Result of zoning overlay and results of classification of coral reefs.

4. Conclusion
The classification results of coral reef conservation class showed that 12 locations in areas with high pressure (stress tolerators) were characterized by the dominance of massive and sub massive coral morphology, 6 locations in areas with high utilization competition characterized by the dominance of nonacropora coral morphology and 11 locations in areas with low disturbance pressure (morphological composition of coral is more diverse) characterized by the absence of coral dominance.

Acknowledgments

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