The growth of Turf alga on hard corals in Barrang Lompo Island, Makassar

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Abstract. Changes in the environment disrupt the balance of coral reef ecosystems and are able to change the structure of communities from coral reefs to macroalgae communities. This study analyzed the growth of alga turf in Acropora branched corals. Experiments carried out in nature, specifically in the waters around Barranglompo Island, with a growth monitoring method for 70 days (approximately ten weeks). The observation of herbivorous fish was carried out by the videography method. The relation of growth with oceanographic conditions was analyzed by principal component analysis. The results showed that alga turf growth on branched hard corals decreased, on A. cervicornis corals by 0.393 mm/day while on A. formosa corals by 0.126 mm/day. The main influencing factor of the growth of alga turf on branched hard corals in Barranglompo Island is herbivorous fish, while oceanographic conditions are not the main factor.

1. Introduction
Coral reefs are very important ecosystems in the sea waters. Coral reefs provide vital ecological and economic functions in a holistic marine ecosystem [1–3]. Coral reef ecosystems are unique and only able to live in certain conditions. Coral life is very dependent on environmental factors such as brightness, temperature, salinity, currents, nutrient concentration, and sedimentation [4]. Coral forming corals mainly come from hermatypic corals or hard corals, one of which is from the branched family of the Acroporidae family of the genus Acropora.

Acropora genus coral is the genus with the largest number of species in Indonesia [5]. Acropora genus coral is an organism that is very sensitive to environmental changes. Environmental changes that occur will cause disruption of the ecosystem balance. Environmental degradation can happen naturally and also by human actions. Natural disorders that occur include diseases, predation by Acanthaster planci and some mollusk species, bleaching, and global climate change. Degradation due to human intervention includes taking up coral for building materials, high sedimentation due to deforestation which causes greater sediment flow into the sea, disposal of waste to sea with a process that is not environmentally friendly, overfishing and eutrophication (nutrient enrichment) [1].

Imbalances that occur can cause changes in the structure of the community from coral reefs to macroalgae communities. Macroalgae is a type of low-level plant that lives around coral reef ecosystems [2]. Macroalgae are divided into four groups based on their growth forms; fleshy algae,
crustose coralline algae, calcareous algae, and turf algae [6]. In the natural environment, macroalgae are an important part of the coral reef ecosystem. However, in the condition of corals that have experienced degradation, the presence of macroalgae will become a competitor [1].

Alga turf is one of the benthic macroalgae groups that cause a lot of coral damage. Alga turf has low biomass per unit area but is able to dominate a number of areas of coral reefs, even in healthy coral conditions. *Corallophila huymansii* alga turf growth in Australia's Great Barrier Reef was reportedly high, which resulted in the death of coral animal tissue [7]. Red algae in the form of *Anotrichium* tenue filament also causes coral tissue death. Observation and monitoring using photography methods show that *Anotrichium tenue*, which has high growth, killed off coral animal tissue [8]. Research conducted on Derawan Island in East Kalimantan shows the dominance of alga turf and crustose coralline algae (CCA) in the Porites spp rock network [9]. Green algae in the form of the filament *Cholodesmis fastigiata* attack the coral immune system with a content of secondary metabolic yields, which results in the condition of coral to decline and then cause coral tissue to die [10]. Experiments carried out on the Southern Pacific Island Central Pacific (Atoll Millennium) using several types of macroalgae show that the interaction of corals with alga turf is the most dominant cause of damage compared to other types of macroalgae [11]. In general, macroalgae will attack corals starting from dead colonies and then extending to living coral colonies [12].

Alga turf can last longer on coral reef ecosystems due to high grazing by herbivorous fish against fleshy algae. Fleshy macroalgae are the main food for herbivorous reef fish, especially from the functional browser group (sorter) [13]. The loss of fleshy algae gives room to the alga turf group to develop.

Barrang Lompo Island is one of the islands in the Spermonde Islands with a high population. The large population causes a high anthropogenic influence on the coral reef ecosystem in the waters of the island, especially the increase in nutrient supply and the condition of herbivorous fish. From various studies that have been performed, it is feared that the growth of macroalgae in coral reef ecosystems will cause changes in the structure of coral communities into macroalgae communities. Therefore it is necessary to conduct research on the growth rate of algae on corals, especially hard corals and environmental factors that play a role in them.

The purpose of this study was to analyze the growth pattern of alga turf on hard corals and the influencing factors. Benefits of this research as information about macroalgal growth patterns, especially alga turf on hard corals that are expected to be used in conservation and prevention of damage to coral reefs, especially in the central area of the world's coral triangle.

2. Methods

The research was conducted from February to April 2014. The marking of coral specimens was carried out on Barrang Lompo Island, Makassar City (Figure 1). Identification of coral and macroalgae species was conducted at the Research Development Center for marine, coastal, and small island research (RDC macsi) Hasanuddin University.
2.1. *Measurement of Alga Turf growth in hard corals*

Measurement of alga turf growth patterns on branched corals using the marking method using a marker rope [14]. Two types of corals were chosen as an example of an experiment, namely 16 species of *A. cervicornis* and 16 branches of *A. formosa* and 16 branches of control coral. The coral-alga interaction limit is marked using a marker rope with a distance of 10 cm. The growth of alga turf was measured from the distance of the marker rope markers with coral-alga interaction limits every 14 days (two weeks) (Figure 2). Growth measurements are carried out using a caliper [10].

![Figure 2. Design of alga growth rate measurement for branched corals [10]](image)
2.2. **Observation of herbivorous Reef fish**
Observation of reef fish used videography method. Video capture was done using an underwater camera. Video capture is done simultaneously with the capture of alga turf growth data. The results of images and videos are used to identify fish in functional groups to their species.

2.3. **Measurement of Nitrate (NO$_3$) and Phosphate (PO$_4$) concentrations**
Water sampling to determine nutrient concentrations was carried out using Van Dorn bottles at all coral marking points. Water samples were taken each time the algae turf growth condition data is collected. Water sampling was carried out in the water column. The water was filtered using a 0.45µm porous WHATMAN HAWP filter paper with a diameter of 47 mm. Further, the sample was put into a dark glass bottle and cooled with ice in a cool box. Determination of nitrate concentrations was carried out using the Brucine method (SNI M-49-1990 03), which was then measured using the DREL 2800 spectrophotometer in mg / L units at a wavelength of 420 nm. Phosphate concentration measurements were carried out using the Stannous chloride method (SNI M-52-1990 03), which was then measured using the 2800 DREL spectrophotometer in mg / L units at a wavelength of 660 nm. Water samples were analyzed at the Oceanographic Chemistry Laboratory of Marine Sciences, Hasanuddin University.

2.4. **Temperature, salinity, and brightness**
Seawater temperature measurements are carried out using a thermometer at the coral marking point. Salinity measurements were performed using a salinometer. Brightness was measured using a disk. Measurements of water temperature, salinity, and brightness are carried out simultaneously with water sampling measurements of nutrient concentrations that are every two weeks during the study period.

2.5. **Data analysis**
The results of measurements of alga turf growth on Acropora branching corals were processed using Microsoft Excel 2010 software and then presented in the form of line charts. To determine the relationship of alga turf growth on branched corals with oceanographic ocean conditions were analyzed using principal components analysis. To find out the significance of growth analyzed using SPSS Statistics 17 with One Way ANOVA analysis method and further tests using Bonferroni.

3. **Results and discussions**
The growth pattern of alga turf in branched coral groups, in general, has decreased (Figure 3). The decrease in alga turf growth is shown in the two marked coral species. Growth rates on A.cervicornis corals increased at a certain time, whereas those on A.formosa corals decreased consistently from the beginning to the end of the study. The control corals marked during the study did not change. The control coral has not been overgrown with algae turf from the beginning of the marking until the end of the study.

The growth curve of alga turf in A.cervicornis corals decreased from day 14 (week two) to day 42 (week six), but on day 56 (week eight) to day 70 (week 10) increased. In the second week, the growth rate of alga turf was 1,148 mm / day, then decreased in the fourth week to 0.442 mm/day, and in the sixth week, it declined to 0.082 mm / day. In the eighth to tenth week, there was a change in the alga turf growth rate pattern. The pattern of growth rate shows an increasing trend. In the eighth week, the growth rate of alga turf to 0.129 mm / day and in the tenth week increased to 0.165 mm / day. However, an increase in the growth rate of alga turf in A.cervicornis corals did not show significant results when compared to a decrease in its growth rate. One way ANOVA test results with a 95% confidence interval (p = 0.05) showed that the growth rate of A.cervicornis algae turf each week was significantly different, with a significance value of 0.015 (p <0.05). Further test analysis using Bonferroni showed a significant difference between the second-week growth rate and the fourth-week growth rate with a significance value of 0.022 (p <0.05).

The growth rate of alga turf in A.formosa species has consistently decreased from the beginning to
the end of the study. In the second week, the rate of growth was 0.459 mm / day. The growth rate continued to decline in the fourth, sixth, eighth to the tenth week with the value of the growth rate of each 0.196 mm / day, 0.149 mm / day, -0.087 mm / day, and -0.087 mm / day. The decrease is quite significant. One way ANOVA test results with 95% confidence interval (p = 0.05) showed that the growth rate of A.formosa type of alga turf between weeks was significantly different with a significance value of 0.018 (p <0.05). Further test analysis using Bonferroni showed a significant difference between the second-week growth rate and the fourth-week growth rate with a significance value of 0.022 (p <0.05). Further test analysis using Bonferroni showed a significant difference between the second-week growth rate and the tenth-week growth rate with a significance value of 0.029 (p <0.05).

![Figure 3](image_url) 

**Figure 3.** The growth rate of alga turf on branched coral

Alga turf growth rates for all types of observations showed significant differences. One way ANOVA test results with a 95% confidence interval (p = 0.05) showed that the growth rate of control algae turf with A.cervicornis and A.formosa types was significantly different with a significance value of 0.000 (p <0.05). The same thing happened between A.cervicornis corals and A.formosa with a significance value of 0.005 (p <0.005).

This difference is most likely due to differences in the character of the coral species used as observations such as the size of the diameter of the branching and the number of branches that affect the organisms associated with the coral, one of which is an abundance of herbivorous fish. This is based on the absence of a close relationship between alga turf growth and oceanographic ocean conditions.

![Figure 4](image_url)

**Figure 4.** Analysis of the main components of alga turf growth with oceanographic oceanography.
Analysis of the main components of the relationship between alga turf growth with nutrient concentrations and other oceanographic factors shows the result that the oceanographic factor is not the main factor influencing the growth rate of alga turf on branched corals (Figure 4). The research location in the reef flat area is ± 500 meters from the shoreline, causing nutrient supply to not affect much alga growth. Seagrass beds that grow along the ± 400 meters from the shoreline become a limiting area large enough to filter nutrients directly into the coral reef ecosystem.

The rate of decline in alga turf on Barranglombo Island was reported by [13]. The growth of alga turf experienced fluctuating and different changes between locations, but in general, experienced a significant decrease in algae up to 85%. This relates to the composition and abundance of herbivorous reef fish. There was a negative correlation between alga turf growth with abundance and biomivor of herbivorous fish. Alga turf is one component of the coral reef ecosystem, which is the main food for most coral fish. The increasing abundance and biomass of herbivorous fish cause the growth rate of alga turf to decrease. The decreased rate of alga growth shows the condition of corals that are starting to improve.

Jompa and McCook [14] found that herbivorous fish was a controlling factor for alga growth in coral reef ecosystems in Australia. Research methods comparing the three treatments on alga-growing corals, namely open, half confinement, and full confinement, show that algae that live in full cages grow faster than the other two treatments. The same thing was obtained by Lirman [15], who conducted research at Biscayne National Park, Florida, with the method of confinement treatment on algae-growing corals showing a significant increase in alga growth.

Setiawan [16], who conducted in Pulau Seribu Islands, found that the closure of macroalgae experienced a peak there in January, which is the west or the rainy season and then decreased in the following months although still fluctuating. In contrast to the results of this study, the results obtained by Setiawan [16] showed a high percent of macroalgae cover in January due to high concentrations of nitrates and phosphates in that month. At least herbivorous fish and echinoids also have a considerable impact on increasing macroalgae.

Herbivorous reef fish found at the study site are from the Scaridae functional scraper (small excavator) and grazer groups. A scraper is a herbivorous fish whose main food is alga turf and its substrate, but the amount of substrate eaten is small. This group of fish bites without digging too deep on the coral substrate but is able to eliminate alga turf [17].

Scraper group has a big role in coral reef resilience, which is limiting the growth of algae, especially alga turf. The high grazing carried out by this fish group provides a clean substrate area for coral recruitment and coralline alga growth [13].

Figure 5. One of the fish group scraper (Scarus flavipectoralis) found at the study site. Photo by G. Allen and R. Hamilton [17].

Scarus flavipectoralis fish are the fish species from the scraper group that is most often found at the study site (}
Figure 5). These fish are generally solitary and have their own territory. This fish habit is attacking other types of fish that enter its territory and are often seen hiding in the gap of coral branching colonies—eating algae that grow on corals and will leave bite marks on the coral substrate but not too deep.

*Scarus flavipectoralis* fish usually prefer areas with high alga turf cover. This affects the scraper group biomass, including *Scarus flavipectoralis*, which is higher compared to other fish species [13]. The functional group of grazers is herbivorous fish that eat algae, especially epilithic alga turf but do not erode or dig up coral substrate while eating. Includes almost all baronang fish (Siganus), all Centropyge species, and many Acanthuridae species [17].

![Image of fish](image-url)

**Figure 6.** The grazer group, *Siganus lineatus*, and *Acanthurus nigricauda* ing-tailed butane fish. Photo by Photo by G. Allen and R. Hamilton Green & Bellwood (2009)

Other fish species most commonly found at the study site were *Siganus lineatus* and *Acanthurus nigricauda* fish (Figure 6). This group of fish is usually clustered and can eat algae in large numbers and on a broader scale. This type of fish is more commonly found in areas with low alga cover; this may be due to fish having grazed before this research took place.

**4. Conclusion**

Growth patterns of alga turf on branched hard corals decreased, on *A.cervicornis* corals by 0.393 mm / day while on *A.formosa* corals by 0.126 mm / day. Oceanographic factors are not related closely with decreased alga turf growth. Another factor that is most likely to affect the growth of alga turf on hard-branched corals in Makassar's Barranglompo Island is the abundance of herbivorous fish. The suggestion for this research is a longer research time (one year) to be able to see the growth pattern of alga turf each month.

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