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Coral conditions and reef fish presence in the coral transplantation area on Kapoposang Island, Pangkep Regency, South Sulawesi

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Abstract. Coral reefs are currently suffering from serious degradation due to human activities. In 2015, the condition of coral reefs in Kapoposang Island has been very poor with the live coral cover only 16%. Therefore, the coral reef ecosystem on this island needs to be rehabilitated. This study aims to assess coral cover based on the age of transplantation and examine abundance of reef fish in relation to age of transplant module at Kapoposang Island which is in the Wallacea region. Coral transplant was carried out from 2014 to 2018. The transplanted corals were corals of the genus *Acropora*. Transplants were carried out at a depth 3 to 4 m. The determination of the transplant module as the reef fish's observation was based on the age of the transplant module, i.e. 1, 2, 3 and 4 years old. Data collection was carried out using the UVC (Underwater Visual Census) method. Data collection was done by using the UPT (Underwater Photo Transect) method. Photograph data was processed using CPCe (Coral Point Count with Excel extension) software using 30 random points for each frame. The significant relationship between live coral cover and reef fish shows that the coral transplantation was successful. There was linear relation between coral habitat cover and the reef fish. The difference in abundance in each transplant module shows the linear relation between the increase of reef fishes and live coral cover. The live coral cover was higher at the two and three years old of the transplant module. During the study, it was found 13 families and 56 species of reef fish. Planktivorous group was the most dominant of reef fish.

1. Introduction

Coral transplantation is a coral rehabilitation technique by planting coral with a fragmentation method, where coral seeds were taken from a particular parent colony with various module models, such as spider frames, stakes, nets, and chains.

A healthy coral ecosystem will be a feeding area for many marine organisms, as well as providing a good microhabitat that supports biological and ecological processes, such as reproduction, recruitment, and protection of larvae from predators [1]. Although coral reefs have high ecological and economic value, Even though coral reefs have high ecological and economic value, coral reefs are still managed



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unsustainably, so they suffer from serious pressure or degradation due to human activities both directly and indirectly [2]. Human activities that have a direct impact come from overexploitation and illegal fishing by trawling and using dynamite and cyanide [3]. Whereas human activities that have a known direct impact come from reclamation or uncontrolled development in coastal areas, agricultural activities, and water pollution by industry. If these activities occur continuously without any prevention or recovery efforts, it will reduce the economical value of coral reef resources, and disrupt the ecological function of the coral ecosystem [1].

Coral transplantation is a coral planting technique using the fragmentation method. In this transplant, coral seeds are taken from a particular parent colony and then planted using a variety of methods, such as using the spider frame, stakes, concrete blocks, nets, and chains. The choice of method is adjusted to the condition of the waters where the transplant will be performed. Coral transplantation aims to accelerate the regeneration of damaged coral reefs, especially to increase diversity and percent cover. Coral transplantation functions as an artificial reef habitat, one of which functions as a fish aggregating device (FAD). This FAD can provide a new habitat for reef fish communities [4]. The artificial reef habitat can function as a shelter that is almost as good as a natural reef habitat for certain species and sizes of reef fish, especially reef fish that are still young. The artificial reef habitat produced by transplantation can produce food for many species of crustaceans and other small fish [5].

Kapoposang Island is one of the islands in the Kopoposang Water Park. The coral transplant was initiated by Coral Reef Rehabilitation and Management Program (COREMAP). Lots of scientific information can be obtained from this coral transplantation area. This study aims to assess coral cover based on the age of transplantation and examine the abundance of reef fish in relation to the age of transplant module at Kapoposang Island which is in the Wallacea region.

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2. Materials and Methods

The study was conducted in the coral transplant area on Kapoposang Island (Figure 1) which was one of the islands under the supervision of the Kupang.



Figure 1. Sampling location in Kapoposang Island, Pangkep Regency, South Sulawesi, Indonesia.

Equipment and materials used were masks, snorkels, SCUBA (Self Contained Underwater Breathing Apparatus), quadrant transect size of 50 cm x 50 cm, underwater camera, stopwatch, pencil, and reef fish identification book. Data collection for reef fish and live coral cover were carried out on transplant modules measuring 120 cm x 120 cm per unit, totaling 20 modules from 73 concrete modules placed in the transplant area of Kapoposang Island (Figure 2).

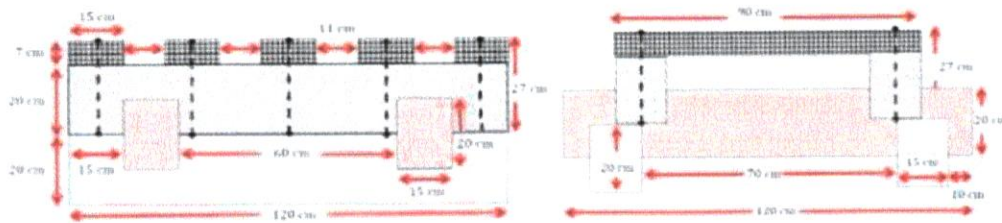


Figure 2. Construction and size of transplanted concrete modules located on Kapoposang Island.

The transplant modules were placed consecutively from 2014 to 2018. The transplanted corals were corals of the genus *Acropora*. Transplants modules were placed at a depth of 3 to 4 m. The determination of the transplant module as the reef fishes observation was based on the age of the transplant module, namely: (1) 5 of 10 modules that were 1 year old (Figure 3A); (2) 5 of 43 modules that were 2 years old (Figure 3B); (3) 5 of 10 modules that were 3 years (Figure 3C); and (4) 5 of 10 modules that were 4 year (Figure 3D). The objects observed were reef fish and coral reef substrate cover in the transplantation modules (Figure E, F, and G).

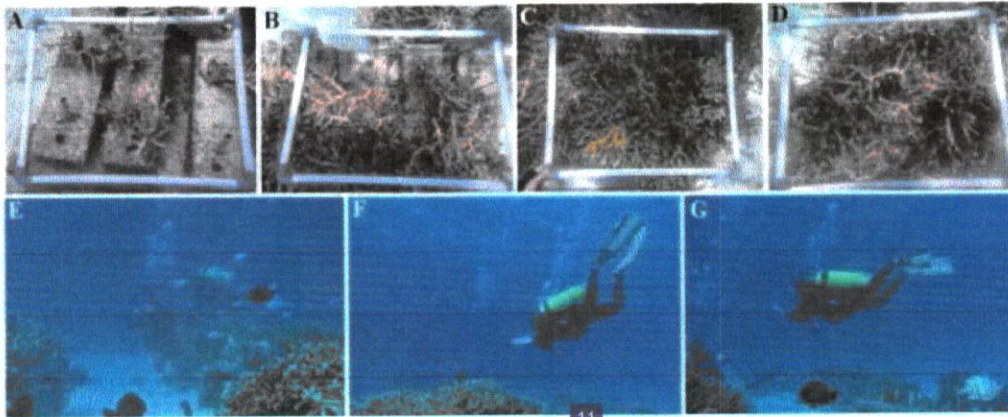


Figure 3. Condition of coral transplantation modules at 1 year old (A), 2 years old (B), 3 years old (C), 4 years old (D), and the condition when observing reef fish (E, F, G).

Data collection for reef fish was carried out using the UVC (Underwater Visual Census) method. The surveyors collected reef fish data by diving in the area of the coral transplant module by means of the Fish Stationery Plot Survey (silent fish survey) for several minutes for each coral transplant module. Observation has been done with a distance of about 2.5 meters from the coral transplant module for 5 to 10 minutes for each coral transplant module.

Data collection on coral reef covers in transplant modules were done by using the UPT (Underwater Photo Transect) method. The data was collected by taking photos of transect quadrants with a size of 0.5 m x 0.5 m placed on a concrete module randomly for 3 replications. Photographs will be analyzed using the application to determine live coral cover and other substrates. Photograph

of coral reef habitat cover data was processed using CPCe (Coral Point Count with Excel extension) software using 30 random points for each frame using the formula:

$$PCC = \frac{\text{Number of category points}}{\text{Number of random point}} \times 100\%, \text{ where PCC was the Percentage of Cover Category.}$$

Reef fish data were analyzed to found out reef fish abundance. The number of reef fish per unit area was indicated by the reef fish abundance. Reef fish abundance was calculated using the formula [6] that is $N = \frac{n_i}{A}$, where N was the abundance of reef fishes (ind/m²), n_i was the number of reef fishes (ind/m²), and A was the area of observation area (m²).

Differences in reef fish abundance at the age of the transplant modules were analyzed using the one way ANOVA test to find out the differences between the variables, if there were significant differences, then a further test or analysis was carried out. The relationship between coral reef cover and the presence of reef fish were analyzed by evaluating the relationship between reef fish and coral cover in the coral transplant modules. A simple linear regression procedure was used to analyze the relations of coral cover and DCA (Dead Coral Algae) to reef fish abundance at each age of the coral transplant modules, which were 1, 2, 3, and 4 years old.

3. Results

3.1. Live coral and dead coral algae (DCA) cover

Live coral cover ranges from 20.66 to 61.43 with an average of 20.66±6.41 for one year old transplant modules, 58.44±22.01 for two year old transplant modules, 61.43±14.80 for three year old transplant modules, and 31.43±10.11 for module two year old transplant modules (Figure 4).

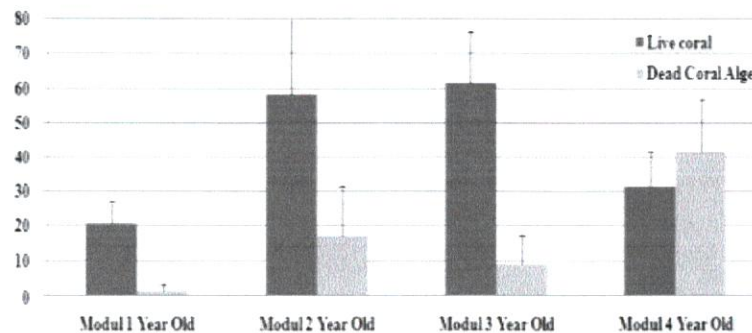


Figure 4. Live coral and dead coral algae (DCA) cover based on the age of the transplant module.

3.2. Reef fish Species Riches

During the study, 13 families and 56 species were found, namely: (1) *Achanturidae* with 7 species, i.e. *Achanthurus auranticavus*, *A. nigricans*, *A. pyroferus*, *A. tompsoni*, *Ctenochaetus striatus*, *Zanclus ornatus*, and *Zebrasoma scopas*; (2) *Apogon* with 2 species, i.e. *Apogon chrysopomus*, and *Apogon chrytaenia*; (3) *Blastidae* with 1 species, i.e. *Suflamen frenatus*; (4) *Chaetodontidae* with 6 species, i.e. *Chaetodon baronessa*, *Chaetodon citrinellus*, *Chaetodon kleinii*, *Chaetodon lunulatus*, *Chaetodon vagabundus*, and *Forsipiger longirostris*; (5) *Labridae* with 9 species, i.e. *Chellinus fasciatus*, *Diproctacanthus xanthurus*, *Helichoeres hortulanus*, *H. melanurus*, *H. trimaculatus*, *Hemigymmus fasciatus*, *H. melapterus*, *Labroides dimidiatus*, *Thallasoma hardwicke*, and *T. Lanure*; (6) *Lutjanidae* with 1 species, i.e. *Lutjanus decussatus*; (7) *Mullidae* with 1 species, i.e. *Mulloidichthys vanicolensis*; (8) *Nemipteridae* with 2 species, i.e. *Scolopsis bilineata* and *S. monogramma*; (9) *Pomacentridae* with 13 species, i.e. *Abudefduf sexfasciatus*, *A. vaigiensis*, *Abyglyphidodon curacao*, *Chromis amboinensis*, *C. atripectoralis*, *C. viridis*, *Dascyllus aruanus*, *D. carneus*, *D. trimaculatus*, *Dischistodus*

perspicillatus, *Plectroglyphidodon dickii*, *Pomacentrus lepydogenys*, and *P. moluccensis*; (10) *Pomacanthidae* with 1 species, i.e. *Centropyge vrolikii*; (11) *Scaridae* with 9 species, i.e. *Chlorurus blekeri*, *C. sordidus*, *Scarus capistratooides*, *S. dimidiatus*, *S. falviperctoralis*, *S. oviceps*, *S. schlegeli*, *S. spinus*, and *S. tricolor*; (12) *Serranidae* with 2 species, i.e. *Chepalopholus argus*, and *Ephinepelus melanostigma*; and (13) *Siganidae* with 2 species, i.e. *Siganus rivulatus*, and *Siganus virgatus*.

Of 56 species, in the morning observation, 22 - 32 species were found, and in the afternoon observation, 24 - 33 species were found (Figure 5A). During the study, 1163 individuals of reef fish were found with a range of 155-366 individuals in the morning observations, and 1230 individuals with a range of 162 - 427 individuals in the afternoon observations. (Figure 5B).

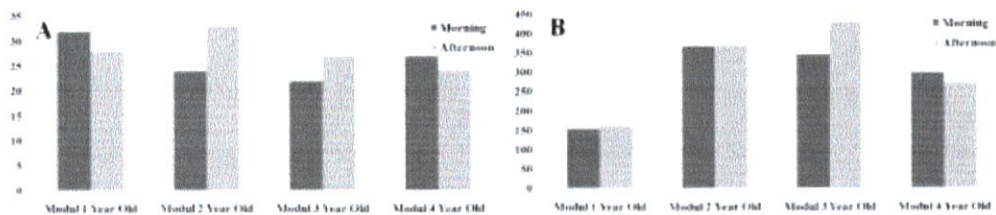


Figure 5. Number of species (A) and specimen (B) of reef fish for each age of the transplant modules.

3.3. Reef fish abundance

Reef fish abundance were 6.7 to 34.5 ind/m² for planktivores, 2.6 to 13.2 ind/m² for omnivores, 0.3 to 12.0 ind/m² for carnivores, 2.7 to 5.2 ind/m² for herbivores, 2.1 to 3.8 ind/m² for invertebrate feeders, 0.4 to 1.0 ind/m² for coralivores (Figure 6A). The percentage of reef fish according to their feeding habits was 1.77 to 55.30% (Figure 6B). During the study it was found 0.4 to 1.0 ind/m² for indicator fishes, 13 to 48 ind/m² for major fishes, and 4.2 to 8.5 ind/m² for target fishes (Figure 7).

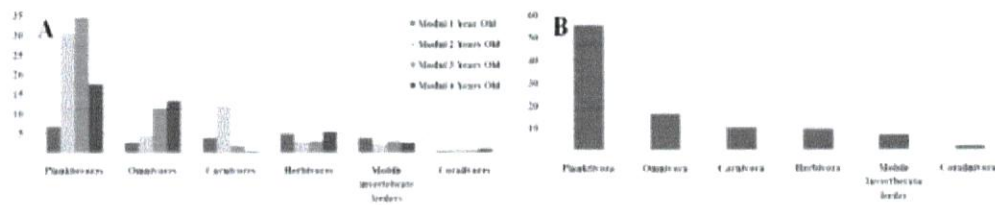


Figure 6. Reef fish abundance (A) and percentage of reef fish based on feeding habits and age of the transplant module (B).

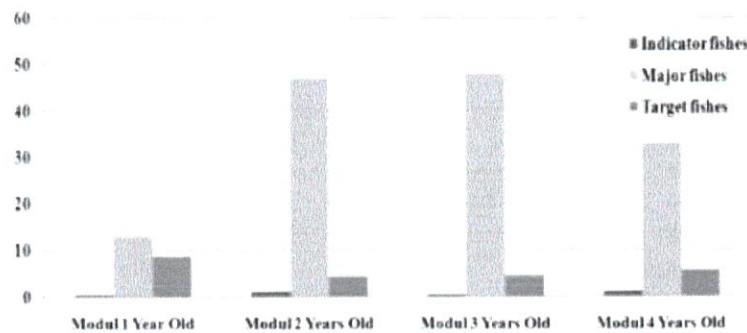


Figure 7. The abundance of indicator, mayor and target fish for each age of the transplant modules.

3.4. Live coral, dead coral alge and reef fish relation

The relationship between live coral cover, DCA cover and abundance of reef fishes indicate that the higher the coral cover, the higher the abundance of reef fish (Figure 8).

4. Discussion

The coral cover increase from the first to the fourth years old of the transplant modules. Live coral cover was in the highest level at ages 2 and 3 years. At the age of 4, coral cover decreases. This decrease was probably caused by predation and the presence of intruding biota in the form of algae filament. These algae can threaten the existence of transplanted corals in terms of space and nutrient competition. At the age of the 4-year old of the module, the presence of DCA was at a high level as indicated by algae and sediment. Sedimentary particles can cover coral polyps. Coral polyps covered by sediment will inhibit zooxanthella from photosynthesis [7]. Another cause of high DCA was the lack of follow-up care after transplant activities.

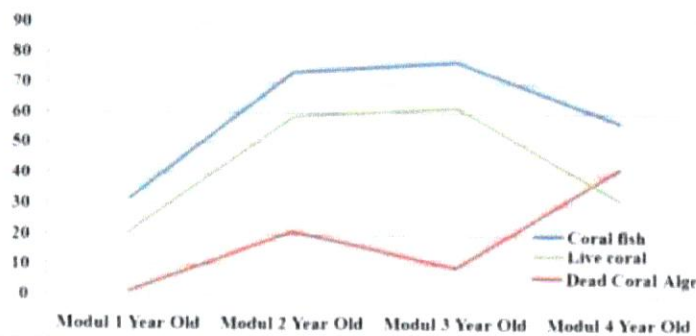


Figure 8. Relationship between live coral, Dead Coral Alge (DCA), and abundance of reef fish related to the transplant module.

The live coral cover condition at each age of transplantation shows the differences in the reef fish species community. This was probably done to the preferences or suitability of reef fishes to habitat, habitat suitability affects the abundance of reef fish. Pomacentridae family had the highest abundance at each age of the transplant modules. This probably has a relation with body size. The small size of the body permits them to live in the crevices of coral branches. Pomacentridae can form groups and settle on branched coral reefs. The most abundant species were *Chormis viridis* and *Chromis amboniensis*. This was in line with the results of previous studies that reported that in the coral transplantation area, the most dominant fish community of the genus *Chromis*, including *Chromis viridis* [7].

This species can be found by schooling activities when they looking for food, so the number of individuals in this species was highest among other species, while the species of *Chromis amboniensis* was strongly influenced by environmental conditions, especially the availability of food sources in coral reef areas, where when observing time, the fish tend to be in the column water on coral reefs; this shows that the fish were gathering to look for food. In addition to the genus *Chromis*, a high number of individuals were found in the *Pomacentrus mollucensis* species. Something similar has been reported previously that *Pomacentrus mollucensis* can dominate coral transplantation areas [8]. In addition, the Labridae and Achanturidae families can also be found in quite a large amount. This was thought to be related to the availability of alge food sources found in coral transplantation areas. Achanturidae was an algae-eating fish where when observations were carried out, this species was found in a state of eroding the surface of the transplant module, this shows the fish were looking for food such as algae or benthic on the concrete surface. This was in line with what was reported by previous researchers that the existence of transplanted concrete shelves allows the growth of algae and

corals, thus allowing the presence of invertebrates which were a source of food for the Achanturidae family [8]. While the presence of the Labridae family in the transplant area was suspected of being an attraction of fish to the existence of food. Fish species of the Labridae family are invertebrate-eating fish species that were often found looking for food in concrete cracks or substrate surfaces. Fish species from the Labridae family were almost found in a coral ecosystems, where they look for food in the form of small invertebrates both at the bottom and in the water column.

The abundance of reef fishes in the two- and three-year-old transplant modules were related to the availability of space to find food and shelter for small fish. The availability of more space than transplant modules one and four years old makes small fish more interested in living and sheltering from predators in the transplant module. The results of previous studies report that there is a relationship between the structure of fish communities and the categories of coral growth forms. In transplanted areas that have a branched type of coral growth form that can provide space for reef fish to settle both to find food and protect from predators [9].

The results of this study indicate that there were differences in the abundance of coral ivory fish. This difference in abundance was related to the nature of coralivore fish, namely facultative and obligate coralivore. The abundance of facultative Coralivore fish was not directly related to the age of the transplant module because this type of fish can utilize other types of food as a substitute for its food. Whereas obligatory Coralivore directly related to the age of the transplant module can only prey on corals as its food. Therefore, obligate coralivore was commonly found in transplant modules that were older, and have a high coral cover. *Chaetodon vagabundus*, *Chaetodon lunulatus*, and *Forsipiger longirostris* were facultative coralivore fish. While *Chaetodon baronessa* was an obligate coralivore. *Chaetodon baronessa* was very fond of *Acropora corals* [10].

This study shows that herbivorous fish abundance was significantly different at all ages of the transplant module, where the highest abundance was found at the age of modules one and four years. The abundance of herbivore reef fishes was related to the presence of macroalgae as food. That was why more herbivore reef fish were found in transplant modules that were overgrown by macroalgae at the age of modules one and four years. Herbivorous reef fish play an important role in coral reef resilience because it can limit the presence and growth of macroalgae. Therefore herbivore reef fish can maintain balance in the coral reef ecosystem [11]. Herbivore reef fish species found with high abundance were *Ctenochaetus striatus* and *Zebrosoma scopas* in transplant modules one and four years old. The results of previous studies report that *Ctenochaetus striatus* species were often found living in groups on coral fragments that were overgrown with algae [4,12].

The results of this study indicate that the highest feeding habit group presentation was occupied by the planktivore group. Planktivore reef fish abundance was dominated by species from the family Pomacentridae were resident species that have territorial behavior that rarely roams away from food sources and shelter. Pomacentridae fish was classified as the major fish in the coral reef ecosystem. Planktivore reef fish species from the family Pomacentridae that were found in this study were *Chromis viridis*, *Ambonis Chromisis*, *Chromis atripectoralis*, *Dacyllus aruanus*, and *Dacyllus trimaculatus*. Whereas the Blastidae family was *Suflamen frenatus*. Planktivorous reef fish abundance was significantly different where the highest abundance was found in the transplant module, with the highest abundance occupied by *Chromis viridis* (20.3 ind/m²) and *Dacyllus trimaculatus* (18.1 ind/m²). Planktivore reef fish abundance was related to the condition of coral cover and branching. High cover with a large number of branches in two and three-year-old transplant modules was a good place for planktivore fish to find food and protect from predators. The results of previous studies in coral transplantation areas also found an abundance of planktivore reef fishes, such as the genus *Chromis* and *Dacyllus* [13]. The results of previous studies also reported that planktivore fish of the Pomacentridae species favored coral reefs covered by branched corals [14].

Omnivorous reef fish species found from the Pomacentridae family were *Centropyge vrolikii*, whereas from the Pomacentridae family are *Abudefduf vaigensis*, *Abudefduf sexfasciatus*, *Ablygophidodon curacao*, *Plectroglyphidodon dickii*, *Pomacentrus lepydogenus*, and *Pomacentrusis* where *Pomacentrus moluccensis* (9.2 ind/m²) and *Pomacentrus lepydogenus* (5.6 ind/m²) were the two

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most common species of omnivore reef fish found in this study. Omnivore reef fish were a group of phytoplankton-eating fish, algae, detritus, zooplankton, mollusks, coral and shrimp, so they tend to be a generalist. This type of fish has good adaptability to fluctuations in available food. This makes the omnivore reef fish have a high abundance in the area of natural and artificial coral reefs. The presence of omnivore reef fish in coral habitats was generally related to the availability of food such as algae, and zoobenthos such as worms, algae, mollusks and small crustaceans, and zoobenthos such as worms, algae, mollusks and small crustaceans, and zoobenthos such as worms, algae, mollusks and small crustaceans [8]. The existence of omnivore reef fish in coral habitats was also related to the existence of corals as a shelter from predator attacks [11]. Omnivore reef fish that have a high density were found living in groups or forming schooling on coral reefs which were shelter and foraging.

The abundance of mobile invertebrate feeder reef fish did not show a significant difference at all ages of the transplant module. This was because these fish species can live well on hard (coral) and soft substrates [15]. Many mobile fish invertebrate feeders in this study are species from the Labridae family, namely *Thallasoma lanure*, *Thallasoma hardwike*, *Thallasoma trimaculatus*, *Helichoeres melanurus*, *Helichoeres holotulanus*, *Helichoeres dimidiatus*, *Chellinus fasciatus*, *Diproctacanthus xanthurus*, *Helichoeres melanurus*, *Helichoeres holotulanus*, *Helichoeres dimidiatus*, *Chellinus fasciatus*, *Diproctacanthus xanthurus*, *Helichoeres melanurus*, *Helichoeres holotulanus*, *Helichoeres dimidiatus*, *Chellinus fasciatus*, *Diproctacanthus xanthurus*, and *Helichoeres melanurus*; and from species of the family Nemipteridae, namely *Scolopsis bilineata* and *Scolopsis monogramma*. Labridae family is a family that can be found easily in almost all coral ecosystems. Mobile invertebrate feeder reef fish are fish that have a high tolerance to varied habitats. Mobile invertebrate feeder reef fish are generally crustacean and mollusk eaters [15].

The results of this study indicate that the lowest group presentation feeding habits were occupied by carnivorous reef fish groups. Carnivorous reef fish occupy the lowest abundance position of all fish groups in this study site. The abundance of carnivorous reef fish was higher at the age of the transplant modules one and two years. Carnivore fish found in this study came from four families, namely: (1) Apogon represented by *Apogon chrysopomus* and *Apogon chrystaenia*; (2) Lutjanidae represented by *Lutjanus decussates*; (3) Mullidae represented by *Mulloidichthys vanicolensis*; and (4) Serranidae represented by *Cephalopholis argus* and *Ephinepelus melanostigma*. Carnivore reef fish from the Apogon family were resident fish species and have territorial behavior so they rarely roam far from their shelter and food sources in the form of juvenile fish, small fish, and crustaceans.

The presence of three functional fish groups, namely major fish, target fish and indicator fish, in the transplant module shows that the coral transplantation on Kapoposang Island was successful. Major fish play a general role in the food chain system in coral reef areas, target fish were fish that have economic value and were consumed by the community, and indicator fish were fish that were parameters for the health of coral reefs [4].

Indicator fish were the types of fish that live most strongly associated with corals or were highly dependent on the presence of corals in a coral ecosystem. Species of fish that were categorized as indicator fish include the family Chaetodontidae. These fish groups have varied because these fish groups depend on the quality of the waters and the condition of the coral reef ecosystem. Indicator fish was a group of fish that has the strongest relationship or association with coral reefs.

Major fish have the highest abundance percentage. This was common occurs in coral reef exocytosis [16]. Pomacentridae was a major fish that has a high abundance. This was supported by the ability to live in groups or form schooling [17] on coral reefs as a place to find food or shelter. The presence of major fish from the family Pomacentridae was easily found in natural and transplanted coral areas because these fish were able to find food in the water column and can use coral reefs as a shelter from carnivorous fish attacks.

Target fish was a type of consumption fish that has important economic value. The target fish found in this transplantation area were from the family Mullidae, Achanturidae, Lutjanidae, Siganidae, Scaridae, Blastidae and Serranidae, which are a group of carnivorous and herbivorous fish. The existence of target fish in this transplantation area was supported by the existence of a transplant

module that was arranged to resemble a pyramid so that it can be used by target fish to find food and protect from predatory attacks [18].

Observations made on the coral transplant area on Kapoposang Island indicate an increase in coral cover. Observations showed an increase in a coral cover presentation in transplant modules 1, 2, 3 and 4 years old. The increase in coral cover is directly proportional to the presence of reef fish. Simple linear regression indicates a linear relationship between coral cover and the presence of reef fish, as well as between DCA cover and the presence of reef fish. According to [19] there is a positive correlation between the presence of reef fish and the condition of living coral cover in a coral reef ecosystem, where the better the coral cover, the higher the presence of reef fish.

5. Conclusion

The significant relationship between live coral cover and reef fish shows that the coral transplantation was successful. There was a linear relation between coral habitat cover and the reef fish. The difference in abundance in each transplant module shows the linear relation between the increase of reef fishes and live coral cover. The live coral cover was higher at the two and three years old of the transplant module. During the study, it was found 13 families and 56 species of reef fish. Planktivorous group was the most dominant of reef fish.

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