Succession of reef fish community at the coral area rehabilitated with coral transplantation and artificial reef in West Sumatra, Indonesia

Indra J. Zakaria, Hidayatul Annisa, Syaifullah

Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, Padang - 25163, Indonesia. Corresponding author: I. J. Zakaria, indrajz@yahoo.com

Abstract. An established technique to rehabilitate the damaged coral reefs is by combining coral transplantation and artificial reef. This technique is able to increase the percentage of living coral cover which becomes new habitat for reef fish and in turn increases the number of species and individuals of fish associated with the coral reefs. This study aimed to determine the succession rate of reef fish at a rehabilitated coral area using aforementioned technique. Observation was carried out a month before implementing the rehabilitation procedure (February 2018), continued with monthly survey from April to June 2018 using Underwater Fish Visual Census Method for collecting data on 60 m^2 rehabilitated area. The observation on reef fish community structure used parameters such as abundance, dominance, diversity and uniformity indices. The result showed increment, yet slightly fluctuative, on reef fish community structure over observation period. In February, five families, 11 species and 39 individuals of reef fish were recorded; in April, eight families with 17 species and 235 individuals were observed; in May seven families, 20 species and 163 individuals sighted; eventually nine families, 23 species, and 263 individuals were recorded on last observation in June. This study indicated that the combination of coral transplants and artificial reef accommodate an advanced succession stage for reef fish community at the rehabilitated coral area. The observation detected presence and absence of certain fish species on monthly basis, with the overall data hinted a moderate diversity, uniform species similarity and no dominant species in the rehabilitated area.
Key Words: coral rehabilitation, reef fish, damaged coral, diversity, Nirwana Marine Park.

Introduction. Coral reef is among the most productive and diverse coastal ecosystems in Indonesia (Suharsono 1999; Zakaria 2004). The coral reef degradation in Indonesia, however, tends to increase where 35.15 percent of total Indonesian coral reefs are in poor condition, while 35.06 percent considerably moderate, 23.40 percent in good condition and only 6.39 percent deemed as in very good condition. These conditional criteria resulted from observation conducted in 108 locations and 1064 monitoring stations across Indonesian marine territory (Zakaria 2007; Zakaria & Nurdin 2016). Among the causative factors to the degradation of coral reefs, the anthropogenic factor gives a major impact. It includes the use of bombs and poisons in fishing, careless anchoring over coral reefs, sedimentation, industrial effluences and coral harvesting for souvenirs (Zakaria 2004; Nyström et al 2000; Wells et al 2006; Liu et al 2012; Sahetapy et al 2017). All of these lead into the reducing of suitable habitats for coral breeding that impacts any biota associated therein, including the reef fishes.

It is imperative to maintain the sustainability of the coral reefs so they can optimally function. Transplantation technique is an effort to ensure this optimal function as it rehabilitates the damaged corals (Clark & Edwards 1995; Yap 2003; Abelson 2006; Rojas et al 2008; Zakaria et al 2019). Coral transplantation is an alternative to restore coral reef community, as it has been conducted in Nirwana Marine Park, West Sumatra, where the coral transplants were in use to fix the damaged and broken coral reefs.

The improvement on the damaged coral reefs increases the coverage of living corals which then provides more habitat for reef fishes (Fadli et al 2012). Availability of more living corals as habitat invite more reef fish species as well as any other organisms associated with coral reefs (Carr & Hixon 1997; Hukom 2010). Similarly, the same effect happened whenever artificial reefs are used to substitute the function of natural corals as habitat for reef fish (Zakaria 2004; Zakaria et al 2019).

Reef fishes are organisms living within or in proximity with coral reef ecosystems. They consist of large amount of species and inhabit the coral reef area; hence, they are the supporters for this ecosystem (Nybakken 1992). Reef fishes prefer reef habitats that provide them food source and protection. Reef fishes also take benefit from coral reef as refugial place from predators (Giyanto et al 2014).

Succession is a regular occurrence in a certain community, where a new community that is different from the original one created over time. Succession is resulted from modification of physical environment around the community or ecosystem. The final stage of community succession process is the formation of climax community form (Odum 1992). The succession can be seen as ongoing occurrence at the area of Nirwana Marine Park, where the coral transplantation induced in a partially damaged area where the natural corals enacted to grow in their own environment and any associated organism is let intact.

Nirwana Marine Park Beach is a saline aquatic body in West Sumatra coastal area where the coral reefs experience damage. Rehabilitation effort through coral transplantation has been carried out couple years ago (Anwar 2016). Therefore, it is necessary to monitor the dynamics on reef fishes at the transplanted area to assess the rehabilitation progress. This study aimed to determine the succession of reef fish in the transplanted area by observing the structure of reef fish community based on the abundance, dominance, diversity and uniformity of associated reef fishes.

Material and Method

Study area, time, and materials. The study was conducted at Nirwana Marine Park, West Sumatra, Indonesia, where coral rehabilitation with combination of coral transplants and artificial reefs was implemented (GPS coordinates 1°00'49" S; 100°23'22" E) from February until June 2018 (Figure 1).

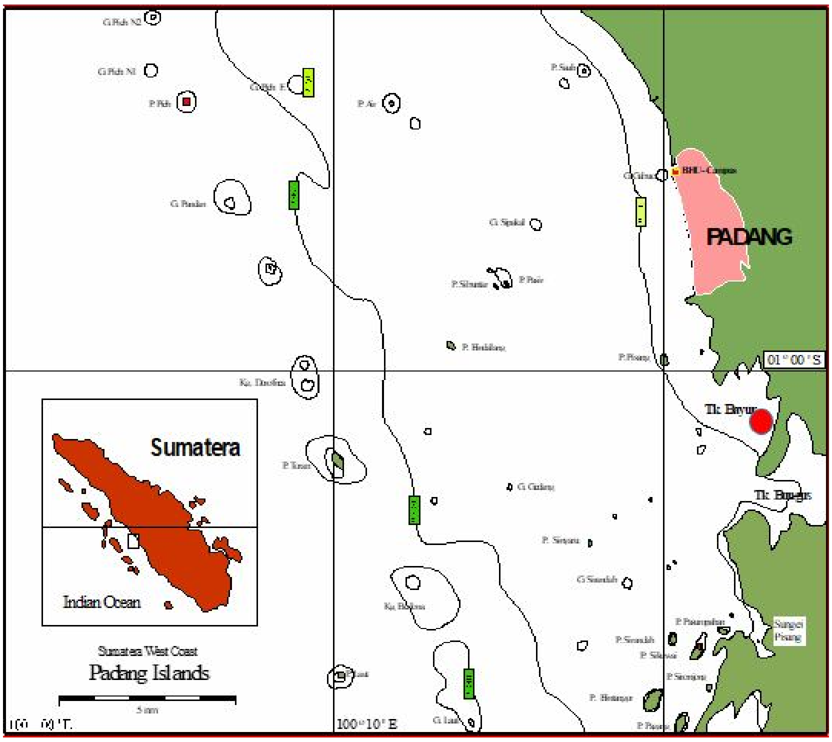

Figure 1. Research location (●).

There were 70 artificial reefs for coral transplants (each with 1m x 0.6m x 0.1m dimension (it was registered with a patent application at the Ministry of Law and Human Rights Republic of Indonesia; Paten ID: P00201608534) to accommodate 630 coral seedlings planted. In total, the artificial reefs reached 60 m^2 of transplantation area (Figure 2). There were nine coral species planted, namely: *Acropora digitifera*, *Acropora donei*, *Acropora formosa*, *Acropora humilis*, *Montipora* sp., *Pocillopora damicornis*, *Pocillopora verrucosa*, *Porites lutea*, and *Porites nigrescens*.

Figure 2. Coral transplants and artificial reefs.

Methodology. The survey used Visual Census Underwater Fish technique for collecting data (English et al 1994; Giyanto et al 2014), and to identify reef fish species we use books of Tropical Reef-Fishes of The Western Pacific; Indonesia and Adjacent Water (Kuiter 1992) and also refered to www.fishbase.org. The underwater work was facilitated with SCUBA apparatus, conducted initially a month before coral rehabilitation commenced (on February 2018) and subsequently on monthly basis (April until June 2018) after the coral transplantation. Observers swam slowly above the coral transplant area and recorded the species and total individual of any reef fish encountered (carried out seven days in every month). Physical and chemical water parameters, consisting of temperature (^{o}C), pH, salinity (‰), dissolved oxygen (DO; ppm), and carbon dioxide (CO_2; ppm) were also analysed once a week during the each month of the study period, at between 3-5 meters depth of water.

Data analysis. Field data was analyzed and presented as fish abundance, Shannon-Weaver diversity index, evenness index and Simpson dominance index. Furthermore, the findings were supplemented with tables and graphics.

Fish abundance was calculated using the formula (Odum 1992):

Fish abundance (N; individual/area) = number of individuals fish to i (ni)/the area of the sample (A).

The Shannon-Wiener diversity index (H') was calculated using the formula (Ludwig & Reynolds 1988), as follows:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

where: H′ = Shannon–Wiener diversity; pi = ni/N (ni is the number of individuals species i, and N is total number for all species in the population, with the criteria of diversity, namely: low (H’ < 1), moderate (1 < H’ < 3), and high (H’ > 3). Paired t test was used to determine differences in diversity index values between months of observation (Poole 1974).

Evenness index is to determine the distribution of each species of reef fish in the area of the observation area. The evenness index (E) was calculated using the formula (Ludwig & Reynolds 1988):

$$E = \frac{H'}{H\ max} = \frac{H'}{In\ S}$$

where: E = evenness index; H' = diversity index; H max = In S, S = number of species. The evenness index ranges as follows: 0-0.50 (the community is in a depressed condition), 0.51-0.75 (the community is in an unstable condition), and 0.76-1 (the community is in a stable condition).

Dominance index or Simpson dominance index (C) was calculated using a formula (Ludwig & Reynolds 1988):

$$C = \sum \left(\frac{n_i}{N}\right)^2$$

where: C = dominance index; n*i* is the number of individuals of *i*th species, and N is total number for all species. Dominance index criteria are $0 < C < 0.5$ (there are no dominant types) and $0.5 > C > 1$ (there is a dominant type) (Odum 1992).

Results

The abundance of reef fishes. There were five families, 11 species with 39 individuals of reef fish recorded on February 2018 during the pre-transplantation observation. The families consisted of Acanthuridae, Labridae, Pomacentridae, Scaridae and Siganidae. On April, after a month of coral transplants installed, the observation recorded eight families; Acanthuridae, Chaetodontidae, Labridae, Nemipteridae, Pinguipedidae, Pomacentridae, Scaridae and Siganidae, along with 17 species and 235 individuals. The families Acanthuridae, Callionymidae, Chaetodontidae, Labridae, Pomacentridae, Scaridae, and Siganidae, with their 20 species and 163 individuals sighted during monthly observation in May. In the last observation, the observation booked 10 families of reef fish (Acanthuridae, Caesionidae, Centriscidae, Chaetodontidae, Labridae, Pinguipedidae, Pomacanthidae, Pomacentridae, Scaridae, and Tetraodontidae) with 23 species and 263 individuals. The abundance of observed reef fish was detailed in Table 1.

Table 1 also signifies that during pre- and post-installment of coral transplants, there were more herbivorous reef fishes than the carnivorous or omnivorous ones, in term of individual number. In term of species number, the carnivorous reef fishes were recorded more than the other two trophic groups.

The herbivorous reef fishes in February were dominated by *Acanthurus auranticavus* (Acanthuridae), *Hemiglyphidodon plagiometopon*, *Pomacentrus nagasakiensis* (Pomacentridae), *Scarus chameleon*, *S. rivulatus*, *Chlorurus bleekeri*, *Siganus doliatus*. While the carnivorous fishes were *Halichoeres hortulanus*, *Thalassoma lunare* (Labridae), and the omnivorous consisted of *Abudefduf vaigiensis* and *Chromis caudalis* (Pomancentridae).

In April, the reef fishes were dominated by the carnivorous species including *Chaetodon triangulum* (Chaetodontidae), *Coris dorsomacula*, *Halichoeres nigrescens*, *H. hortulanus*, *Labroides dimidiatus, Thalassoma lunare* (Labridae), *Scolopsis affinis* (Nemipteridae), and *Parapercis cylindrica* (Pinguipedidae). It was seconded by the herbivorous group that consisted of *Acanthurus auranticavus*, *Zebrasoma scopas* (Acanthuridae), *Plectroglyphidodon lacrymatus* (Pomacentridae), *Scarus chameleon*, *S. rivulatus*, *Chlorurus bleekeri* (Scaridae), *Siganus doliatus* (Siganidae). While the omnivorous were still with the two species recorded in the previous month.

The carnivorous reef fisher still dominated in May, where the species such as *Anaora tentaculata* (Callionymidae), *Chaetodon triangulum* (Chaetodontidae), *Halichoeres nigrescens*, *H. hortulanus*, *H. marginatus*, *H. leucurus*, *Hemigymnus fasciatus*, *Stetojhulis trilineata*, *Labroides dimidiatus* and *Thalassoma lunare* (Labridae) recorded. For herbivorous group, the reef fishes were *Acanthurus auranticavus* (Acanthuridae), *Hemiglyphidodon plagiometopon*, *Pelectroglyphidodon lacrymatus*, *Pomacentrus nagasakiensis*, and *P. chrysurus* (Pomacentridae), *Scarus chameleon*, *S. rivulatus* (Scaridae), *Siganus doliatus* (Siganidae); there was no change on omnivorous group at this month.

The species number of trophic group during last observation stayed the same. The carnivorous fishes were recorded more than others, encompassed *Caesio caerulaurea* (Caesionidae), *Aeoliscus strigatus* (Centriscidae), *Chaetodon collare*, *C. vagabundus*, *Heniochus acuminatus* (Chaetodontidae), *Coris dorsomacula*, *Halichoeres nigrescens*, *H. hortulanus*, *Labroides dimidiatus*, *Thalassoma lunare* (Labridae), and *Parapercis cylindrica* (Pinguipedidae). The herbivorous species included *Acanthurus lineatus* (Acanthuridae), *Centropyge eibli* (Pomacanthidae), *Hemiglyphidodon plagiometopon*, *Neopomacentrus azysron*, *Plectroglyphidodon lacrymatus*, *Pomacentrus nagasakiensis*, and *P. chrysurus* (Pomacentridae), *Scarus chameleon*, and *S. rivulatus* (Scaridae). While on omnivorous group recorded new species *Canthigaster solandri* (Tetraodontidae), in addition to *Abudefduf vaigiensis* and *Chromis caudalis* (Pomacentridae) that had been recorded in previous months.

Table 1

The abundance of reef fishes on 60 m^2 coral rehabilitation area during pre- and post-installment of coral transplants

No	*Family*	*Species*	*Trophic level*	*Month of observation (individual)*			
				February	*April*	*May*	*June*
1	Acanthuridae	*Acanthurus auranticavus*	H	2	15	5	-
		A. lineatus	H	-	-	-	5
		Zebrasoma scopas	H	-	1	-	-
2	Caesionidae	*Caesio caerulaurea*	C	-	-	-	28
3	Callionymidae	*Anaora tentaculata*	C	-	-	2	-
4	Centriscidae	*Aeoliscus strigatus*	C	-	-	-	48
5	Chaetodontidae	*Chaetodon triangulum*	C	-	1	1	-
		C. collare	C	-	-	-	1
		C. vagabundus	C	-	-	-	1
		Heniochus acuminatus	C	-	-	-	1
6	Labridae	*Coris dorsomacula*	C	-	6	-	2
		Halichoeres nigrescens	C	-	12	18	23
		H. hortulanus	C	1	3	4	3
		H. marginatus	C	-	-	1	-
		H. leucurus	C	-	-	2	-
		Hemigymnus fasciatus	C	-	-	2	-
		Stethojulis trilineata	C	-	-	2	-
		Labroides dimidiatus	C	-	2	2	2
		Thalassoma lunare	C	6	28	45	50
7	Nemipteridae	*Scolopsis affinis*	C	-	3	-	-
8	Pinguipedidae	*Parapercis cylindrica*	C	-	2	-	2
9	Pomacanthidae	*Centropyge eibli*	H	-	-	-	1
10	Pomacentridae	*Abudefduf vaigiensis*	O	2	1	3	3
		Chromis caudalis	O	4	15	18	25
		Hemiglyphidodon plagiometopon	H	1	-	6	8
		Neopomacentrus azysron	H	-	-	-	1
		Plectroglyphidodon lacrymatus	H	-	9	14	18
		Pomacentrus nagasakiensis	H	1	-	2	2
		P. chrysurus	H	-	-	1	1
11	Scaridae	*Scarus chameleon*	H	10	46	17	20
		S. rivulatus	H	8	62	15	17
		Chlorurus bleekeri	H	2	26	-	-
12	Siganidae	*Siganus doliatus*	H	2	3	3	-
13	Tetraodontidae	*Canthigaster solandri*	O	-	-	-	1
		Total individuals		39	235	163	263
		Number of species		11	17	20	23

Note: H = herbivore; C = carnivore; O = omnivore.

Shanon-Wiener diversity index (H'), Evenness index (E), and Simpson dominance index (C) of reef fishes. The dynamics in diversity, equitability, and dominance of reef fishes on 60 m^2 coral rehabilitation area can be seen in Figure 3. The diversity index during pre-installment of coral transplants (February 2018) was 2.09, which mean moderate diversity level. The subsequent observations during post installment of coral transplant still showed a moderate diversity of reef fishes, but with steadily increased indices from month to month; 2.21 on April, 2.39 on May and 2.44 on June. Moderate level for the diversity of reef fishes signified that the reef fish community was in normal condition. The t-test analysis confirmed the diversity index was not significantly different ($p < 0.05$) across the period of study.

On pre-installment observation, the evenness index for reef fishes in the coral rehabilitation area was 0.39, meaning unequal distribution of reef fishes. This condition showed improvement, as on post-installment of coral transplants, the evenness index increased into 0.77 on April, 0.79 on May but slightly decreased to 0.77 on June. It indicated that species distribution tend to equalize within the coral rehabilitation area.

On the other hand, the dominance of certain species over the rehabilitated coral area showed a lowering trend. As of February, it was 0.16 before steadily decreased to 0.14 on April, 0.12 on May, and reached the lowest 0.11 on June. In general, the overall dominance indices were lower than 0.50, indicating that none of the recorded reef fishes dominated the rehabilitated coral reef.

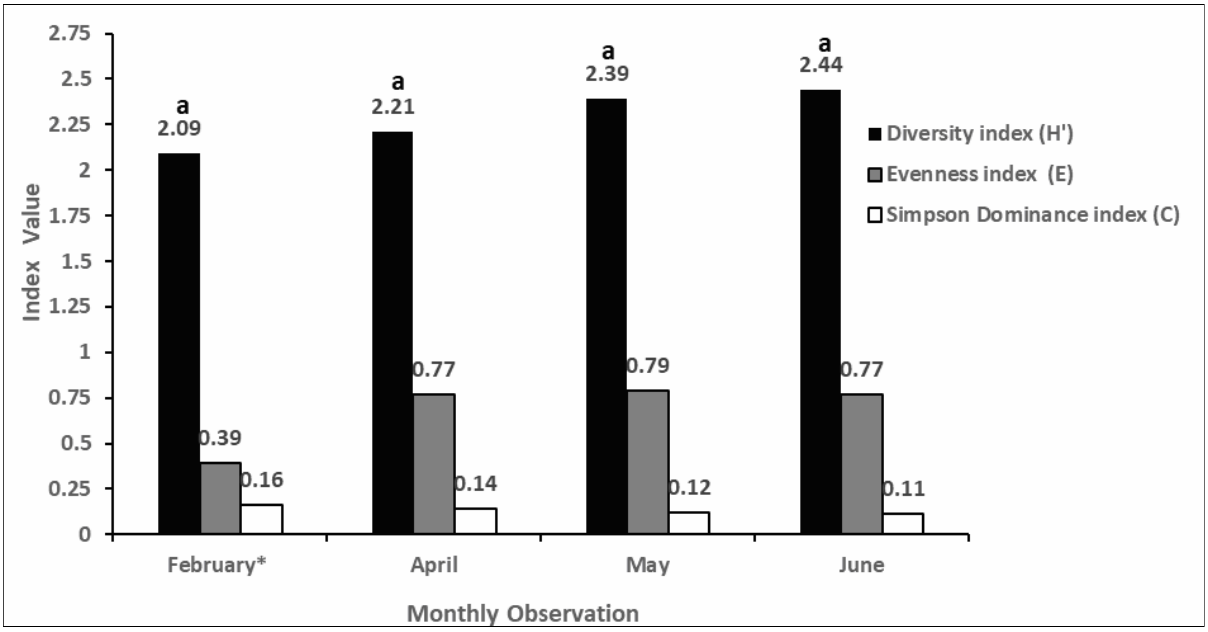

Figure 3. Diversity index (H') and t-test analysis with lowercase ($p < 0.05$), Evenness index (E), and Simpson Dominance index (C) of reef fishes at the coral area rehabilitated with coral transplantation and artificial reef in West Sumatra, Indonesia.

Physical and chemical aspects of aquatic environment. The measurement for physical and chemical factors of aquatic environment included water temperature (^oC), salinity (‰), pH, DO and CO_2 level. The result is presented in Table 2. Water temperature during the study period ranged from 29 to 31°C, while salinity ranged from 32 to 34‰, pH 7.6-8.0, DO level 4.9 to 6.2 ppm and CO_2 level between 2.3 and 4.4 ppm.

Table 2

Physical and chemical aspects of aquatic environment in Nirwana Marina Park

Parameter	*Unit*	*Months of observation*			
		February	*April*	*May*	*June*
Temperature	^oC	29	31	31	31
Salinity	‰	34	33	32	33
pH	-	7.6	8.0	7.8	7.9
DO	ppm	5.0	5.1	4.9	6.2
CO_2	ppm	4.4	4.4	3.1	2.3

Discussion. Succession in coral reef is initiated by the emergence of benthic organisms such as diatom or algae, and molluscs that attach upon corals (Syam 1994; McClanahan 2008; Zakaria et al 2016). This process is presumably happened on transplanted corals and artificial reefs too (Zakaria et al 2019). On April, or a month after coral transplants initiated, the rehabilitated area was dominated by herviborous fishes from the families Acanthuridae, Pomacentridae, Scaridae and Siganidae with species abundance reached 162 individuals within 60 m^2 area (Table 1). The colonizing algae on corals attract herbivorous reef fishes to feed on at the rehabilitated area. Reef fishes such as *Acanthurus auranticavus*, *Zebrasoma scopas*, *Abudefduf vaigiensis*, *Chromis caudalis*, *Plectroglyphidodon lacrymatus*, *Scarus chameleon*, *Scarus rivulatus, Chlorurus bleekeri* and *Siganus doliatus* (Table 1) were thought to feed on these sessile biotas.

The appearance of herbivorous reef fishes during this stage will endorse the recovery of corals. These fishes become key biotic component that inhibit the growth of micro-and macro-algae, hence give corals more resources to recover (Damhudy et al 2011).

The increasing number of carnivorous reef fishes was observed in May, where species like *Anaora tentaculata*, *Halichoeres nigrescens*, *H. hortulanus*, *H. marginatus*, *H. leucurus*, *Hemigymnus fasciatus*, *Stethojulis trilineata*, *Labroides dimiatus*, and *Thalassoma lunare* appeared, subsequently followed by the decreasing of herbivorous reef species and individuals number (Table 1). There seems to be a connection between the population of herbivorous reef fishes with the existence of the carnivorous ones, as the earlier provide energy (food source) for the latter (the consumer) within the food chain scheme (Choat & Belwood 1991; Froehlich & Kline 2015). The population dynamics of herbivorous reef fish affects the distribution and composition of algae within the ecosystem, as well as projecting behavioral patterns and the demographic of the overall reef fishes.

In May, several species (herbivorous and carnivorous) were not found anymore, namely: *Zebrasoma scopas*, *Coris dorsomacula*, *Scolopsis affinis*, *Parapercis cylindrica* and *Chlorurus bleekeri* (Tabel 1). The decrease on overall individuals of reef fishes on May was thought to relate with unstable environmental conditions, in addition to rapid current during observation. Many factors influence the community structure and abundance of fish at a certain coral ecosystem, including the percentage of living coral (Bell & Gazlin 1984; Jones et al 2004; Yanuar & Aunurohim 2015), zonation of habitat such as inner reef flat, outer reef flat, crest, reef base, sand flat (Green 1996) and physical changes like current, brightness and temperature (Annisa et al 2019). Fishes will generally gather on the sites that are rich with food sources, while avoid crashing waves and current by occupying the deeper region of water (Frimanozi et al 2019).

The structure of artificial reefs can attract reef fishes from surrounding the reef to settle therein (Choat & Belwood 1991; Frimanozi et al 2019). There were eight additional species observed in June, through the incoming of species *Acanthurus lineatus*, *Caesio caerularea*, *Aeoliscus strigatus*, *Chaetodon collare*, *C. vagabundus*, *Heniochus acuminatus*, *Centropyge eibli*, *Neopomacentrus azysron* and *Canthigaster solandri*. Meanwhile, some species observed in May were not recorded on the subsequent month, namely *Acanthurus auranticavus*, *Anaora tentaculata*, *Chaetodon triangulum*, *Halichoeres marginatus*, *H. leucurus*, *Hemigymnus fasciatus*, *Stethojulis trilineata*, and *Siganus doliatus* (Table 1). The addition and absence of certain species in the rehabilitated area were influenced by the existence of species on the previous month, habitat dynamics, and food availability. Each fish species requires specific needs, even the individuals within a species act differently in the way of taking shelter, finding food, or preferring specific habitat (Green 1996; Jones et al 2004; Coker et al 2014). Species composition of reef fish will be affected by the distribution of fish species within the surrounding habitats, the existence of juveniles and adults as well as the dynamics of pelagic fish that feed on corals (Walsh 1985; Almany 2003; Becker et al 2017; Frimanozi et al 2019).

Coral reefs provide decent shelters for reef fishes, especially the small ones or the juveniles (Maduppa et al 2007). The structure of coral reefs enacts the surrounding fishes to take cover from current and conserve their energy. Hence, the increase of species and individual number as observed in this study was caused by the arrival of juveniles and new species from around of rehabilitated area. In turn, the community of small fishes will attract bigger fishes that look for prey to feed on (Coker et al 2014).

The composition and abundance of reef fishes were determined by the conditions of the aquatic body, form and width of living corals, bottom substrates, and the association with benthic organisms. The optimum coral reef can be achieved within a healthy aquatic environment where space and food are sufficiently available, which then support species diversity and optimal population (Frimanozi et al 2019). The movement of current is also essential to ensure food source (e.g. microorganisms) and oxygen availability. The current also averts the dirt build-up and sedimentation on the surface of the coral reefs (Zakaria 2004).

The diversity of reef fishes at the rehabilitated area in Nirwana Marine Park within the period of February to June 2018 showed a moderate diversity level ($2.0 < H' \leq 3.0$). It meant that ecological pressure in this area was also on a moderate level (Ludwig & Reynolds 1998).

Previous research in the aquatic body of Makian Island, North Maluku Province showed relationship between reef fish diversity with total coverage of living corals in that area (Najamuddin et al 2012). The wider the coverage of living corals, the more diverse and abundant the reef fishes in that ecosystem (Hukom 2010). In adversely, the increase of dead corals will negatively correlate with number of species and individual of associative reef fish. The high diversity in coral reefs resulted from the ability to coexist among various organisms, especially those highly specialized and adapted to avoid competition (Nybakken 1992; Yanuar & Aunurohim 2015).

Another influencing factor for the diversity of reef fishes in rehabilitated area is the coral species used as transplant. The rehabilitation in Nirwana Marina Park use *Acropora* coral, which has branching as its morphological feature. Therefore, some specific reef fishes that specifically associate with this coral were observed in this study. The transplanted coral used in coral rehabilitation effort is indeed determinant to the fish species attracted, as there has been some specific adaptation between coral and fishes that attach to them (Valentino 2004; Yanuar & Aunurohim 2015). Example, the association between *Apogon* fishes with *Porites* corals and *Amblyglyphidodon* fishes that use *Acropora* coral for shelter.

The evenness of species within the rehabilitated area ranged from 0.77 to 0.79 during the study period. This range, which is slightly bigger than the standard for this index ($E = 0.75$) indicated that the reef fishes distributed evenly in each month of observation (Ludwig & Reynolds 1988). The more even individual across species distributed within an ecosystem, the better the balance within it (Utami 2010).

The dominance index (C) for reef fishes within the rehabilitated area was calculated between 0.11 and 0.14 (Figure 3). These values fell whithin the range of low category for species dominance ($0 < C \leq 0.50$), meaning that no reef fish species dominated other species or certain resource within the rehabilitated area (Ludwig & Reynolds 1988). This was also supported by the moderate diversity index recorded for the same rehabilitated area, as explained above.

According to Fujita et al (1996) and Rooker et al (1997) reef fishes in artificial reefs are dominated by certain groups of fish, due to the fish's preference for artificial reefs, or because of biota attached to artificial reefs. The results of the observation showed that the dominance value of all observations were relatively low from the range of 0-1, so there were no dominance of certain fish species in the fish community.

Coral reef succession consists of the recovery phase, advanced community and climax community. The climax community occurs at the end of the succession process where a community is stable and achieves balance (Alfaridy 2010; Utami 2010). All of these diversity (H'), evenness (E), and dominance (C) indices on the rehabilitated area of Nirwana Marine Park hinted that the ongoing succession was far from reaching climax. The succession in the reef fish community will happen whenever the coral is already stable. It will be marked with the high concentration and diversity of reef fishes. The dynamics in the relative abundance of corals within a reef community give the significant capability to self-recover from disturbance (Wilkinson et al 2003).

All measured parameters still fell within the normal range of feasible physical and chemical aspects for coral life. Coral reefs are generally restricted to waters being never below 18^{o}C and not exceeding 36^{o}C, with an optimal range of 26-29^{o}C. This is expressed in latitudinal patterns of coral reef distribution and diversity (Birkeland 1997; Suharsono 1999; Zakaria 2004). Within this range, certain corals will grow faster or slower, depending of temperature. Drastic thermal shifts can result in reduced coral vitality (e.g., bleaching, reproduction inhibition) or, in extreme instances, total destruction of entire reef systems (Birkeland 1997).

The other limiting factor of growth of corals is salinity. Corals as well as coral reefs are limited to areas of reasonably normal marine salinity (32-35 ‰), but they can grow at a high levels of salinity (42 ‰) (Nybakken 1992; Birkerland 1997). Futher, according to Birkeland (1997) the range of pH values suitable for coral reefs is 7 to 8.5.

Conclusions. From the observations on reef fish community structure at the coral rehabilitation area in Nirwana Marine Park, West Sumatra, there was strong indication that the fish community was at advanced succession stage where there was species fluctuation in each monthly observation. Furthermore, the rehabilitation area was also characterized with moderate diversity, uniform species similarity and no dominant species.

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Authors:
Indra J. Zakaria, Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, Padang - 25163, Indonesia, e-mail: indrajz@yahoo.com
Hidayatul Annisa, Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, Padang - 25163, Indonesia, e-mail: annisa.aca@gmail.com
Syaifullah, Biology Department, Faculty of Mathematic and Natural Sciences, Andalas University, Limau Manis, Padang - 25163, Indonesia, e-mail: poellah@gmail.com

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