INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 11, Issue 3, July-September 2020: 857-864 www.ijcs.ro

CORAL REEF CONDITIONS OF MANADO BAY, NORTH SULAWESI, INDONESIA

Silvester B. PRATASIK[1*], SUPRIHARYONO[2], Haryani SAMBALI[1], Lefrand MANOPPO[1]

[1]Faculty of Fisheries, Sam Ratulangi University, Manado, Jl. KampusBahu Manado-95115, North Sulawesi, Indonesia;
[2]Faculty of Fisheries and Marine Science, Diponegoro University, Jl. Prof. H. Soedarto, S.H.-Tembalang Semarang, Central Java, Indonesia 50275

Abstract

Coral reefs are a complex coastal ecosystem and possess important roles in supporting the early stages of marine organisms, such as fish, mollusk, and many other invertebrates, through providing various types of habitats and shelters. This study aims to investigate the coral reef condition in Malalayang II waters, Manado, and Kalasey waters, Minahasa regency. This work was achieved in order to promote the conservation of branching coral species that support the availability of egg placement habitat of cuttlefish Sepia latimanus. Data were collected through SCUBA dives at seven stations using Line Intercept Transect method at three, five, and ten meter depth. Results showed that the coral reef ecosystem condition at Manado Bay waters, particularly Malalayang II, was sufficiently productive to support marine biota in the area. It is indicated with low to medium coral cover, low to medium coral diversity, and high coral evenness. Other biotic components of the coral reefs help also support the marine life in this area. These conditions reveal that Manado Bay waters can maintain the availability of coral reef habitats

***Keywords**: LIT method; Percent living coral cover; Bioiversity; Evenness.*

Introduction

Coral reefs are a complex coastal ecosystem and known possessing important roles in supporting the early stages of marine organisms, such as fish, mollusk, and many other invertebrates, through providing various types of habitats and shelters. As an archipelagic country, Indonesia has coral reef spread of about 60,000 km^2 from the west to the east of Indonesia and represents about 1/8 of world coral reefs.

The habitat availability in the coral reefs strongly affected the reef fish abundance as either obligate residents [1-4], or species with specific shelter requirements [5-7]. Environmental factors may also influence the abundance patterns [8], and therefore, the relationship between fish abundance and habitat characteristics can vary with locations [9-11]. The relationship between habitat availability and reef fish abundance becomes weaker and weaker with space size increment as well [11-13].

Coral reef destruction, especially in Indonesia, occurs very fast from human activities and natural causes and it has enlarged the pressure on the natural coral reef ecosystem. Good coral reef condition is only about 6.2%, but the exploitation rate of the coral reef seems to be high enough because of poor management system, even though the quantity of coral trade has, in fact, been limited by the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) [14]. It makes coral cover decrease, coral species composition

* Corresponding author: sbpratasik@unsrat.ac.id

change, and loss of habitat complexity so that all of these will reduce the diversity and the abundance of coral fish groups and change the species composition [15]. This condition is supported by previous studies [15-21]. Several families of reef fishes, such as butterfly fish (*Chaetodontidae*), cardinalfish (*Apogonidae)*, and gobies (*Gobiidae*), are more dependent upon the corals than other fish families and can be directly influenced by loss of corals [15, 22]. Loss of corals can have serious impact on growth and body condition of coral-feeding fish species [23] and may affect the reproductive success of the fish population.

Furthermore, there is a strong positive relationship between structural complexity and fish density and biomass, likely mediated through density-dependent competition and refuge from predation. More variable responses were found when assessing individual fish families, with all families examined displaying a positive relationship to structural complexity, but only half of these relationships were significant. Clearly, structural complexity is an integral component of coral reef ecosystems, and it should be incorporated into monitoring programs and management objectives [24]. Furthermore**,** coral structural complexity also highly influences the reproductive success of cuttlefish *Sepia latimanus* that utilize crevices of the branching corals to lay eggs, and it reflects that branching corals have important role in supporting the population of *S. latimanus* as either egg placement site or shelter for cuttlefish [25].

This paper addresses the coral reef conditions in relation with the availability of egg placement habitat selection of the cuttlefish *Sepia latimanus* in the coastal waters of Malalayang II village, Manado, and Kalasey waters, Minahasa regency, North Sulawesi. In the past, Manado Bay is a long beach with a variety of coastal habitats, from coral substrate, boulders, and sandy bottom and some areas were filled with algae.

Methodology

Coral reef condition of Manado Bay was assessed using *Line Intercept Transect* (LIT) method [26]. Transect lines, as long as 50m, were set at the depth of three, five and ten meters from zero tide level. Each coral colony passed by the transect line was recorded the lifeform. The transitional point of each lifeform was also recorded. Length of each lifeform was taken as difference between the transitional points of each lifeform [27].

Water quality parameters, such as temperature, salinity, depth, and tide, were measured when coral surveys were done. Temperature measurements were taken *in situ* using a divecom at the dives, while water salinity was obtained using a refractometer after taking water sample.

Percent cover of living corals was calculated as follows:

$$Ni = Li / L \times 100 \quad (1)$$

where Ni = percent cover of benthic component i (%), Li = length of benthic component i (cm), and L = length of transect line (5.000cm). Coral condition classification employed Yap and Gomez as follows [28]: 0÷24.9% cover as "poor", 25÷49.9% "moderate", 50÷74.9 "good" and $\geq$ 75% "very good". The assessment of coral reef ecosystem productivity used Shannon-Wiener's diversity index [29]:

$$H' = -\sum_{i}^{s} \frac{ni}{N} log \frac{\mathrm{ni}}{N} \quad (2)$$

where H' = diversity index, s = number of genera, ni = number of genera i, and N = total number of individuals. Coral reef productivity criterion was determined by the extent of environmental pressures as follows: H' < 1 means "very strong environmental disturbance", 1 > H' < 3 is for "moderate environmental disturbance", and H' > 3.0 means "evenly balanced ecosystem". To support the performance of coral reef ecosystem in holding aquatic organisms in Manado bay, evenness index was applied [30]:

$$J = H' / H'_{maks} \quad (3)$$

Where J = evenness index and H'_{maks} = log $S.J$ ranges from 0÷1 to reflect the condition equality of number of individuals per genus, with the following criteria: 0.6÷1 as "high genus evenness", 0.4 > J > 0.6 as "moderate genus evenness", and J = 0÷0.4 as "low genus evenness".

Results and Discussion

Manado bay possesses clear seawater with extensive fringing reef spread along the coast, particularly in Malalayang II. Water currents move northwestwards at low tide and eastwards at high tide. During the study, water temperatures were between 27°÷28°C and salinity between 31 ÷33‰, indicating that Manado bay has small temperature and salinity variations. Both water quality parameters are still in optimum range for coral growth according to Nybakken [31].

In general, station 1 is dominated by wide sandy bottom and grown with seaweeds, then also occurs a reef flat at the intertidal. The depth of three meters is occupied by genus *Favia, Porites, Stylophora, Hydnophora, Crynoid, Goniastrea, Favites, Ascidia, Caulastrea, Symphyllia, Oxyphora, Halimeda,* and *Pocillopora.* Genus *Folios* occurs down to approximately 25m depth. There is also small coral reef with various coral genera distributed between 3÷15m depth.

Coral reef at station 2 starts approximately 75m distant from the coastline with reef flat, followed with coral hills northwards and sandy bottom northeastward down to 7m depth, then another coral reef at three to four meters depth, and some corals are also found in deeper waters. Coral distribution in station 2 reaches about one km distant from the coastline. Based on the LIT survey, the depth of 5m was occupied by *Hydnopora, Astreopora, Favites, Montipora, Galaxea, Gardinoseris, Lobophyllia, Pocillopora,* and *Porites,* while the depth of 10m was inhabited by *Galaxea, Astreopora, Plerogyra, Montipora, Porites, Acrelia, Doploastrea, Mycedium, Ascidia, Oxypora, Turbenaria,* and *Stylophora*.

Station 3 is characterized by shallow reef flat and gets drought at the lowest tide, with patchy ponds of about 30cm deep. This area was mostly dominated by massive corals, dead corals, soft corals, and other benthic organisms. Transect data showed that the depth of five meters was occupied by *Hydnophora, Oxyphora, Euphyllia, Montipora, Lobophyllia, Caulastrea, Cyphastrea* and *Favites*, while deeper area was generally covered with sandy substrate and some small coral colonies.

Station 4 was characterized with reef flat, big boulders, dead corals, and other benthic organisms. The depth of five meters was occupied by *Hydnophora, Favia, Diploastrea, Montipora, Euphyllia, Lobophyllia, Plathygira, Symphyllia, Merulina, Oulophyllia, Galaxea, Pocillopora,* and *Mycedium.*

Station 5 was characterized with reef flat starting from 15m distant from the coastline. Field observation indicated that the depth between three and five meters was occupied by *Lobophyllia, Platygira, Goniastrea, Merulina, Favia, Mycedium, Hydnopora, Oxypora, Fungia, Diploastrea, Halomitra* and *Montipora,* while the depth of 10m was inhabited by *Merulina, Lobophyllia, Fungia, Herpolitha, Alveopora, Oxypora, Caulastrea, Porites, Euphyllia,* and *Plerogyra*.

Station 6 is flanked by two small streams, 0.5m wide and two meters wide, respectively. Reef flat starts at the distance of about 15m from the coastline and sandy substrates at the left and the right sides, then followed with steep wall. The depth of five meters was occupied by *Montipora, Gardinoseros, Diploastrea, Euphyllia, Merulina, Symphyllia, Oulophyllia, Pocillopora* and *Fungia.*

Station 7 is a coral reef ecosystem near shore (±15m) with sufficiently steep slope and the reef depth reaches to 27m. The depth of three meters was occupied by *Porites, Montipora, Lobophyllia, Hydnopora, Pachyseris, Favites, Mycedium, Pocillopora, Galaxea, Herpolita, Favia, Coeloseris, Oxyphora, Turbinaria,* and *Fungia* and *Crynoid*, while the depth of ten meters was occupied by *Montipora, Mycedium, Diploastrea, Hydnophora, Crynoid, Pachyseris,* *Goniastrea, Herpolitha, Galaxea, Turbinaria, Anacropora, Sandalolita, Lobophyllia, Porites, Symphillia, Fungia*, and *Favia*.

Table 1. Coral percent cover, diversity index, and evenness index.

Station	Depth (m)	Cover (%)	Condition	H'	Category	*J*	Category
1	3	22.2	Poor	0.95	Low	0.91	High
2	5	31.4	Moderate	1.12	Medium	0.93	High
2	10	9.8	Poor	0.94	Low	0.87	High
3	5	32.2	Moderate	0.85	Low	0.86	High
4	5	18.4	Poor	1.17	Medium	0.96	High
5	5	25.36	Moderate	1.20	Medium	0.92	High
5	10	34.2	Moderate	0.96	Low	0.86	High
6	5	14.6	Poor	1.18	Medium	0.94	High
7	3	40.4	Moderate	1.06	Medium	0.85	High
7	10	15.4	Poor	1.16	Medium	0.94	High

Note: *H'* = diversity index; *J* = evennes index.

Coral percent cover varied from 9.8% to 40.4%. It means that coral reef conditions of Manado bay, particularly Malalayang II waters, according to Yap and Gomez [28], range from poor to moderate. Genus diversity reflected that coral reef in this area had moderate to strong environmental pressures, and genus evenness index indicated high species equilibrium reflecting that the coral reef ecosystem of Manado bay has enough ability to support marine life in this area (Table 1). According to this category [28], the coral reef condition at three meters depth of station 1 is poor. Low species diversity and high species evenness reveal that this waters could support the marine life in this area despite strong environmental disturbance (Table 1).

Based on number of biotic and abiotic components, station 1 had sufficiently high number of coral colonies, both *Acropora* and non-*Acropora*. branching corals represented more than 57% of total number of biotic components (Table 2) and 14% of total coral percent cover, respectively. These colony numbers indicate that the colony size is small and the biotic components are still in growing phase. High number of colonies have sufficiently contributed to the extent of coral percent cover.

Table 2. Number of biotic, abiotic, and other components

Station	Depth (m)	Biotic component	Biotic component of branching coral	Dead coral	Other fauna	Algae	Abiotic component
1	3 m	26	15	29	12	1	5
2	5 m	35	4	24	10	2	11
2	10 m	22	9	14	12	1	4
3	5 m	22	6	6	8	2	10
4	5 m	32	4	19	26	0	9
5	5 m	40	14	24	4	3	3
5	10 m	27	2	13	7	1	5
6	5 m	36	5	30	4	0	1
7	3 m	46	6	26	14	0	0
7	10 m	32	5	8	14	0	20

Station 2 had moderate condition with 30% coral cover at five meters depth, while coral condition at ten meters depth was poor (Table 1). The former is a reef flat with high occurrence of live corals, and the latter occurs at the edge of coral reef ecosystem with dead corals and boulders as attachment substrate of small-sized coral colonies and other biotic components. Diversity index (H') showed that depth of five meters had moderate species diversity and high species evenness, while the depth of ten meters had low species diversity and high species evenness (Table 1). It indicates that the coral reef ecosystem of the area has enough ability to support the marine life despite under sufficiently strong environmental pressures. In station 2, depth of five meters and ten meters had the highest number of biotic components, but the coral percent cover ranged only 9.8% to 30%. Similar to station 1, the biotic components were dominated by young small-sized coral colonies (Table 2). The branching corals occupied only 22.8% of total numbers of biotic component colonies and 6.2% of total percent cover of live corals of non-*Acropora* group in station 2. In spite of that, high number of biotic components in this station highly influences their ecological roles in the coral reef ecosystem, particularly for early life stage of marine organisms.

Abiotic components dominated 49% of total coral cover in station 3. Coral condition is moderate due to high cover of live corals. Branching corals covered 13.3% of total live coral percent cover. Low genus diversity and high evenness reflects good environmental stability to support the marine life in the area (Table 1). It is also supported by the occurrence of other biotic components, such as soft corals, algae, sponge, and other biota, that also influence the marine ecosystem condition. Station 3 of five meters depth also showed that the highest number of biotic components was dominated by non-*Acropora* group (Table 2). Branching corals represented about 27.3% of the biotic components and 12.5% of total coral percent cover in station 3. High biotic components, either live corals or other benthic organisms could give high ecological roles.

Coral reef condition in station 4 was poor. The occurrence of branching corals in this station was only 1.8% of the total coral cover. The deeper water was dominated by sandy bottom and boulders in patchy distribution. Despite poor coral condition, various biotic components beyond hard corals extend over large enough coverage indicating that appropriate site condition for other living organisms could also help increase the ecosystem stability. It is also supported with high biological diversity and evenness (Table 1), and thus, this area has sufficiently high ability to carry the marine life. In station 4, high number of biotic components was also contributed by several coral genera. The highest number of coral colonies in this area gave only low contribution to the coral percent cover due to consisting of small-sized colonies (Table 2). This condition reflects that the hard corals in these waters belong to developing young corals and could give crucial contribution to the productivity of the waters. The high occurrence of biotic components other than hard corals could also support other forms of living organisms.

Moreover, line intercept transects showed that station 5 had moderate coral condition with sufficiently high cover of live corals. Besides, this area had moderate diversity and high evenness of corals at five meters depth and low diversity and high evenness of corals at ten meters depth (Table 1). It reflects that station 5 is stable enough to carry the marine life. Station 5 showed high number of biotic components as well at the depth of five and ten meters, and this number has represented 22% and 34% of total coral cover, respectively. Branching corals covered 8.28% of total percent cover. The occurrence of other biotic components also plays also important role in the coral reef ecosystem. This condition indicates that the live corals in this area are small-sized and still growing, and thus, this area together with other non-coral biotic components could support the ecosystem equilibrium.

Station 6 had poor coral condition and mostly dominated by dead corals**.** Branching corals covered only 2% of total coral cover. The reef flat was almost drought at the lowest tide and experienced a lot of anthropogenic disturbances**.** At the lowest tide, many people came to collect fish and other marine biota trapped between corals for food, sometimes using ennvironmentally unfriendly practices, such as breaking corals, in order to get the animals. Nevertheless, the coral reef ecosystem in this station had moderate genus diversity (H' = 1.18) and high genus evenness (J = 0.94), reflecting that the area possesses sufficiently biotic components to be able to maintain the equilibrium of the ecosystem functions in the organism-environment interactions. Station 6 also possessed the highest number of biotic components (Table 2) as coral reef building components, but this proportion did not give enough contribution to the total live coral percent cover. This condition reflects that the biotic components consist of small colonies and belong to young coral colonies. The presence of young coral colonies in high numbers together with other coral reef components could highly contribute to the ecological equilibrium in this area.

Percent cover of live corals in station 7 demonstrated that coral condition was good enough at three-meter depth and poor condition at ten meters depth. However, station 7 had moderate coral diversity and high evenness at both depths surveyed (Table 1). It means that this coral reef ecosystem has high ability to support the marine life in the area. The biotic components at the 2 depths of station 7 were the highest among all biotic components. These give very high contribution to the stability and the productivity of the coral reef ecosystem in the area. Nevertheless, high number of biotic components with poor to moderate conditions of corals reflects that the individual size of the biotic components consists of young small-sized corals. Branching corals only represented 4.4% of the colony cover at the depth of three and five meters and 4.4% at the depth of ten meters. Field observations revealed that coral distribution in Manado bay, especially the coastal waters of Malalayang II, in general, occurs at the reef flat with low slope level, except station 7, while deeper waters than five meters is generally dominated with sandy bottom and some locations with big boulders. Thus, general coral conditions at five meters depth, except station 7, is better than that at ten meters depth, as a whole number of biotic components is higher than that of abiotic components (Table 2).

The occurrence of coral reef community supporting components, such as algae and other fauna, influences also the ecological interactions in carrying the ecological role of each coral reef ecosystem component. Branching corals that are crucial components in supporting *S. latimanus* population as egg placement site occur only in very low numbers. Some of proper sized-branching coral species selected for the cuttlefish’s egg placement were damaged from anchoring or other human activities (field obs.), but many of them are small-sized and need time to grow bigger in order to be able to hold the egg in the crevice. This condition needs conservation efforts, such as protection area establishment, and other restoration efforts, such as providing artificial crevices, in order to give opportunities that the selected coral species [25] for egg placement site of *S. latimanus* to grow bigger and to give sufficient numbers of proper crevices.

Since Manado Bay waters is very potential to support the fisheries resources, the coral reef habitats need to be conserved through various types of protection efforts, such as marine protection area (MPA) [32] to protect and improve the ocean health and no-take area establishment [33] to increase the fish density and biomass [34]. Although the present MPAs are not able to play important role in the ecosystem-based management (EBM) development [35], the habitat protection efforts have been done.

Conclusions

According to the study of coral reef along the coast of Manado Bay, it can be concluded that the water quality parameters are still in optimum range for the life of coral. Percentage of living coral cover varied from 9.8% to 40.4%. It means that coral reef of Manado bay, range from poor to moderate conditions. The number of genera recorded about 35 genera from all stations. While the index of genus diversity was obtained about 0.94÷1.20. That value reflected that coral reef in this area had moderate to strong environmental pressures. However, the value of evenness index, which ranged 0.85÷0.96, showed that the number of individuals per genus is more or less equal to other genera. Moreover, it reflected that the coral reef ecosystem of Manado bay has enough ability to support marine life in this area, included of supporting the availability of egg placement habitat of cuttlefish *Sepia latimanus*.

Acknowledgements

We would greatly appreciate the Directorate General of Higher Education, the Department of Education and Culture of Indonesia for the financial support, the Dragonet Diver and Mr. James Saerang for dive gear facilities assistance, and Mr. Brando Supit as field assistant in data collection. All these contributions have encouraged the authors to come up with this valuable information.

References

[1] P.L. Munday, G.P. Jones, M.J. Caley, *Habitat specialisation and the distribution and abundance of coral-dwelling gobies,* **Marine Ecology Progress Series**, **152**(1-3), 1997, pp. 227–239.
[2] J.D. Bell, R. Galzin, *Influence of live coral cover on coral-reef fish communities,* **Marine Ecology Progress Series**, **15**(3), 1984, pp. 265–247.
[3] Y. Bouchon-Navaro, C. Bouchon, M.L. Harmelin-Vivien, *Impact of coral degradation on a chaetodontid fish assem-blage (Moorea, French Polynesia),* proceedings of **The Fifth International Coral Tahiti**, 27 May-1 June 1985, M. Harmelin-Vivien and B. Salv, **5**, 1985, pp. 427–432, http://www.reefbase.org/pacific/pub_A0000000301.aspx
[4] S. Jennings, D.P. Boulle, N.V.C. Polunin, *Habitat correlates of the distribution and biomass of Seychelles reef fishes,* **Environmental Biology of Fishes**, **46**, 1996, pp. 15–25.
[5] C.L. Roberts, R.F.G. Ormond, *Habitat complexity and coral reef fish diversity and abundance on Red Sea fringing reefs,* **Marine Ecology-Progress Series**, **41**, 1987, pp. 1-8.
[6] J.R. Buchheim, M.A. Hixon, *Competition for shelter holes in the coral-reef fish Acanthemblemaria spinosa Metzelaar,* **Journal of Experimental Marine Biology and Ecology**, **164**(1), 1992, pp. 45–54.
[7] R.D. Clarke, *Population shifts in two competing fish species on a degrading coral reef,* **Marine Ecology Progress Series**, **137**(1-3), 1996, pp. 51–58.
[8] M.J. Caley, M.H. Carr, M.A. Hixon, T.P. Hughes, G.P. Jones, B.A. Menge, *Recruitment and the local dynamics of open marine populations,* **Annual Review of Ecology, Evolution and Systematics**, **27**, 1996, pp. 477–500.
[9] H.P.A. Sweatman, *The influence of adults of some coral-reef fishes on larval recruitment,* **Ecological Monographs**, **55**(4), 1985, pp. 469–485.
[10] M.J. Caley, *Community dynamics of tropical reef fishes: local patterns between latitudes,* **Marine Ecology Progress Series**, **129**(1-3), 1995, pp. 7–18.
[11] N. Tolimieri, *Effects of microhabitat characteristics on the settlement and recruitment of a coral-reef fish at 2 spatial scales,* **Oecologia**, **102**(1), 1995, pp. 52–63.
[12] N. Tolimieri, *Contrasting effects of microhabitat use on large-scale adult abundance in two families of Caribbean reef fishes,* **Marine Ecology Progress Series**, **167**, 1998, pp. 227–239.
[13] J.E. Caselle, R.R. Warner, *Variability in recruitment of coral reef fishes: The importance of habitat at two spatial scales,* **Ecology**, **77**(8), 1996, pp. 2488–2504.
[14] R.A. Hutagalung, *Lombok frags-the first sustainable coral cultivation on Indonesia for trade and reef conservation,* **The 9th International Aquarium Fish & Accessories Exhibition & Conference**, Aquarama, Singapore, 2005.
[15] M.S. Pratchett, S.K. Wilson, A.H. Baird, *Declines in the abundance of Chaetodon butterflyfishes following extensive coral depletion,* **Journal of Fish Biology**, **69**(5), 2006, pp. 1269–1280, https://onlinelibrary.wiley.com/doi/10.1111/j.1095-8649.2006.01161.x
[16] T. Kokita, A. Nakazono, *Rapid response of an obligately corallivorous filefish Oxymonacanthas longirostris (Monacanthidae) to a mass coral bleaching event,* **Coral Reefs**, **20**(2), 2001, pp. 155–158.
[17] M.D. Spalding, G.E. Jarvis, *The impact of the 1998 coral mortality on reef fish communities in the Seychelles,* **Marine Pollution Bulletin**, **44**(4), 2002, pp. 309–321.

[18] A. Halford, A.J. Cheal, D. Ryan, D.M. Williams, *Resilience to large-scale disturbance in coral and fish assemblages on the Great Barrier Reef*, **Ecology**, **85**(7), 2004, pp. 1892–1905. https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/03-4017
[19] P.L. Munday, *Habitat loss, resource specialization, and extinction on coral reefs,* **Global Change Biology**, **10(10)**, 2004, pp. 1642–1647.
[20] D.R. Bellwood, A.S. Hoey, J.L. Ackerman, M. Depczynski, *Coral bleaching, reef fish community phase shifts and the resilience of coral reefs,* **Global Change Biology**, **12**(9), 2006, pp. 1587–1594.
[21] D.J. Coker, M.S. Pratchett, P.L. Munday, *Coral bleaching and habitat degradation increase susceptibility to predation for coral-dwelling fishes*, **Behavioral Ecology, 20**(6), 2009, pp. 1204-1210.
[22] S.K. Wilson, N.A.J. Graham, M.S. Pratchett, G.P. Jones, N.V.C. Polunin, *Multiple disturbances and the global degradation of coral reefs: are reef fishes at risk or resilient?*, **Global Change Biology**, **12**(11), 2006, pp. 2220–2234.
[23] M.S. Pratchett, S.K. Wilson, M.L. Berumen, M.I. McCormick, *Sublethal effects of coral bleaching on an obligate coral feeding butterflyfish*, **Coral Reefs**, **23**(3), 2004, pp. 352–356.
[24] N.A.J. Graham, K.L. Nash, *The importance of structural complexity in coral reef ecosystems*, **Coral reefs**, **32**(2), 2013, pp. 315–326.
[25] S.B. Pratasik, Marsoedi, D. Arfiati, D. Setyohadi, *Egg placement habitat selection of cuttlefish, Sepia latimanus (Sepiidae, Cephalopod, Mollusca, in North Sulawesi waters, Indonesia,* **AACL Bioflux**, **10**(6), 2017, pp. 1514-1523.
[26] S. English, C. Wilkinson, V. Baker (ed.), *Line Intercept Transect* (Chapter 2.3), **Survey Manual for Tropical Marine Resources,** *Line Intercept Transect*, Australian Institute of Marine Science, 2nd edition, 1997, pp. 34-51, https://www.aims.gov.au/sites/default/files/Survey%20Manual-sm01.pdf
[27] J.E.N. Veron, **Corals of Australia and the Indo-Pacific,** University of Hawai'i Press, 1993, p. 644, https://uhpress.hawaii.edu/title/corals-of-australia-and-the-indo-pacific/
[28] H.T. Yap, E.D. Gomez, *Coral Reef Degradation and Pollution in The East Asian Seas Region: A Regional Approach,* **UNEP Regional Seas Reports and Studies No. 69**, 1985, pp. 185- 207, http://www.reefbase.org/resource_center/publication/pub_193.aspx
[29] C.J. Krebs, **Ecological Methodology**, Harper & Row Publishers, New York, USA, Second edition, 1989, p. 654. https://openlibrary.org/books/OL2043033M/Ecological_methodology#editions-list
[30] E.P. Odum**, Principles to Ecology**, translated by T**.** Samingan**,** Gadjah Mada University Press, Yogyakarta**,** Indonesia**,** 1993, p. 697 [translation in indonesian language].
[31] J.W. Nybakken (editor), **Readings in Marine Ecology**, Harper & Row Publishers, 2nd edition, 1986, pp. 289-291 [translation in indonesian language].
[32] R.A. McKinney, *Prioritizing urban marine habitats for conservation,* **Journal of Coastal Conservation**, **12(4)**, 2009, pp. 217-231.
[33] A.C. Alcala, G.R. Russ, *No-take Marine Reserves and Reef Fisheries Management in the Philippines: A New People Power Revolution,* **Ambio**, **35**(5), 2006, pp. 245-254.
[34] D.H. Williamson, G.R. Russ, A.M. Ayling, *No-take marine reserves increase abundance and biomass of reef fish on inshore fringing reefs of the Great Barrier Reef*, **Environmental Conservation**, **31**(2), 2004, pp. 149–159.
[35] B.S. Halpern, S.E. Lester, K.L. McLeod, *Placing Marine Protected Areas onto the Ecosystem-Based Management Seascape,* **Proceedings of the National Academy of Sciences of the United States of America**, **107**(43), 2010, pp. 18312–18317.

Received: November 28, 2019
Accepted: August 26, 2020