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Ecological status of target fishes inside and outside marine conservation area of Batbitim, Misool, Raja Ampat

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Abstract. Batbitim marine conservation area (MCA) of Misool, Raja Ampat has been set as an area that is prohibited for fishing activities since 2005. The only activities allowed in that area are tourism and research activities. The difference in the management status between area inside the Batbitim MCA and outside the MCA might affect ecosystem components such as fish and coral reef in the respective area. The present study aims to investigate the ecological status of target fishes in the two areas. Data were collected by using an underwater visual census at 5 sites, in which at each site 3 transects were placed. Collected data are then used to assess ecological indices for the target fishes. It is found that there were 38 species of target fish belonging to 13 families. The diversity index of Shannon was found to be in the range between 0.99 (inside MCA) to 1.67 (outside MCA) and dominance index ranged between 0.26 (outside MCA) and 0.61(inside MCA). The abundance of individual target fish in each location varies between 960 ind ha^{-1} (outside MCA) and 9413 ind.ha^{-1} (inside MCA). Those results indicate that there is a discrepancy between the ecological status of the target fish at locations inside and outside the MCA.

1. Introduction

Raja Ampat Regency consists of 4 major islands namely Waigeo Island, Batanta, Salawati and Misool [1]. This regency has rich marine diversity, with over 550 scleractinian coral species and over 1,400 fish species [2]. Misool Island may be the most popular place in Raja Ampat after Wayag Island. Misool is located in the southernmost part and has the largest conservation within the marine protected area (MPA) network in Raja Ampat with an area of 366,000 ha [3].

Rapid Ecology Assessment (REA) and Rapid Assessment Program (RAP) were carried out in 2001 and 2002 in Raja Ampat waters, including in Misool waters. This assessment found that Misool waters have the highest diversity in terms of fish and coral reefs[4]. There is a close relationship between coral reef ecosystems and reef fish; reef fish are more diverse in the coral reef ecosystem when compared with other ecosystems in the ocean [5]. Reef fish can be grouped into three groups: major fish group, indicator fish group, and target fish group. Target fish are categorized as economically important fish and are usually captured for consumption [6]. The target fish include the family of *Serranidae*, *Lutjanidae*, *Lethrinidae*, *Nemipteridae*, *Caesionidae*, *Siganidae*, *Haemulidae*, *Scaridae* and *Acanthuridae*.

The MPA in Misool is protected and managed through a zoning system to warrant a sustainable resource and environmental management. Among the zoning system, there are traditional use zones

(TUZ) and marine conservation area (MCA) [3]. Traditional fishing and other economic activities are allowed inside the TUZ, while inside the MCA, only marine tourism activities (e.g. skin diving and SCUBA diving) are allowed [7]. One of the MCA is known as Batbitim MCA. Batbitim has been designated as an MCA since 2005 [8]. Since then, fishing activities in the area are no longer permitted. The traditional fishing activities are allowed only inside TUZ, including in Wayaban waters. It is expected that fishing activities outside protected coral reef areas would benefit from the coral reef protection[9][10] since fish within the protected area might have the opportunity to reproduce or to grow before caught by fishers. While it is necessary to evaluate the performance of the MCA in terms of its impact on diversity and abundance of fish, until today there are very limited studies that assess ecological status target fish inside and outside the MCA, particularly in Misool. The present study is an effort to overcome the gap.

2. Materials and methods

2.1. Site and data collection

Data for the present study taken from 5 stations (sites) inside the Misool MPA, where 3 sites (site 3, site 4 and site 5) are located at Batbitim MCA and 2 sites (site 1 and site 2) are located at Wayaban waters (See Fig 1). Data collections were conducted in January of 2019.

Collecting reef target fish data used underwater fish visual census (UVC) [6] especially the belt transect method [11][12]. The UVC was done by 3 surveyors. Three replicates of 50 m x 5 m belt transect were placed at each site. The target fish at a belt of 2.5 meters to the left and right of the line transect was identified and counted. In addition to target fish data, we also collected life form data of coral reef by using point intercept transects (PIT) [13]. The line transects were placed at the same sites as of belt transect at depth of 10 m. The observations of target fish were carried out first and then followed by coral observations.

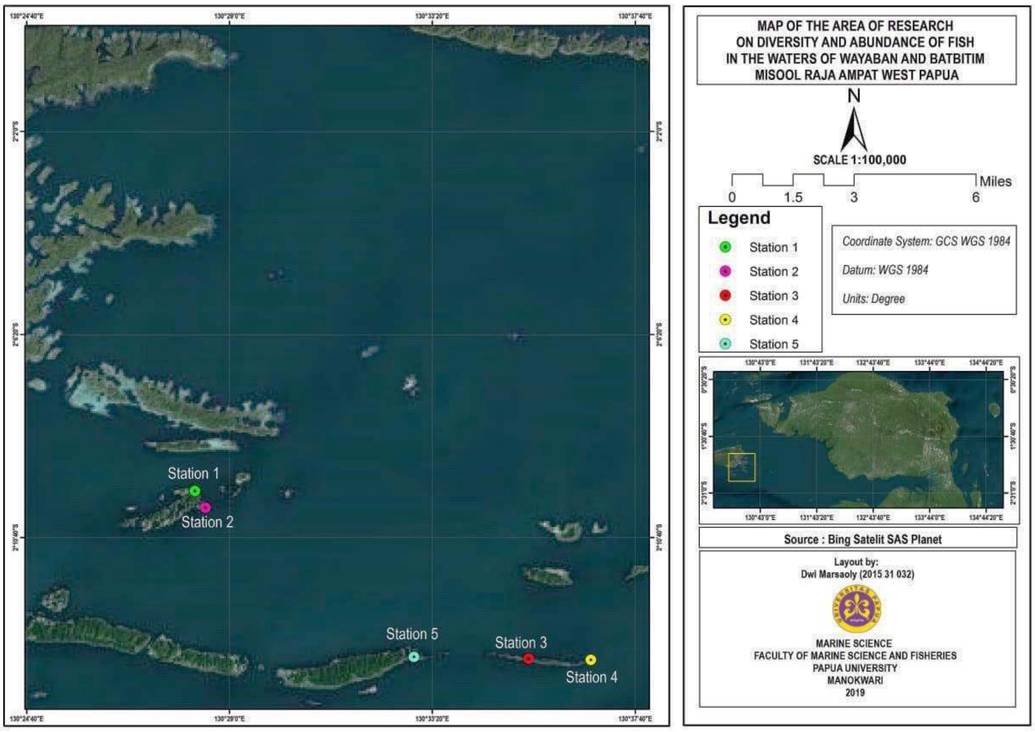

Figure 1. Research stations (sites) at Misool marine protected area.

2.2. Data analysis
Collected data of target fish were then analyzed to assess several ecological parameters, such as diversity index, dominance index, absolute density and relative density for the target fishes.

Analysis of the diversity (Diversity Index/H) of species of fish is calculated by the Shanon-Wiener equation by using the following formula [14][15]:

$$H' = -\sum_{i=1}^{s} pi \ln pi \quad (1)$$

Where
H '= Shannon-Wiener diversity index
Pi = ni / N
Ni = number of individuals of species-i
N = total number of individuals
S = number of species / species

Criteria:
a) H <1 = low diversity
b) 1 <H <3 = moderate diversity
c) H> 3 = high diversity

Dominance index (C) of target fish is calculated using the Simpson diversity index with formulas follows [14][15]:

$$C = \sum_{i=1}^{s} pi^2 \quad (2)$$

Where
C = dominance index
pi = proportion of the number of individuals in reef fish species (Pi = ni / N)
Dominance index values range from 0 to 1. If C approaches 1 then there is a tendency for one or more species to dominate the other species, whereas if C approaches 0 then there is no tendency for species to dominate the other.

An absolute abundance of reef fish is the number of individuals from certain species that are in a certain area. The abundance of reef fish can be calculated by using the formula :

$$D = \frac{Ni}{A} \quad (3)$$

Where
D = Abundance of individual fish (Ind/Ha)
Ni = Number of individual fish species i (Ind)
A = Area (Ha)

3. Result and discussion

3.1. Community structure of target fish
Many fish target species found in the study sites were 38 species belonging to 13 families (Tabel 1). Except for *Scarus* sp, not all species have appeared in all sites; Most of the species were found only at most three sites. The number of individuals of each species varied among sites, with the most individual appeared on site 1 belonging to families of Scaridae and Carangidae, on-site 2 belonging to families of Scaridae, Achanthuridae and Caesionidae, on-site 3 belonging to family Caesionidae, on-site 4 belonging to families of Caesionidae and Balistidae, and on-site 5 belonging to family of Caesionidae. In total, the number of individuals for all species was higher at sites 3, 4, and 5 which is located inside Batbitim MCA.

3.2. Shannon index of diversity

The ecological index of the diversity of target fish at sites outside the Batbitim MCA was relatively higher than that of at sites inside the MCA (Fig 2). Even though the Shannon index of diversity increases as some species increases but it also depends on the distribution of abundance among each species [15]. Therefore, the index figures in Fig 2 do not necessarily explain that inside the MCA were more species of target fish than that outside the MCA. It might explain that the community structure of target fish outside the MCA was distributed relatively more equal among the species within each site than that inside the MCA.

Table 1. Composition of target fish species found in the observation sites and their relative abundance at each site.

No	Spesies	Family	Site 1	Site 2	Site 3	Site 4	Site 5
1	*Achanturus sp*	Achanthuridae	4.2	**19.4**	4.0	-	3.8
2	*Naso hexsacanthus*	Achanthuridae	-	4.3	-	-	-
3	*Naso vlaminggi*	Achanthuridae	-	-	-	0.8	-
4	*Macolor macularis*	Lutjanidae	-	2.2	0.4	0.4	-
5	*Lutjanus decussatus*	Lutjanidae	4.2	1.1	-	0.4	2.3
6	*Lutjanus carponotatus*	Lutjanidae	4.2	4.3	-	-	-
7	*Lutjanus gibbus*	Lutjanidae	-	1.1	-	-	-
8	*Lutjanus rivulatus*	Lutjanidae	-	-	0.3	-	-
9	*Lutjanus bigutattus*	Lutjanidae	-	-	0.3	-	6.8
10	*Plectropomus leopardus*	Serranidae	1.4	-	-	-	-
11	*Variola lauti*	Serranidae	1.4	-	-	-	-
12	*Cephalopholis argus*	Serranidae	-	5.4	-	-	-
13	*Plectropomus areolatus*	Serranidae	-	2.2	-	-	-
14	*Cephalopholis miniata*	Serranidae	-	-	0.6	1.2	-
15	*Aethaloperca rogga*	Serranidae	-	-	-	1.6	-
16	*Cephalopholis urodeta*	Serranidae	-	-	-	0.8	-
17	*Cephalopholis cyanostigma*	Serranidae	1.4	4.3	-	0.8	-
18	*Siganus doliatus*	Siganidae	1.4	2.2	0.1	-	-
19	*siganus crysospiles*	Siganidae	-	2.2	0.0	-	-
20	*Siganus vulpinus*	Siganidae	-	-	0.1	-	1.5
21	*Siganus lineatus*	Siganidae	-	-	0.3	-	-
22	*Siganus chrysospilus*	Siganidae	-	-	-	0.8	-
23	*Caesio tille*	Caesionidae	-	-	**28.3**	-	-
24	*Caesio cuning*	Caesionidae	6.9	**16.1**	**53.8**	4.1	-
25	*Pterocaesio tille*	Caesionidae	-	-	5.0	-	-
26	*Pterocaesio pisang*	Caesionidae	-	-	-	**40.7**	**75.2**
27	*Gnathanodon speciocus*	Carangidae	**20.8**	1.1	-	-	1.5
28	*Caranx ignobilis*	Carangidae	-	-	0.4	-	-
29	*Caranx melampygus*	Carangidae	-	-	0.7	-	-
30	*Pseudobalistes fuscus*	Balistidae	-	1.1	-	-	-
31	*Odonus niger*	Balistidae	-	-	-	**34.6**	-
32	*Letrinus olivaceus*	Lethrinidae	-	-	0.3	-	-
33	*Lethrinus erytropterus*	Lethrinidae	-	-	0.1	2.0	-
34	*Platax teira*	Ephippidae	-	1.1	-	0.4	-
35	*Plectorhinchus lineatus*	Haemulidae	-	-	0.1	-	0.8
36	*Cheilinus undulatus*	Labridae	5.6	1.1	-	-	-

No	Spesies	Family	Site 1	Site 2	Site 3	Site 4	Site 5
37	*Carcharhinus melanoterus*	Carcharhinidae	-	-	-	0.8	-
38	*Scarus sp*	Scaridae	**48.6**	**31.2**	5.1	10.6	8.3
	Number of species		**11**	**17**	18	15	8

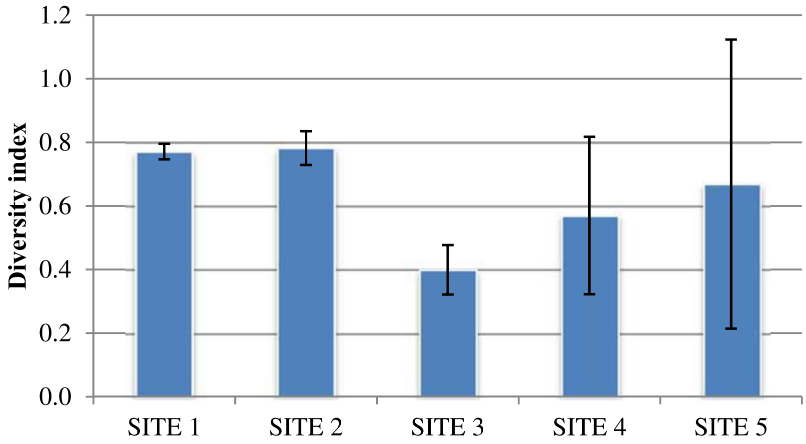

Figure 2. The diversity index of Shannon for target fish species at five observation sites.

3.3. Dominance index

On average, indices of abundance of target fish were higher at sites inside the MCA (0.48 – 0.61) than outside the MCA (0.26 – 0.32). These figures explain that the degree of dominance was higher at sites inside the MCA; that was one or more species consisting of large number individuals in the sites. For example, *Caesio tille* and *Caesio cuning* contributed more than 80% of individuals of target fish at sites 3 and *Pterocaesio pisang* contributed about 75% of individuals at site 5.

The dominance of certain species, especially inside the MCA, explains the possibility of disturbance to the ecosystem or target fish community. As areas inside the MCA are used only for tourism activities (diving), it should be aware of the increase in many divers and their behavior in a diving spot. Diving spots are commonly characterized by a high diversity of corals and other marine lives. While there is no study about the impact of diving activities on fish communities in diving spots around Misool or Raja Ampat, some research elsewhere has reported that diving activities may affect fish behavior [16] and fish abundance and community structure [17].

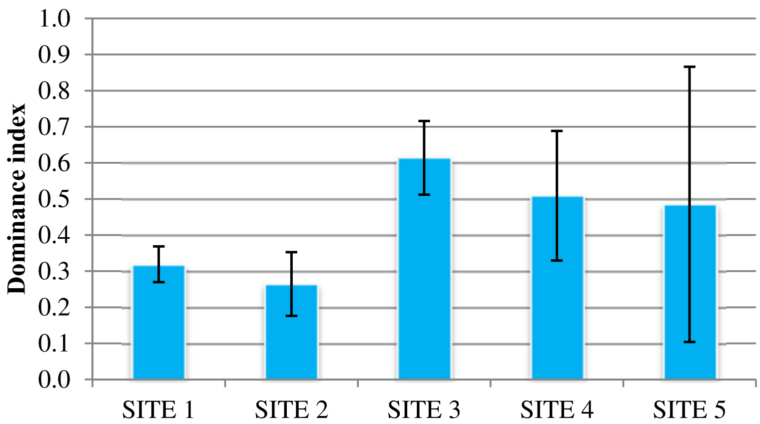

Figure 3. Dominance index for target fish species at five observation sites.

3.4. Abundance
Estimation of the abundance of target fish at each site was based on an underwater visual census using three replication of 50 m belt transect. The results showed that target fish abundance varies among sites. On average, higher target fish numbers were found at locations within the MCA, with values ranging from 1770 to 9400 ind.ha^{-1} (Fig 4). At sites located outside the MCA, on average target fish abundances were 960 to 1240 ind.ha^{-1} which were less than those at inside the MCA.

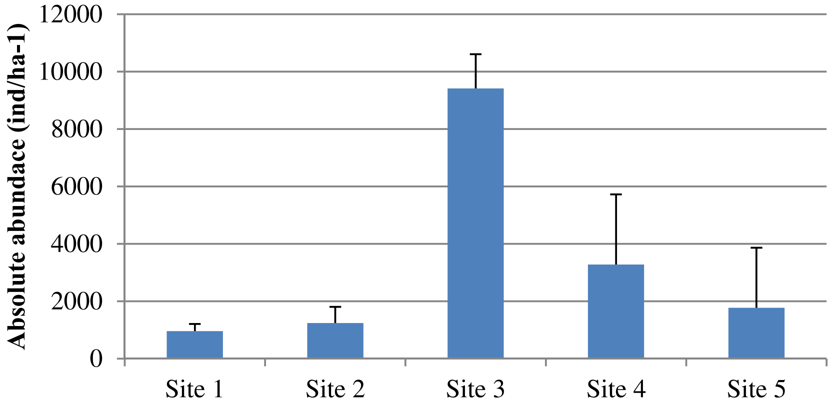

Figure 4. The abundance of target fish species at five observation sites in Misool.

3.5. Impact of coral reef condition on the ecological status of target fish species
Examination of coral condition, represented by percent cover, showed that sites inside the MCA had higher percent cover of coral compared with sites outside the MCA. Live coral (hard and soft coral) covered about 53.5% to 59.3% of site areas outside the MCA. On the contrary, sites inside the MCA were covered by 71% to 73% of live coral. The differences in the coral conditions might be brought about the different impacts on the ecological status of target fish.

Fig 5 and Table 2 show a possible relationship between coral percent cover and ecological status of target fish. The diversity index of Shannon tended to decrease as the coral cover increases, while the dominance index as well as fish abundance increase in line with the percent cover of coral. The good condition of coral cover is thought to provide protection and a feeding place for certain fishes so that the fish become dominant and abundant in the areas. However, high coral cover is not always followed by high coral species richness. Some species of reef fish, particularly highly economical value species may be less in number due to fishing [18][19]. When fish species richness is high, it is possible to have a large number of species present in the areas [20].

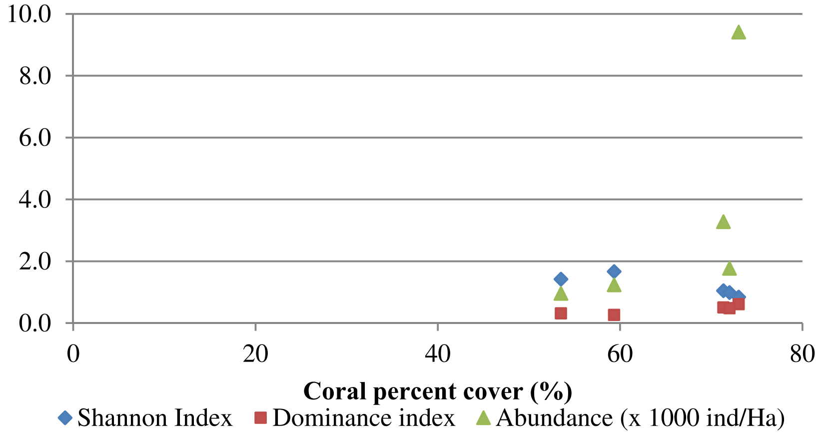

Figure 5. The plot of percent cover of coral against Shannon index, dominance index and abundance of target fish.

Table 2. Matrix of correlation between coral percent cover and index of diversity (Shannon), index of dominance and abundance of target fish in Misool Raja Ampat.

	Shannon Index	Dominance index	Abundance
Coral Percent cover	-0.87	0.89	0.61

4. Conclusion
Areas inside the MCA of Batbitim tended to have a high abundance of target fish but they were dominated by some particular species or the fish communities were less diverse in the areas. The ecological status of target fish inside and outside the MCA is likely to be affected by coral reef condition in the respective areas.

5. Reference
[1] Manuputty A E, Souhoka J, Hukom F D, Cappenberg H A, Sihaloho H F, Widyastuti E, Irawan A, Limbong S R, Salatalohy A, Picasouw J et al 2015 *Health Baseline Study of Coral Reefs and Related Ecosystems on the Waters of Salawati Island and Batanta Island Radja Ampat Regency, West Papua* (Indonesia: COREMAP CTI LIPI Jakarta)

[2] Mangubhai S, Erdmann M V, Wilson J R, Huffard C L, Ballamu F, Hidayat N I, Hitipeuw C, Lazuardi M E, Muhajir, Pada D et al 2012 Papuan Bird's Head Seascape: Emerging threats and challenges in the global center of marine biodiversity *Marine Pollution Bulletin* **64** p 2279-2295

[3] Muhajir, Purwanto, Mangubhai S, Wilson J, and Ardiwijaya R 2012 *Marine resource use monitoring in Misool Marine Protected Area, Raja Ampat, West Papua 2007-2011* (Indonesia: The Nature Conservancy, IndoPacific Division)

[4] McKenna S A, Allen G R and Suryadi S 2002 A marine rapid assessment of the Raja Ampat Islands, Papua Province, Indonesia *RAP Bulletin of Biological Assessment* **22** (Washington DC: Conservation International)

[5] Panggabean A S 2012 Keanekaragaman jenis ikan karang dan kondisi kesehatan karang di Pulau Gof Kecil dan Yep Nabi Kepulauan Raja Ampat *Jurnal Penelitian Perikanan Indonesia* **18** 2 p 109-115

[6] English S, Wilkinson C and Baker V 1997 *Survey Manual for Tropical Marine Resources* Second ed. (Townsville: Australian Institute of Marine Science)

[7] Pranata R T H and Satria A 2015 Strategi adaptasi nelayan terhadap penetapan kawasan konservasi perairan daerah di Misool Selatan, Kkpd Raja Ampat *J. Kebijakan Sosek KP* **5** 2

[8] WildAid 2012 *Enforcement Assessment: BatBitim and Daram no-take zones* (WildAid: San Francisco)
[9] Mumby P J, Dahlgren C P, Harborne A R, Kappel C V, Micheli F, Brumbaugh D R, Holmes K E, Mendes J M, Broad K, Sanchirico J N et al 2006 Fishing, trophic cascades, and the process of grazing on coral reefs. *Science* **311** 5757 p 98-101
[10] Sala R, Simbolon D, Wisudo S H, Haluan J, and Yusfiandayani R 2018 Suitability of fishing gear type in traditional use zone of Misool, Raja Ampat. *Marine Fisheries: Journal of Marine Fisheries Technology and Management* 9 1 p 25-38.
[11] Caldwell Z R, Zgliczynski B J, Williams G J, and Sandin S A 2016 Reef fish survey techniques: Assessing the potential for standardizing methodologies *Plos One* p 14
[12] Beck H J, Feary D A, Figueira W F, and Booth D J 2014 Assessing range shifts of tropical reef fishes: A comparison of belt transect and roaming underwater visual census methods *Bulletin of Marine Science* **90** 2 p 705-721
[13] Lam K, Shin P K S, Bradbeer R, Randall D, Ku K K K, Hodgson P, and Cheung S G 2006 *A* comparison of video and point intercept transect methods for monitoring subtropical coral communities *Journal of Experimental Marine Biology and Ecology* **333** 1 p 115-128
[14] Wiley J and Sons 2002 *Ecological statistics* ed. Abdel H E and Walter W P vol **2** (Chichester)
[15] McPherson G R and DeStefano S 2003 *Applied ecology and natural resource management* (New York: Cambridge University Press) 165
[16] Andradi-Brown D A, Gress E, Laverick J H, Monfared M A A, Rogers A D, and Exton D A 2017 Wariness of reef fish to passive diver presence with varying dive gear type across a coral reef depth gradient *Journal of the Marine Biological Association of the United Kingdom* **98** 7 p 1733-1743
[17] Dearden P, Theberge M and Yasué M 2009 Using underwater cameras to assess the effects of a snorkeler and SCUBA diver presence on coral reef fish abundance, family richness, and species composition *Environmental Monitoring and Assessment* **163** p 531
[18] Mudjirahayu, Bawole R, Rembet U N W J, Ananta A S, Runtuboi F and Sala R 2017 Growth, mortality and exploitation rate of Plectropomus maculatus and P. oligocanthus (Groupers, Serranidae) on Cenderawasih Bay National Park, Indonesia. *Egyptian Journal of Aquatic Research* 43 p 213–218
[19] Bawole R, Mudjirahayu, Rembet U.N.W.J, Ananta A S, Runtuboi F and Sala R 2017 Growth and mortality rate of the Napan-Yaur coral trout, Plectropomus leopardus (pisces: Serranidae), Cenderawasih Bay National Park, Indonesia. *Biodiversitas* 18 2 p 758-764
[20] Messmer V, Jones G P, Munday P L, Holbrook S J, Schmitt R J, and Brooks A J 2011 Habitat biodiversity as a determinant of fish community structure on coral reefs *Ecology* **92** 12 p 2285-2298

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